

**A CLASSIFICATION SYSTEM OF BEHAVIOR INDICATORS EXHIBITED IN
TEAM COMMUNICATION: THE INTRICATE ROLE OF TEAM REFLEXIVITY
WITH TEAM COGNITION, REGULATORY PROCESSES AND PERFORMANCE**

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DEDICATION

To my parents
who always give me the security
that they would catch me if I fall.

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This dissertation represents one of the greatest challenges I have ever undertaken. To finally reach the end of it seems almost unbelievable. At the beginning of this journey, I quite naively believed that I could successfully combine full-time work and dissertation studies at the same time. The fact that I still completed my dissertation in four years simply astounds me, but it has not, of course, been without incredible sacrifices.

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SUMMARY

Effective information processing is the pillar of adaptive teams for developing cognitive processes. Research has shown team reflexivity to advance team regulatory processes and performance¹. However, research has predominantly relied on static measures to examine the nature of the unfolding processes, the relationships and interplay with regulatory processes, cognitive emergence and team performance². As part of this work, a classification system of behavior indicators as an objective communication-based method was developed to assess the dynamics and complexity of the unfolding processes. The theoretical background and requirements of the measurement instrument constituting the classifiers of the classification system was based on intensive literature review, training and testing of the coding analysis procedure. The data supporting this dissertation is the product of the virtual teams' participation during objective communication exercises.

Drawing on the interaction team cognition theory and reflexivity, a theoretical model of all involved constructs was created to reflect upon the complexity of virtual team situations. It was proposed and found, by assessing the pre-defined cognitive behavior and reflexivity communication classifiers, that receiving team reflexivity expedited the externalization of reflexivity and cognitive behaviors in communication. Further, the tested theoretical model results showed that cognitive behaviors of situation awareness and transactive memory have a direct effect on performance, and, that transactive memory mediated the relationship between reflexivity and performance. Finally, these virtual teams stayed initially longer on reflexivity transition phase for strategy development and exhibited different volumes of cognitive behaviors across time. The result was higher team performance.

This research tested the theoretical propositions using 62 virtual teams that communication via a chat while completing a collective task. The results support hypotheses, indicating team reflexivity to have a more intricate relationship with performance through team communication and cognition. Virtual teams were culturally aware of their ethnic and language diverse team members and had no impact on team processes or performance. The study did show that reflexivity was a beneficial approach for exhibiting behaviors relevant for strategy development and composition for language diverse teams. This research indicates team reflexivity to have a more intricate relationship with performance through team

¹ E.g., Schippers, Homan, & Van Knippenberg, (2013).

² E.g., Gevers, Uitdewilligen & Passos, (2015).

communication and cognition. This research advanced beyond the static to a higher order dynamic measure for understanding the complexity of team processes in socio-technical environments. It also demonstrates further opportunities that the growth of communication methods can offer.

Keywords: Virtual teams; Cognitive behaviors; Situation awareness, Transactive memory; Team Reflexivity; Communication; Classifiers.

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LIST OF SYMBOLS

α : Reliability coefficient

β : Beta coefficient

CI: Confidence Interval

d : Cohen's d

F : ANOVA

f^2 : Cohen's f - Square Effect Size

κ : Cohen's Kappa Coefficient

M : Mean

$M - D$: Mean Difference

N : Total sample size

n : Sample

OR: Odds Ratio

p : Significance

r : Effect Size for Mann- Whitney- U

R^2 : R-squared

φ : Effect size

φ_c : Effect size

SD : Standard deviation

SE : Standard error

t : t -test

U : Mann- Whitney- U test

Wald χ^2 : Wald - Test

χ^2 : Chi- Square

z : Standard score

1 Introduction

Chapter 1 positions the research theme and provides an overview of the dissertation studies. The goal of the first Chapter is to present the aim and objective of this dissertation and its overall contribution to research. The first Chapter concludes with an overview of the dissertation Chapters.

1.1 Positioning of Research Theme

Within dynamic and complex socio-technical environments teams have become quintessential building blocks for organizations (Salas, Cooke, & Rosen, 2008; Widmer, Schippers, & West, 2009). As the work environment is faced with the reality of constant change that presents high levels of complexity and unpredictability, organizations rely on the ability of teams to respond quickly and effectively to these changing circumstances (Gevers, Uitdewilligen, & Passos, 2015). With the demands for rapid adaptation and capacity to generate quick solutions, organizations have adopted organizational structures and technologies that enable to rapidly reconfigure manpower and resources (Rosen, Fiore, Salas, Letsky, & Warner, 2008). Many enterprises are paying more attention to virtual teams as a preferred organizational structure of conducting global business to generate advantage through regional and topic expertise (see Rosen et al., 2008). These teams are formed to collaborate and effectively adapt to the changing environment that with a traditional team structure could not be managed (e.g., Agranoff & McGuire, 2001).

A distinct characteristic of virtual teams is that they form temporary for highly specific tasks, and are more or less *virtual* in nature (e.g., Powell, Piccoli & Ives, 2004). The team has its members distributed in time and space, who are dependend on technology to communicate with each other to fulfill the task (Powell, Piccoli & Ives, 2004). The name definition of these teams are used interchangeably in literature: virtual, geographically dispersed, remote or distributed teams (Gibson and Coehn, 2003; Gibson & Gibbs, 2006; Powell et al., 2004). For the purpose of positioning this research, the term ‘teams’ refers to *virtual teams*.

Research has addressed virtual teams from many different angles, including studies of leadership (e.g., Jones and Hinds, 2002), knowledge management (e.g., Rosenberg, 2000), coordination (e.g., Bechky, 2006; Farad & Xiao 2006; Majchrzak, Jarvenpaa, et al., 2007), sense making processes (e.g., Weick 1990; 1993), terms of virtuality (e.g., Saunders & Ahuja, 2006), and communication (e.g., McKinney, Barker, Smith, & Davis, 2004). The

science of virtual teams is therefore a critical driver in understanding their effectiveness and adaptability in highly complex socio-technical environments.

Literature on factors influencing team performance (Gevers and colleagues, 2015) expanded tremendously during the last decade (e.g., Kozlowski & Ilgen, 2006; Mathieu, Maynard, Rapp, & Gilson, 2008). In addition, several studies address how teams adapt to new and challenging situations (e.g., LePine, 2005; Randall, Resick, & DeChurch, 2011). Recent findings postulated the dynamic aspect of team cognition, entailing mental abilities and processes related to information processing, to be essential for understanding all facets of team adaptation processes (e.g., Cooke, Gorman, Myers & Duran, 2013; Burke, Stagl, Salas, et al., 2006; DeChurch & Mesmer-Magnus, 2010; Gevers et al., 2015). Particularly, as team cognitive constructs enable detection and management of unexpected events (Endley, 1995; Gevers et al., 2015; Lewis 2004). Research literature on team cognition demonstrate that teams with well-developed cognitive processes (i.e., situation awareness or transactive memory system) provide the team access to a larger pool of knowledge (Hollingshead, 1998), help to reduce individual cognitive load (Hollingshead, 1998), enhance task coordination (Lewis, 2003), and result in superior team performance (Brandon and Hollingshead 2004; Hsu, Shih, Chiang, & Liu, 2011; Lewis 2004; Lewis, Lange, & Gillis, 2005).

The study of team cognition has therefore led to a better understanding of improving the predictions of ‘when’ and ‘why’ teams succeed or fail. Researchers have noted that many examples of catastrophic socio-technical system failures can, for instance, lead to a breakdown in team cognition (Cooke et al., 2013). In many cases, the complexity of collaboration posed constraints on team cognition, which through a failure to interact led to severe consequences (e.g., Salas, Cooke & Rosen, 2008). An example framing such challenges for virtual teams are self-organized, highly specialized teams in the military domain known as Network Enabled Capability (NEC; Walker, Stanton, Salmon, Jenkins, Rafferty, & Besell, 2009). The teams “can work together to adapt to a changing environment, and develop shared vision of how best to employ forces and effectively defeat the enemy” (Ferbrache, 2005, p.104). Even with those highly effective and specialized teams, their success or failure depends on dynamic factors (e.g., Rosen et al., 2008). Rosen and colleagues (2008) propose that teams must, for example, demonstrate successful performance by mastering interaction and communication between all team members in multiple locations and possibly with dissimilar technologies. They must also demonstrate overall adaptability and effectiveness.

According to Dörner, Kreuzig, Reither, and Stäudel, 1983, complex situations are evident when the solution for the problem requires a series of operations. In addition, the parts of the problem relevant to the solution process are rather large, are highly interconnected, and change dynamically over time (Dörner et al., 1983). Dörner and colleagues (1983) demonstrate that in many complex situations, an unexpected condition can emerge and require teams to perceive, evaluate, weight, and factor unexpected results into their task solution. Moreover, parameters of the environmental characteristics occurring during the task also generate a number of simultaneous goals, which include parameters such as time, pressure, information/ knowledge uncertainty, dynamic information, and large sets of information necessary for analysis and performance assessment (Dörner et al, 1983, Rosen et al., 2008).

Table 1. Situation Parameters in Complex Environments (adapted from Rosen et al., 2008).

Situation Parameter	Description	Example Issues for Virtual Teams
Time pressure	Time as a limiting factor on cognitive processing, team communication or coordination devoted to task performance	<ul style="list-style-type: none"> • Local time constraints communicated in virtual teams • Provided instant Feedback
Information and knowledge uncertainty	Inadequate information to build an accurate representation of the situation	<ul style="list-style-type: none"> • Communication of uncertain information • Communication without paralinguistic content
Dynamic information	Information that becomes invalidated and outdated; and meaning alteration by additional information or replaced new information	<ul style="list-style-type: none"> • Communication and interpretation of local information pieces • Pattern recognition of historic use of information
Large amount of information	Environmental demands exceeds the cognitive resources of an individual or team	<ul style="list-style-type: none"> • Distribution and synthesis of information across team members • Filtering information to guide attention

Table 1 summarizes environmental characteristics and challenges these parameters pose for supporting virtual teams. An analysis of information available from both internal and external resources is necessary to determine whether problem solutions contain collective responses for each complex situation (Rosen et al., 2008). Precise and effective communications are critical for updating cognitive processes to cope with highly complex and dynamic situations (e.g., Mileti, 1999; Vieweg, Hughes, Starbird, & Palen, 2010). Yet, organizational and compositional characteristics of virtual teams pose additional challenges on team processes and cognition. Besides the aforementioned factors (e.g., temporal, physical distribution, expertise, and knowledge), factors of cultural heterogeneity and role allocation pose issues in virtual team collaboration (Rosen et al., 2008). Team members must consider

all additional factors needed to communicate in multicultural settings or languages. It is important that members have a complete understanding of each other's (real or simulated) capability, intent, and action to coordinate effectively (Walker et al., 2009). In addition to the complexity of fast evolving situations, team composition and diversity, the reduced social contact cues in virtual teams and the utilization of different communication media, challenges the operation of these teams (e.g., Sproull & Kiesler, 1986). The problematic context of collaborating and communicating in such highly complex socio-technical environments raises questions as to whether team interventions (*team reflexivity*) may improve team cognition and communication processes by mitigating the constrained conditions, which define the operation.

Especially, since effective communication seems to be the pillar of modern adaptive virtual teams for developing and maintaining cognition in complex socio-technical environments (see Cooke et al., 2013). During collaboration, communication is the product of the joint activity allowing knowledge to be exchanged (Fiore, Rosen, Smith-Jentsch, Salas, Letsky, & Warner, 2010, Fiore & Salas, 2004, McMillan, Entin, & Serfaty, 2004). This exchange shares knowledge containing aspects of cognition in form of language and meaning that furthers team activity (e.g., Fiore et al., 2010, Cooke et al., 2013). The type of cognitive information shared and how will depend on the sender (Wegner, 1995; Woods & Hollnager, 2005; Cooke et al., 2013). Individuals differ in the behavior of how they compose the meaning and communicate messages (e.g., inferences used; Vieweg, 2010). If the intent of the speaker is to convey a message, the behavior of individuals can be considered communicative (e.g., Cooke et al., 2013). This research refers to these behaviors, which are cognitive in nature, as *cognitive behavior*³. For positioning this research theme, the term *cognitive behavior* is used in a general sense, and defined as:

*Cognitive processes that display meaningful behavior
to produce action on oneself or by others.*

Attention is drawn to the notion that these cognitive behaviors are mediated through team communication which produces action in one way or another and may influence overall

³ The term *cognitive behavior* first appeared in the domain of cognitive behavior modification in the late 1970 (e.g., Donald Meichenbaum, 1977) focusing on dysfunction in self-talk (self-verbalizations). In order to change unwanted behaviors, it is now –referred to as Cognitive Behavioral Therapy. The term *cognitive behavior* also appeared in connection with Bloom's taxonomy of educational objectives (1956) exemplifying six definitions of major categories in the cognitive domain. Categories consist of several behavioral terms, that when compared with other categories, allow differentiation between activities requiring higher or lower levels of cognitive functions.

team effectiveness (Cooke et al., 2013, Fiore et al., 2010, Fiore & Salas, 2004, Rosen et al., 2008). Therefore, team members' interaction (e.g., e-mail, phone or face-to-face) define cognitive processes of existing and new knowledge observable in form of both cognitive behaviors and coordination patterns (e.g., communication flow of who talks to whom; Cooke et al., 2013). As cognitive processes occur within the situational context and emerge over time (Gevers et al., 2015), observing the communication of cognitive behaviors may provide insight into all facets of team cognition and its relationship to overall team effectiveness.

In the past, research of cognitive processes relied mostly on static measurements of team cognition data, besides team cognition being an unfolding process over time (Randall et al., 2011; Gevers et al., 2015; Uitdewilligen, Waller, & Pitariu, 2013). Because knowledge is limited about these emerging cognitive processes; this research aims to capture the dynamic aspect of team cognition by adopting a communication-based approach. Communication refers to a function of any human interaction that without no meaningful or coherent activities can occur (Thomason, 1988; Ochieng & Price, 2010). Communication can be considered the backbone for the development and maintenance of cognition in teams (see Cooke et al., 2013).

Acknowledging the gap and scarcity in the body of knowledge, interrelations of team cognitive constructs - situation awareness and transactive memory - in virtual team communication and approaches to assist adaptiveness of teams to result in performance improvements form the ultimate research theme of this dissertation. An overview of this Chapter outline follows; it describes the features of the research objectives.

1.2 Overview of Dissertation Studies

This dissertation studies three separate constructs that when combined, form a theoretical model. To evolve the theoretical model from the developed constructs, several foci of research were defined. In the first part, the research focuses on the development of a classification system for cognitive components that allows automatic analysis of cognitive behaviors and reflexivity. The design, of an effective classification system, required a thorough understanding of the use of a common or natural language composition in virtual teams. The second part concerns the impact of cultural diversity on overall team processes and performance. Although, cultural diversity research is extensive in the area of cultural differences, behavioral data, and non-verbal/ verbal communication styles (Gudykunst & Ting-Toomey, 1988), there is a paucity of studies about the effect of cultural diversity on team communication and team performance in computer-mediated environments. The third

part describes an approach for mitigating challenges in virtual teams. Particularly, that of the development of team cognition to improve cognitive behavior communication and performance by means of team reflexivity. While literature surrounding team reflexivity demonstrate positive effect of this approach (Schippers, Den Hartog, Koopman, & Wienk, 2003), there is paucity in literature, and the analysis of team reflexivity is not well understood.

1.2.1 Overview of Research Part I

Teamwork using virtual teams has become a popular approach for achieving organizational goals. While the importance of team understanding and communication is often implied, research literature about explicit communication of a team's cognition is limited and not well understood. This is an important issue in cognitive research because the team's interactive communications among its members is the primary backbone necessary for team members to share cognitive information during times of dynamic, constraint-bound situations (Cooke et al., 2013, Rosen et al., 2008). This type of information is cognitive in nature, and is a primary goal of research. The increasing complexity of socio-technical systems, leads to a variety of emerging cognitive constructs that operate at the team level. The emerging constructs benefit communications among team members as well as *developing team cognition* (Fiore & Salas, 2004), *team situation awareness* (Bolstad & Ensley, 2000; 2003) and *transactive memory system* (Wegner, 1986). The function of communication within teams is to gain new research momentum to identify and expand team cognitive processes. Within the virtual team's communications domain, identifying cognitive factors is very elusive, with only limited success in developing the empirical data to support investigation of cognitive behaviors in communication.

Besides exploring types of communication as a rich source of data for understanding team cognition, the practical part of this research establishes a classification system to support automation of communication analysis and real-time processing. The goal is to support teams in case anomalies occur, by (a) monitoring their communication, (b) using the classification system to analyze and interpret cognitive communication patterns, and (c) diagnosing team states. Such a type of monitoring could, for example, provide instructive feedback during or for subsequent training. This extends the research literature to include answers to the following questions:

1. Do teams demonstrate cognitive behaviors in team communication?
2. How to construct teams linguistically?
3. Which cognitive behaviors relate to team effectiveness?

1.2.2 Overview of Research Part II

In the team literature, cultural diversity is a frequent analysis factor. It remains largely equivocal, but it does provide a central emphasis on testing the main effects of diversity. Cultural diversity research efforts must include how and when cultural diversity affects team processes and effectiveness in-order-to, accurately model and examining diversity effects on computer- mediated communication. Literature on computer-mediated communication inherent in cultural diversity is vague or non-existent. This dissertation explores diversity, specifically ethnic and language diversity of English and non-native English communicators. A clear understanding on their effect on language choice and communication can create a critical relationship of members and to team effectiveness.

1.2.3 Overview of Research Part III

A unique and defining feature of this dissertation is the use of team reflexivity to examine its effects on behavioral cognitive communication and team effectiveness. Reflexivity is an approach by which team member's iterative process of sharing information may be manifested in team behavior and communication (e.g., West, 2000). The following Chapters discuss reflexivity more extensively.

Much of the team literature reflects the use of questionnaires to identify the effectiveness of reflexivity on overall team outcomes (see Schippers et al., 2013). Subjective data collection methods, in the form of questionnaires, provide an effective and timely mean for analysis of its target data. However, such data may lose efficiency because it provides limited to no insight into true team communication events. On the other hand, communication analysis portrait evidence of verbal activity taking place (e.g., Cooke & Gorman, 2009, Cooke et al., 2013). Communication, throughout the exchange, may therefore be a variable source of information pertaining to the effectiveness of team reflexivity, based on reflexivity components and content regarding cognitive processes. It may be for this reason that the communication activity, or interaction patterns of teams, will differ for teams that engage in team reflexivity compared to others that do not. There is research evidence to support this notion (e.g., Schippers, Homan, & Van Knippenberg, 2013; West, 2000; Widmer, Schippers,

& West, 2009). There is, also, an evidence base suggesting that teams that engage in team reflexivity make better team decisions, are more effective, and increase levels of team cohesion (Schippers et al., 2003; Van Kinkel, Tindale, & Van Knippenberg, 2009). This research shows the importance for inclusion of reflexivity components into the classification system. It also indicates a need for further investigation of reflexivity components and temporal phase effect in team communications.

To date, reflexivity research received little attention, especially to the individual reflexivity components that may be responsible for improving team effectiveness. Although implied, research does not yet support by significant empirical evidence that shows the nature of bridging iterative processes to influence team effectiveness (Widmer et al., 2009). In order to provide greater clarity to these issues, this dissertation design attempts to identify these effects and determine their relative importance in explaining variance in cognitive behaviors and team effectiveness. If teams engage in team reflexivity, then consistent types of communication patterns emerging for reflexivity components as well as team cognition should be apparent. Reflexivity can offer a range of efficiencies in terms of team coordination, a shared understanding, and higher decision quality -or- when teams fail to harness goal-directed behavior or misapply the reflexivity approach, it can also create inefficient teams (Carter & West, 1998, Van Kinkel, Tindale & Van Knippenberg, 2009). Therefore, this part extends the literature by addressing the following questions:

4. What is the relative importance of team reflexivity in explaining the variance in cognitive behaviors and team effectiveness?
5. Do teams demonstrate reflexivity in team communication?
6. Which of the reflexivity components are relate to team effectiveness?
7. Which entail what aspects of behavioral cognitive communication?

1.3 Research Aims and Objective

The aim of this research is to extend the existing literature on team communication and cognition by investigating situation awareness and transactive memory cognitive behaviors within team communication. The research develops and applies a coding scheme in an effort to extract cognitive and reflexivity relevant information pieces from communication. This research aims to broaden the understanding of cultural diversity in virtual teams. It investigates computer-mediated communication effects, and whether cultural awareness/diversity has a final effect on team performance. Lastly, the research also

determines whether team reflexivity has an effect on cognitive communication behavior and overall performance. It does this by exploring whether cognition explains variance in team communication measures, cluster-analyzing team communication data, and then testing whether specific types of cognitive behaviors, or exhibited reflexivity components in communication, relate to team performance.

The specific objectives of this dissertation are:

1. Develop a coding scheme that clusters relevant cognitive behaviors of situation awareness transactive memory, and reflexivity components.
2. Investigating whether cultural diversity of language choice have an effect on computer- mediated communication and whether team reflexivity aids in such teams.
3. Determine whether team reflexivity has a positive effect on cognitive behaviors that related to overall team effectiveness.

1.4 Contribution to Research

This research contributes to the evidence base by providing new information on cognitive behavior and reflexivity in computer-mediated communication. In particular, this research identifies cognitive behaviors extracted from team communication that becomes important for team effectiveness. This research offers the following contributions:

1. Development of coding scheme to outline information types relevant to team cognition, based upon the examination of computer-mediated communication in teams.
2. An outline of linguistic features used in team communication that communicated situation awareness, transactive memory, and reflexivity.
3. Information that provide a foundation for the development of natural language processing techniques to classify team communication based on their content.
4. Results of the relationship between team cognition communicated and team outcome including the effect of the reflexivity approach.
5. Results of teams that are language diverse and its implications to team outcomes.

This research is significant in that it:

1. Uses a diverse sample pool of data; most, if not all, prior research used only a university student population generated database. This study randomly selected participants with a diverse culture and from different career fields.
2. Uses virtual team communications as the source for measurements of team cognition and reflexivity. To date, most research has investigated team cognition, situation awareness, and transactive memory system by using objective or subjective questionnaires to collect data for measuring the constructs. This research tested the model by measuring team cognition based on active team communication data, and provides insight into the effects of reflexivity and individual reflexivity factors.
3. Identifies the nature of cognitive behaviors for virtual teams and extends the understanding of team cognition by providing evidence of the cognitive behaviors of situation awareness and transactive memory exhibited during communication. This research also shows how certain cognitive behaviors correlate with better team effectiveness and confirms how reflexivity supports these behaviors.
4. Examines the difference in language use and communication patterns in diverse teams. Specifically, it examines those that might have implications for communication exchanges and team performance.
5. Analysis the nature of reflexivity indicators and the temporal nature of transition and action phases within team communication. The model was tested based on active team communication data and provides insight into the effects of reflexivity and individual reflexivity factors.
6. Classifies content of communication based on cognitive behavior and reflexivity for an automated analysis of team communication.

1.5 Overview of Dissertation Chapters

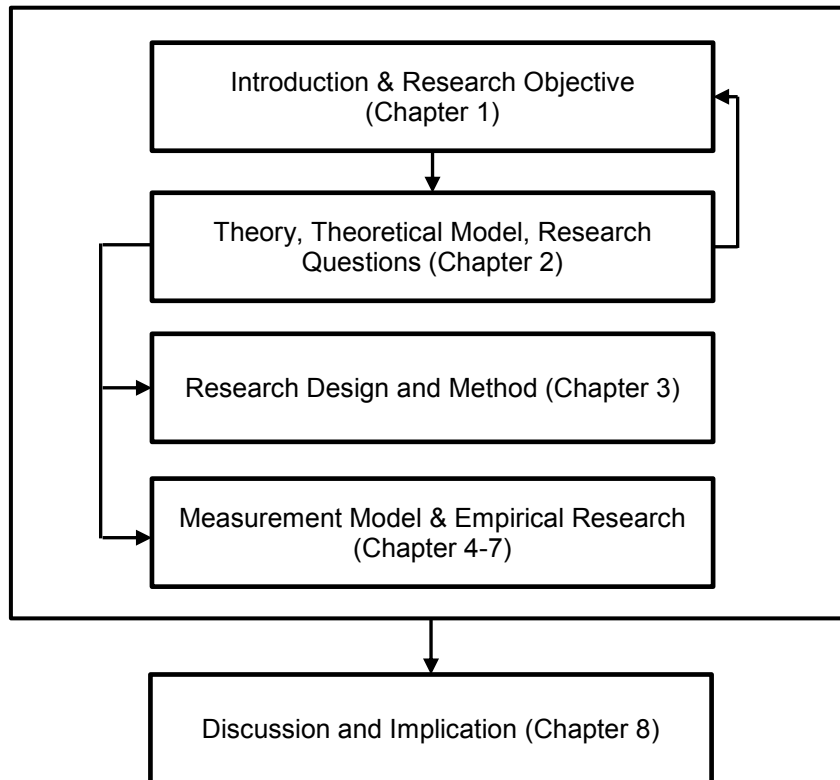
This Introduction Chapter presented a framework for the research undertaken, and, it provides an overall background on the guiding research theme, and underscores the importance of the research pursued (See Figure 1). The dissertation contains seven Chapters and a concluding Chapter. Chapter Two (2) is a review of relevant literature on virtual team cognition, virtual team communication including linguistic aspects. It identifies methods of measuring team cognitive communications, and team information processing barriers and

failures. It discusses cultural awareness and diversity in team composition, and presents the overall theoretical-based modeling approach to study team reflexivity. Chapter Three (3) outlines design and methods. Chapter Four (4) describes the requirements and approach for the communication-based measurement, and includes the coding scheme and coding procedure of the discourse analysis. Chapter Five (5) presents the results of the coding process as well as case analyses of identified indicators and the developed classification system for both cognitive behaviors and reflexivity. This Chapter also covers the effect of team reflexivity on cognitive processes, reflexivity, and overall team performance. Chapter Six (6) presents findings on cultural awareness and diversity and its effect on communication and team performance. Chapter Seven (7) evaluates the proposed theoretical model and its constructs, presents results from hypothesis testing of the examination of developed classifiers in. Chapter Eight (8) concludes this dissertation by summarizing findings and offering future directions for research.

Figure 1. Setup of this Dissertation.

1.6 Summary

Chapter One (1) has provided a detailed overview of the key objectives of the research explored in this dissertation. It has noted that virtual teams are regular feature in complex socio-technical systems and their popularity often belies empirical evidence of their effectiveness. Central to the effectiveness of virtual teams is the communication they engage in to complete mission tasks. While communication can be measured in a variety of different ways, this dissertation will take on a communication-based approach explore the exhibition of cognitive behaviors and reflexivity in computer-mediated communication and their role in achieving high performance.



2 Critical Review of the Current State of Research

To create a classification system of cognitive behavior indicators and to understand the intricate role of team reflexivity with cognitive processes and performance, current scientific presentations on relevant research foci are reviewed and considered in sum. Different understandings of cognitive behaviors and its related constructs are conceptualized, systematized and captured in a theoretical model. Further, research on current methods are critically acknowledged to create the basis from which the research questions and hypotheses of the present work are derived.

2.1 Introduction to Team Cognition

Part I, Section I. Part I reviews the current literature on team cognition, concentrating specifically on findings relating the cognitive processes situation awareness and transactive memory. Team cognition received much attention in the research community during recent years, and is increasingly important in team performance or in the effectiveness of socio-technical systems (Cooke, Gorman, & Winner, 2007). Researches define team cognition as a dynamic activity that represents the knowledge of an entire team while it interacts within a socio-technical system (Cooke et al., 2013). Cooke and colleagues (2013) suggest that team cognition emerges over time in form of cognitive and dynamic processes; and refer to occurring mental activities at the team level. The processes include learning, planning, reasoning, decision-making, and problem solving, remembering, designing, and assessing assigned or environmental situations (Cooke et al., 2013). Team cognitive processes are congruent to individual cognitive processes, except that team cognition is readily observable through interaction, team communications, or the distribution of responsibilities of team members' resources (Lewis, 2003).

Since the majority of teams' performance involves cognitive tasks, processing information has become essential for task completion (Cooke, Salas, Cannon-Bowers & Stout, 2000; Salas, Dickinson, Converse & Tannenbaum, 1992, Schippers, Edmondson & West, 2014). Therefore, scholars, frequently, refer to these teams as *information-processing systems* (Schippers et al., 2014). The product of information processing is the communication and interaction, which includes the sharing of individual member's cognition with other team members' (Brauner & Scholl, 2000). Thus, information processing represents a combination of cognitive processes and social processes of communications (e.g., Cooke et al., 2013). To date, two theories exist that describe cognition information-processing systems more

extensively, the Input-Process-Output Model (IPO) by Hackman (1987) and the Interaction Team Cognition (ITC) Theory by Cooke and colleagues (2013).

2.1.1 Input-Process-Output Model

In the early 20th century, the paradigm of team cognition followed general theoretical perspectives and led to development of the Input-Process-Output Model by Hackman (1987). This model views team cognition as shared cognition of the collective team members (the Input), rather than individuals in which sharing refers to complimentary or overlapping knowledge (Cooke et al., 2013). Different to the later described Interaction Team Cognition Theory (Cooke et al, 2013) in section 2.1.2, the primary unit of analysis of the IPO Model is the team member rather than the entire team. The individual held cognition model requires users to aggregated solutions in order to form a team model outcome (Cooke, Gorman, & Rowe, 2009). Because of the models level of analysis, its limitations have been extensively discussed in literature. Several studies demonstrated a disconnect between aggregated measures of team knowledge and team performance (e.g., Cook et al., 2013; Cooke, Kegel, & Helm, 2001), and the failure to demonstrate expected cognitive convergence as teams get more experienced (Levesque, Wilson, & Whole, 2001; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). The following limitations of the Input-Process-Output Model have therefore been drawn (Cooke et al., 2013):

1. The model focuses solely on the knowledge structure within teams, rather than the interaction process, and misses the development of team cognition over time.
2. The perspective of this model holds the entire team knowledge equal to the collective knowledge of all team members.
3. The team members are cognitively homogenous, and hence the similarity metrics do not reflect the knowledge of heterogeneous team members.
4. Lastly, team members' interactions are more fluid and adaptable than individuals in highly dynamic environments.

Conclusively, the IPO Model posits the reliance on aggregation of cognitive components in teams. It accounts, only indirectly, for the interaction among team members that make them function as a system (Cooke et al, 2013).

2.1.2 Interaction Team Cognition Theory

The Interaction Team Cognition (ITC) theory by Cooke and colleagues (2013) focuses on the cognitive processes and interactions at the team level. While individual knowledge is a prerequisite for team cognition, ITC theory takes individual knowledge and its contribution to team cognition into account and builds on the emergent knowledge state-

of-the-team. Although, this theory posits a relationship between individual knowledge and team performance, the ITC theory primarily predicts team interactions to account more for the variance in team performance than knowledge does as teams develop. Cooke and colleagues propose in this theory, that knowledge aggregation is therefore irrelevant, and that team interactions simultaneously aggregate the knowledge of individual team members. Based on the theoretical ground of the ITC theory, team cognition becomes especially active during interaction and communication phases of team members. A team would therefore fail to succeed, if the phases did not coordinate properly to changes or unusual situations (Gorman, Amazeant, & Cooke, 2010). Table 2 below presents an exaggerated depiction of the shared cognition and ITC perspective (Cooke, Gorman, Myers & Duran, 2011).

Table 2. Two Perspectives on Team Cognition (after Cooke et al., 2011).

	Shared Cognition	Interactive Team Cognition
Focus	Static knowledge	Dynamic activity
Drives team cognition	Shared mental models	Team interactions
Primary locus of team cognition	Intracranial	Extracranial
Unit of analysis	Aggregation of individual data	Team level

As mentioned before, during the interaction phases, cognitive processes are directly observable as explicit communication (e.g., e-mail, phone, chat) or as coordination patterns (e.g., communication flow of who talks to whom; Cooke et al, 2011, Cooke et al., 2013). Yet, even cross-level interactions, as well as some upwards or downward interactions, become causalities in the interaction framework, regardless of the observable level-of-analysis (Cooke & Gorman, 2009). Additionally, influence from both organizational and individual constraints at the team level is apparent. It makes the interactions meaningful in an entire team context (Cooke & Gorman, 2009, Cooke et al., 2013). Therefore, evaluators must study or assess teams as a system, without a focus on subcomponents, to understand how team members share information. Particularly, during critical changes in the environment that could potentially threaten future team outcomes (Cooke et al., 2013). Cooke and colleagues formulated the following suggestions for team effectiveness supported by the ITC Theory:

1. Joint perception in environmental changes by two or more team members, but not all members, which would be unnecessary or become inefficient due to the teams' heterogeneity.
2. Coordinate perception and interpretation of the task or environmental change.
3. Coordinate team actions to prevent future impacts of changes by one or more team members.

Thus, assessment of team awareness and state of their task environment pose to be critical factors forming team interactions and communications. Not only is it critical for teams to assess their current task environment to take actions, but, it is just as important to assess how teams will accomplish their goals. Because of the increasing cognitive system complexity, a variety of cognitive constructs originated, that operate at the team level of interacting processes such as team *situation awareness* and *transactive memory*. Given the limitations of the IPO Model, the following Chapters of this dissertation build upon the framework of the ITC-theory.

2.2 Situation Awareness Theory

Gathering and acquiring of data collection by team members, from internal, external, or both sources, is a prerequisite for knowledge construction before engaging in decision-making and save action taking (Schaub, 2008). The process of gathering information, assessing the situation, leads to the creation of *situation awareness* (SA; Endsley & Jones, 1997). Situation awareness is a cognitive process of perceiving what is happening in the immediate environment, comprehending and evaluating what the information means for a particular situation, and then projecting how those elements relate to one another in the near future (Endsley, 2000; Sarter & Wood, 1991). Figure 2 depicts situation awareness levels with its surrounding factors that influence the information process of achieving situation awareness.

Endsley (1995) postulates that the first step in achieving SA is to perceive the status attributes and dynamic nature of elements within the environment. For example, a fire fighter needs accurate information on the status, spread characteristics, and location of the fire outbreak. To achieve the task goal, comprehension of the situation includes an understanding of the significance of those elements and objects by forming a holistic picture of the environment (Endsley 1995).

For instance, a fire fighter must comprehend the outbreak of a fire within a certain proximity to other surroundings, and understand the impact of the fire on certain geographical locations relevant to the current operation. Projection of the future status is achieved through knowledge of the status and dynamics of elements as well as the comprehension of the situation (both perception and comprehension; Endsley 1995). For example, knowing that the wind is coming from a certain direction and with certain speed, allows fire fighters to project that the fire will be spreading in a given direction. This allows the fire fighter to form a basis for making future decisions. Hence, SA is a broad construct and has many underlying

cognitive processes. These processes are essential for current and future behavior exhibition in complex and dynamic situations to increase safety of socio-technical system (e.g., Schaub, 2008).

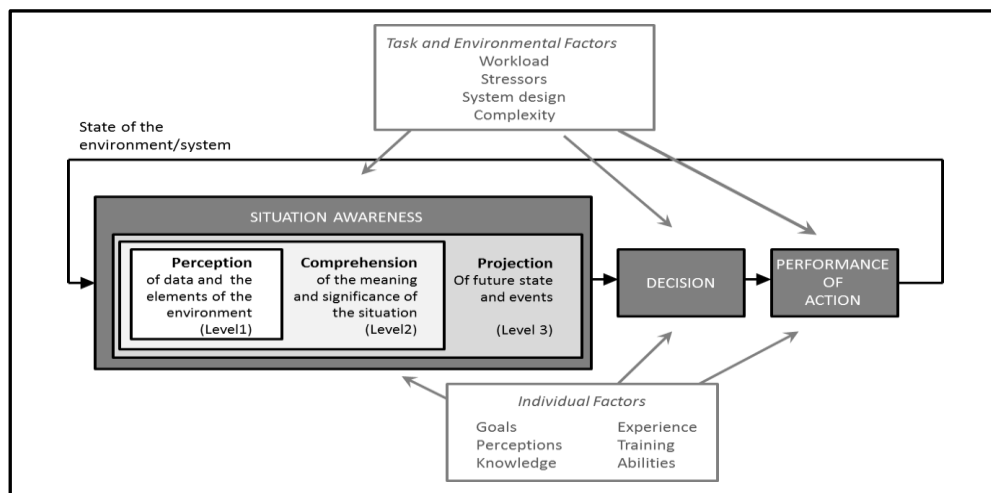


Figure 2. Situation Awareness Model in Dynamic Environments (after Endsley, 1995).

The dynamic nature of a situation demands adaptability as the situation changes, so must SA; otherwise it is inaccurate (Endsley, 1995; Endsley & Garland, 2000). SA is therefore a dynamic construct. SA changes at a tempo dictated by the actions, task characteristics, and the surrounding environment (Endsley & Garland, 2000). As new inputs enter the cognitive system, the person incorporates them into a mental representation, making changes as necessary, in plans and actions (Endsley, 1995). The outcomes from the continuous SA assessment will supply the responses to the following questions. *What is happening right now? What will happen next?* These questions initiate plans to decide on the next course of action that allow operations to function in a timely and effective manner (Blandford & Wong, 2004). Overall, SA is the critical link for operational effectiveness and contemporary system design (Endsley, Bolte, & Jones, 2003).

2.2.1 Team Situation Awareness

In general, a pre-reflexive process of adaptation characterizes SA (Gorman, Cooke, & Winner, 2006). In regard to teams, such adaptive cognitive processes require continuous coordinating among team members. According to Endsley and Jones (1997) SA in teams refers to the degree of awareness each team member possesses necessary to complete their assigned tasks. Most coordination at the team-level is the result of aggregating individual member's SA and share SA through communications (Schraagen & Van de Ven, 2011).

For example, command-and-control research uses exercises by army battalions (Sonnenwald & Pierce, 2000), to set objectives for teams to attain 1) individual situation awareness, 2) intragroup situational awareness, whereby members share within the groups, and 3) intergroup situation awareness as intragroup share externally across groups. Experimental research results on SA have shown that early collection and exchange of information, along with strategy development, can provide high levels of situation awareness, and that high levels of SA relate to high performance levels (Cooke, Salas, Kiekel, & Bell 2004). Cooke and colleagues demonstrate SA to be a consistently good predictor of team performance, as teams with high SA tend to be better performing teams. Nevertheless, SA literature assumes too often that higher levels of team SA will yield better performance, and that poor performance occurs due to inaccurate SA - when there is no correct action for the situation, or when other factors limit correct action (Endsley & Jones, 1997). Endsley and Jones (1997) found that situation awareness is significant, when it relates to performance for those team members who had the operational and cognitive capabilities to utilize situational knowledge. Their results show that lower levels of SA do not lead to poor performance if team members realize their lack of SA and are able to modify their behavior accordingly. However, correct assessment of any situation is not always achieved individually; team members may share a common but incorrect assessment due to the lack of common ground, misunderstanding of information needs or other factors (Kaber & Endsley, 1998; Schraagen & Van de Ven, 2011). It is therefore not sufficient for one member of the team to be aware of critical information, as poor SA of any team member can lead to critical errors and can result in severe implications for process, safety, and performance (Endsley & Jones, 1997). Thus, Endsley and Jones postulate that high levels of SA can serve as factors that increase the probability of good performance.

2.2.2 Factors Affecting Situation Awareness

The failure, of not perceiving a change of elements in the environment can lead to an incorrect understanding and prediction of future events resulting in poor decision-making (Endsley, 1995), and could place one's own operation at a disadvantage. For instance, a momentary loss of SA by a jet pilot arising from the failure to detect or perceive changes in the attitude of a hostile aircraft, could allow the hostile aircraft to maneuver into a superior tactical position (Wickens, 2000). According to Wickens, there is individual need to create and maintain SA, not just for one area but several areas. Examples of this need are: 1) external environment or hazard awareness (e.g., weather, terrain, other objects in the

surrounding space; 2) system awareness that reflect effectiveness and processes controlled by the system, the individual is using (e.g., communication technologies), and 3) task awareness to be aware of the state of coordinated activities (Wickens, 2000).

Other factors that affect developing and maintaining SA are task and environmental factors such as the workload placed on each team member, internal and external stressors, the overall system design of being able to function and communicate, as well as the complexity of the situation or the task (Endsley 1995). In addition, individual factors such as the individual goals, perception of an individual's knowledge and experience, the training received and an ability to complete the task, can have effects on developing and maintaining SA (Endsley 1995). Any deficiencies can lead to major challenges for developing and maintaining SA. Kaber and Endsley (1998), suggest that for intra-team SA, communication about decisions to develop and maintain current SA is particularly useful. The authors noted that training interventions could be useful and helpful in training team members to a) passing information effectively, b) providing feedback about the outcome of a particular action of other team members and c) mitigating factors that may affect SA, and/or resulting in higher SA levels.

2.2.3 Situation Awareness and Communication in Virtual Teams

As suggested above, information processing is crucial for SA development and maintenance to coordinate actions (Endsley & Jones, 1997, Kaber & Endsley, 1998). Most of SA development across teams is attributed to the coordination and the transfer of information from one team member to another (Endsley, 1999). To develop SA, coordination involves more than just sharing data; it also requires an active sharing of team members' comprehension and projection of the situation (e.g., Endsley, 1995). In addition, early information exchanges, along with the development of a strategy provide a link to higher levels of SA and increased performance levels (Cooke et al., 2004).

Only a few studies exist that analyzed communications to predict SA in performing entities. Gorman, Weil, Cooke, and Duran (2007) explored measuring SA from an interaction-based perspective about how teams change during an evolving situation based on the communications exchange within organizations. Authors conducted a flow-analysis of e-mails from the Enron incidents. The results indicated that coordination or flow shifts in communications occur in response to critical corporate events. A lack of such a shift would be indicative of a loss of SA. A study by Bolstad, Folts, Franzke, Cuevas, Rosentstein, and Costello (2007) analyzed SA in team communications and its relationship to team

performance. Results of this research indicated teams that were highly occupied with perceiving information in their task environment showed low performance. To the contrary, teams that communicated extensively about actions and future states of the operating environment showed increased performance. It may therefore be important for teams to exhibit the right mixture and to demonstrate the transfer from the projection and comprehension to the projection and action stage in order to perform well. An example statement given by Bolstad and colleagues (2007) of future state (i.e., projection) would be, “We probably want to do it somewhere in between that way we are not easily detected.” Bolstad and colleagues (2007) suggested that communication is a building block for SA in both team development and in decision-making.

Other research on SA also indicated that through knowledge coordination in virtual teams collaboration can be improved (Malhotra & Majchrzak, 2012). Another study by Verma, Vieweg, Corvey, Palen, Martin, Palmer, Schram, and Anderson (2011) explores the use of Twitter during mass emergencies and extracted information that contributed to situation awareness. Of four different crisis events messages of a varying nature and magnitude were collected. The researchers categorized the messages exhibiting aspects of SA in the field of specific emergency events.

Although aviation, emergency, and military operations differ from most teams in the industry, the teams have several things in common. First, they must combine information from numerous sources (Sonnenwald & Pierce, 2000). Next, the teams have the requirement to comprehend a situation or market, especially, for new or changing requirements. Finally, they must have the ability to react using the information, within a constrained period of time (Endsley, 1995). Yet, according to Vieweg and colleagues (2010), when faced with very dynamic situations, industry often lacks the direct communications infrastructure and organizational protocols to react, as does the military to understand the effectiveness of the teams involved. Protocols for tracing and assessing information regarding SA are frequently incomplete, and do not have, in advance, sound methodical procedures (Vieweg et al., 2010). Research shows that despite the lack of direct communications during dynamic events, the use of technology to broadcast information contribute to SA (Verma, et al., 2011; Vieweg et al., 2010). Particularly, members who get involved in periodic situation awareness updates, communications may contain behaviors regarding SA, cognitive processes of current event states, decision-making, and other activities.

2.2.4 Situation Awareness - Cognitive Behavioral Indicators

Based on the theoretical ground and SA theory, SA behaviors of individual team members may be observable in communication. As the definition of SA implies, three levels of cognitive processes are necessary for high SA before teams engage in action (Endsley, 1995). These cognitive processes display behavior in regards to perception, comprehension, projection, which according to the ITC theory teams need to share information, for team cognition to evolve (Cooke et al, 2013). SA is a precursor for decision-making and carrying out actions (Endsley & Garland, 2000). Teams or individual team members can therefore decide what decisions to make in a specific event and whether to carry out any necessary actions or not. Because a strong link between situation recognition/ classification and associated action selection exists (Klein, 1989; Klein, Calderwood, & Clinton-Cirocco, 1986), behaviors of action are of interest as such linkages indicate frequent instigation of the decision making process (Endsley & Garland, 2000). According to literature and Endsley & Garland (2000) decisions are constructed based on SA, and SA is influenced by decisions. To date there is a lack of theoretical indicators as well as empirical evidence about the types of SA and about how SA cognitive behaviors occur in team communications. There are few theoretical indicators or empirical evidence about SA, and about how SA cognitive behaviors occur in team communications. This research studies the nature of SA cognitive behaviors in team communication to answer the following questions.

Research Question 1.1: Which types of SA cognitive behaviors do teams communicate?

Research Question 1.2: Does the occurrence of individual SA cognitive behaviors differ?

Hypothesis 1.1: Different SA cognitive behaviors are displayed in teams in regards to high versus low team performance.

2.3 Transactive Memory System Theory

Over two decades have passed since Wegner and his colleagues (1985) introduced the concept of transactive memory system to denote a collective cognitive system that dyads use to encode, store, and retrieve knowledge (Wegner, Giuliano, & Hertel, 1985; Wegner, 1986). The concept of transactive memory system relates to team cognition management. Transactive memory system displays emergent properties in team development, promotes

building better team understanding, communication exchange, and team effectiveness (Cooke et al., 2007, Farad & Sproul, 2000, Yoo & Kanawattanachai, 2001). The transactive memory system refers to a group memory that consists of team members' individual transactive memory, the knowledge about individual areas of expertise within a group, and the knowledge about the capabilities of other team members, "who knows what?" in the team (Wegner, 1986). Transactive memory enables team members to tap the expertise and experience of other members as needed, for example:

Marcus does not know how to write quantitative requirements, but he knows that his team member Katy does. On the other hand, Katy does not know how to set up a mockup for a prototype, but she knows that Marcus does. As they work together on a joint task that requires both to write quantitative requirements and set-up a prototype mockup, both Markus and Katy can access and use necessary knowledge that exist between each other.

Building on others transactive memory, individuals gain knowledge that becomes beneficial to the entire team process. Over-time the individually held concepts develop into a *transactive memory system* (TMS; Lewis, 2003).

The concept of TMS is similar to, but varies distinctively from related concepts like team mental models (Klimoski & Mohammed, 1994), shared-task-, or cross understanding (He, Butler, & King, 2007; Huber & Lewis, 2010). Even though these concepts are common in capturing cognitive representations shared among members. TMS differs from those in that it includes knowledge about who knows what instead of team goals, strategies, beliefs, or preferences, and instead supports cognitively the labor for learning, remembering and communicating knowledge (Wegner, 1986). Teams with a highly developed TMS thus display knowledge differentiation in which different members specialize in learning, remembering, and sharing diverse knowledge (e.g., Lewis, 2003). One requisite for TMS development, however, is task interdependence and some degree of cognitive interdependence, as team members rely on each other's knowledge to complete mission goals (Hollingshead, 1998, 2001). This reliance can be more or less explicitly observed in team communication depending on the circumstances of the presence or readiness state of plans or agreements (e.g., Wittenbaum, 1998; Wittenbaum & Strasser, 1998). The working of TMS or development of TMS can directly be attributed to cognitive interdependence (Brandon & Hollingshead, 2004) and communication (Hollingshead & David, 2003). Virtual teams may also use the approach whenever newly applied contexts of emergent groups must respond to disasters, new or planned, or to manage knowledge based integration into developing virtual

teams (e.g., Alavi & Tiwana, 2002). In the following sections the TMS structure and process, cognitive behavioral indicators of a TMS, and a framework of TMS in teams represent the benefits as the models mature using the TMS and other modeling tools.

2.3.1 Transactive Memory System Structure and Process

The TMS concept consists of two interrelated components, the structure, and the process (Lewis, Belliveau, Herndon, & Keller, 2007). First, the TMS structure begins to develop in form of representations once team members have an understanding about one another's expertise (Hollingshead, 2001). These become more developed as members increase their task-related knowledge from internal or external team knowledge sources to refine their understanding of who knows what (Wegner, 1986). According to Wegner (1986), after the initial TMS processes and structures are in place, members draw their initial understanding of 'who knows what' to allocate new information encountered by the team members and to query others about information they are presumed to have. During these interactions, Wegner (1986) postulates team members' may discover new information about the breadth or depth of members' knowledge that causes them to revise or update their understanding of 'who knows what'. In turn, new understandings about the distribution of knowledge contained in the TMS structure affects what members choose to learn, remember, and communicate (Wegner, 1986).

Wegner, Raymond, and Erber (1991) identified three progressive learning methods to gain almost instant knowledge about someone's capabilities. These learning methods are: 1) stereotyping (e.g., inferences from roles, age, or sex; Hollingshead and Fraidin, 2003), 2) self-disclosure (e.g., of traits, past activities, skills, and preferences), or 3) meta-knowledge that is developed based on facts about other's access to the information source (e.g., who accessed the source; Wegner et al., 1991). TMS processes, which occur as team members' allocate, update, and retrieve information relevant to the team and task defines the second component of TMS (Wegner, 1986). Based on the concept by Wegner (1986) these processes use data collection to coordinate learning and for retrieval of member's knowledge so that the knowledge can be made available. TMS structure and processes function synergistically within a team's TMS, with the TMS structure providing the initial guidance for transactive memory processing letting both cognitive and performance benefits emerge (Lewis et al. 2007).

2.3.2 Factors Affecting Transactive Memory System in Teams

Changes in tasks, memberships, communication channels, team dynamics, or environments factors, all contribute to the working TMS, and its impact on team performance (Ren & Argote, 2011). Ren and Argote (2011) summarized these factors by displaying antecedents of TMS that were studied in preceding research (see Figure 3); key components of TMS as well as indicator and measures; consequences of TMS that included team learning, creativity, members satisfaction, and most commonly team performance; and lastly moderate factors between TMS and TMS outcomes. Given that team members of most virtual teams or dynamic organizations flow in and out of teams rather frequently, transactive memory might deteriorate at the team level compared to traditional organizations (Moreland & Argote, 2003). Lewis and colleagues (2007) inferred a promising intervention to support team members to cope with membership turnover, by giving teams time to reflect on their own specialization and the specialization of their team members. Results of such an intervention increased team members' adaptation response by adjusting their specialization to the addition of a newcomer, improving the efficiency of TMS processes and overall performance (Lewis et al., 2007).

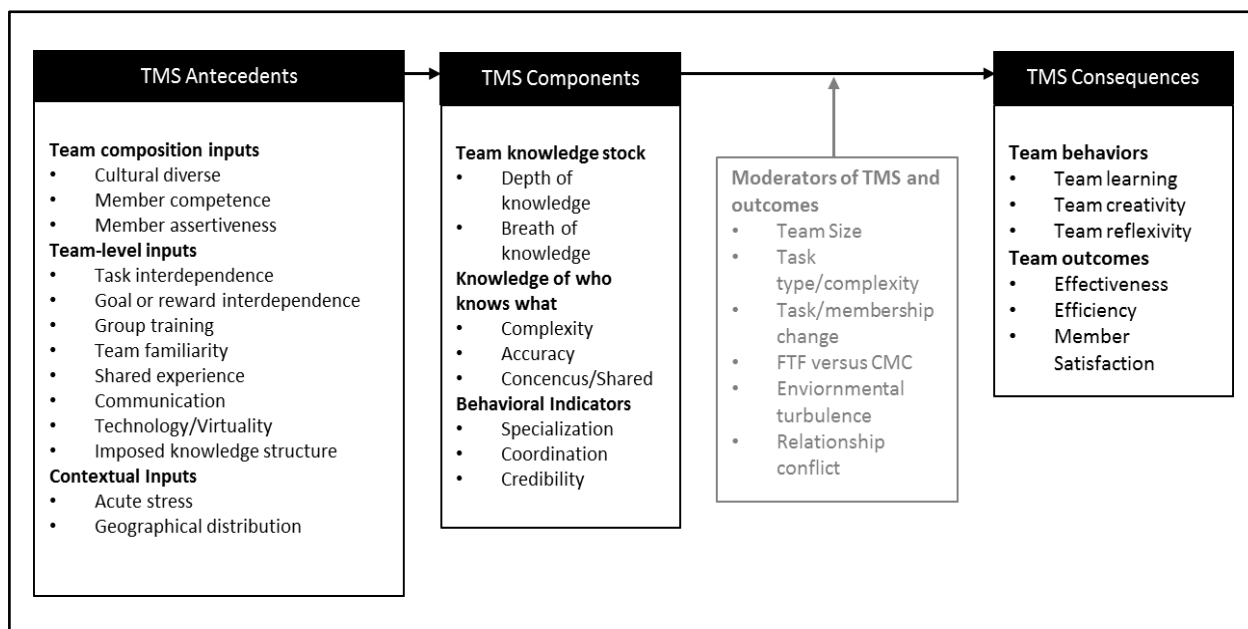


Figure 3. Framework of TMS in Teams (after Ren & Argote, 2011).

2.3.3 Transactive Memory System and Communication in Virtual Teams

Communication is linked to be one of the most significant factors in the development of TMS. Authors Hollingshead and Brandon (2003) for example, inferred that communications assist in moving team members from a stereotypical perception of others' expertise, to precise and accurate ascriptions. Several other studies have examined the effect of communication frequency on the development of TMS. For instance, Lewis (2004) found apposite relation between communication frequency during the planning phase and TMS emergence in a study of MBA consulting teams. In addition, He, Butler and King (2007) demonstrated the number of face-to-face meetings and communication via telephones to have a significant positive effect on awareness of the location of expertise. Kanawattanachai and Yo (2007) collected three waves of data on transactive memory development. They found that task-oriented communication led to expertise location and trust in the initial stages of team operation. The effects disappeared, however, in later weeks of team operations, which suggests that the effects of communication on TMS development is fundamental in early stages of operation, rather than in later team stages (Ren & Argote, 2011).

Prior research on TMS development focused on no face-to-face communication such as in virtual teams, and it supports the effectiveness of early TMS development (e.g., Yoo & Kanawattanachai, 2001). According to past studies on transactive memory and face-to-face environments, teams develop transactive memory systems by using relevant available information, including surface characteristics, assignments of the task, past experiences, and informal communication among team members (Lewis, 2004; Yoo & Kanawattanachai, 2001). However, due to the lack of such cues in virtual teams, early in the team development process, teams must communicate effectively to exchange expertise related information for TMS development (Yoo & Kanawattanachai, 2001). For instance, in the study by Kanawattanachai and Yoo (2007), teams were culturally diverse and solely relied upon computer-mediated communication to finish their task effectively. The researchers found positive effects of computer-mediated communication on team members' belief and trust about others' specialized knowledge, but only in teams with early TMS development. Hence, TMS development is observable in computer-mediated communication, as communication is used to update and retrieve valuable TMS behavioral information (Richter & Lechner, 2009).

On the other hand, teams, in early team stages, in which TMS in communications are sparse, might lack an understanding or a highly developed TMS. As earlier research suggests, some virtual teams perform well even with limited team communication in place, that is,

when a highly developed TMS is already in place and needs to only be updating in newly evolving situations (e.g., Wegner, 1986). Hence, virtual teams with a highly developed TMS intentionally minimize their volume of communication to collaborate faster, without negatively affecting team effectiveness (Kanawattanachai & Yoo, 2001). Group discussion might provide members with an opportunity to discuss and demonstrate their expertise, which in turn allows for greater precision in determining who is an expert in a particular knowledge domain and provides means for faster TMS development (Ren & Argote, 2011). Van Dijk and Broekens (2010) implied that the faster virtual teams could create their TMS when operating in a time pressured environment, the faster successful collaboration occurs. Events of virtual teams' show that despite the lack of face-to-face communication, communication through technology contributes to TMS development (Kanawattanachai & Yoo, 2001). Due to the effectiveness of communication in the development of TMS in early team development stages, TMS cognitive behaviors may be observable in team communication.

2.3.4 Transactive Memory System - Cognitive Behavioral Indicators

The TMS theory, based on the theoretical grounds, and TMS behavior of individual team members may be observable in communication. TMS characteristics support behavior to facilitate quick and coordinated access to specialized knowledge of other team members. This allows a greater amount of task-relevant expertise for teams to apply (e.g., Lewis et al., 2007). Based on previous research, TMS defines behaviors of specialization, credibility, and coordination (Liang, Moreland, & Argote, 1995; Moreland & Myaskovsky, 2000). When teams develop TMS, they start to specialize and differentiate uniquely held knowledge (Lewis, 2003). According to Lewis (2003), this uniquely held knowledge may be absent, if no communication about respective expertise occurs or can be developed redundantly. Hence, team members' have to be certain of the reliability of knowledge (i.e., credibility) shared. Coordination behaviors depend on members to have a good understanding of who has what knowledge and how it can be intertwined or combined (Cannon-Bowers, Salas, & Converse, 1993). This understanding evolves during the development of specialized knowledge and credibility that lets coordination processes run efficiently (Lewis, 2003). Teams need to combine their respective knowledge quickly and easily for efficient coordination activity (Lewis, 2003).

Therefore, the virtual and supportive memory characteristics of TMS can manifest themselves in team member behaviors of specialization, credibility, and coordination (e.g., Liang et al., 1995; Moreland & Myaskovsky, 2000). Assessing TMS in form of cognitive

behaviors in highly dynamic situations could provide insight about the TMS development process. However, to date research is scarce and no methodical procedures to locating TMS cognitive behavior are of existence. Given the lack of theoretical indicators or empirical evidence as to which types of TMS, and how the TMS cognitive behaviors occur in team communication, this research explores the nature of TMS cognitive behaviors in team communication. This research further extends the literature by addressing the following questions:

Research Question 1.3: Which types of TMS cognitive behaviors do teams communicate?

Research Question 1.4: Does the occurrence of individual TMS cognitive behaviors differ?

Hypothesis 1.2: Different TMS cognitive behaviors are displayed in teams in regards to high versus low team performance.

2.4 The Nuance of Virtual Team Communication

Part I, Section II. The second section reviews current literature on communication in virtual teams, concentrating specifically on findings relating to computer-mediated communications. An introduction to how language is used in computer-mediated settings, and interaction with behavioral and linguistic presentations is provided.

Communication is essential for the functioning of virtual teams. Many theorists propose single communication to face more difficult challenges in attaining effective communication compared to face-to-face teams. Not only due to reduced social context cues, but also, because of the temporal and spatial separation among team members, cultural diversity, and the utilization of technology media as primary means to communicate (Kanawattanachai & Yoo, 2007). Different results exist in the distributed and virtual team literature on whether teams have declined communication exchanges. Martins, Gilson and Maynard (2004) suggest that the overall amount of communication seems to decline as the virtual aspect moves higher on the continuum. However, no difference in participation equality or total number of remarks exchanged in distributed groups compared to face-to-face groups was found (e.g., Weisband, 1992) - in some groups participation was even higher (Jessup & Tansik, 1991). This may explain the reduction in status differences resulting from the diminished social cues during which participation levels become more equalized (Hollingshead, 1996; Martins et al, 2004; Straus, 1996). In addition, during the first stage of

development, teams use increased communication occurrences when newcomers actively ‘seek’ information while established team members ‘provide’ information (Ahuja & Galvin, 2003). When observing communication processes, the interchangeable roles of individuals involved need to be taken into account (e.g., sender and receiver; Wegner, 1995; Woods & Hollnager, 2005) as well as the communication constitution of messages from symbols (verbal and nonverbal) for which senders and receivers’ co-construct meaning (Keyton & Beck, 2010).

Once teams develop a certain communication pattern for communicating, teams tend to stick to it (e.g., Beebe & Masterson, 1997). Communication theories consider factors, such as culture, context of the communication, group identity, and the surrounding context that influence communication (e.g., it (e.g., Bormann, 1972, Hollnager & Woods, 2005). For example, the symbolic convergence theory focuses on the development of a common identity or team cohesiveness, by engaging in mutually fulfilling social interactions such as sharing emotions, motives, and meanings (Bormann, 1972). Meanings of messages depend on the relationship between messages, awareness, development of specific communication patterns, and context (Keyton & Beck, 2010). Because of the complexity, the meaning of messages may not be readily available in messages, and the meanings within the message require interpretation by the sender or receiver alone to reconstruct meaning. As a result, team members participate in an interchangeable activity that takes into account the sender of an utterance, the meaning of words, the mode of delivery, and the surrounding environment (Vieweg, 2012).

2.4.1 Computer-Mediated Communication

In virtual environments, teams have to fall back on using computer-mediated communication. Early research defined computer-mediated communication as *anonymous*, *impersonal*, and *egalitarian* (Herring, 2001). Research served as the predecessor for later studies regarding computer-mediated applications in different contexts, and, as an appropriate tool to attain various goals (Herring, 2003; Panyametheekul & Herring, 2003). An important feature is that it allows multiple participants to communicate simultaneously, in ways that would be difficult, or even impossible to achieve in other media (Herring, 2001). Computer-mediated discourse (i.e., a specialization of computer-mediated communication focusing on language use), displays no distinct delineation between spoken and written, and despite it being in written form, users consider it “speech like” (Herring, 2001; Vieweg, 2011). Based on the competency model by Spitzberg (2006), messages transmitted through the selected

media are filtered by the expectation of the receiver, the team member. Those expectancies are products of the team members experience with computer-mediated communication. According to the competency model, team member's culture, the chronology of messages, the relationship, present environmental factors, the anticipated function of the message, and its meaning further underline the complex issue. In addition, through an ongoing interaction, these expectancies can become fulfilled, misused or discarded, or undergo renegotiation. The overall product of the message exchange and the degree to fulfill the message function satisfactorily, results in the outcome of the process for both the original sender and receiver(s) (Spitzenberg, 2006).

Research literature about text-based interaction indicates new forms of language to emerge as a primary strategic resource for creating social reality (Herring, 2001). Rather than simplifying communication, team members apply compensatory strategies (e.g., emoticons to represent facial expression) to adapt their communication to their expressive needs and to replace social cues normally conveyed by other channels such as face-to-face interaction (Herring, 2001, Spitzenberg, 2006). A popular perception exists, describing computer-mediated discourse as less correct, complex or coherent and containing non-standard features than standard writings (e.g., Herring, 2001). However, according to Herring (2001) a relatively small percentage of these features are errors caused by inattentiveness or lack of knowledge of the standard language. To majority, these choices represent the user to economize on typing effort or mimicking spoken language features. Especially, since the primary goal of communication is the efficient transfer of knowledge and information (Brown & Yule, 1983). While parts of messages are oriented to convey correct information about details (Brown & Yule, 1983), the users often “delete subject pronouns, determiners, and auxiliaries; use abbreviations, do not correct typos, and do not use mixed cases” (Murray, 1990: 43-44).

2.4.1.1 Limitation of Computer-Mediated Communication and Linguistics

Computer-mediated communication comes with its own set of limitations and affordances (Vieweg, 2011). Computer mediated communication is currently text-based. It means that team members send and receive text messages, as screen data, generated by a person at a different location than from the location of the message originator (Herring, 2001). Text-based computer-mediated communications include a variety of applications. Examples are e-mail, discussion groups, real-time chat rooms, and virtual reality role-playing games. According to Herring, (2001), because of technology advances, message traffic can

transfer in either synchronous or asynchronous modes. The author describes the asynchronous mode to allow users not to be logged on with one other, then transmit a message and respond to a message that was received (e.g., e-mail). The synchronous mode allows user applications to simultaneously synchronize log on activity, and provide the capabilities (including speed, memory, and processing power) for all team members to instantly receive, as well as send messages at the same time.

In the past, communication used a send-receive, one-way traffic at a time, to communicate and did not provide interactive communications during the send period nor feedback (Herring, 2001). Responses were slow because of the send-receive then display process. Today, modern computers automatically provide both features at the same time by using real time memory and storage, as well as a more powerful processor. Most important, cost and access are available to users worldwide. Today two-way communication is common and instantaneous (interactive, face-to-face or digital-to-digital applications; Herring, 2001). This enables rapid feedback to communicators as team members speak, listen, and monitor message traffic in real time (Brown & Yule, 1983). Although, computer mediated communication is not essentially deterministic, there is little to no ability for users to eliminate built-in system-constraints. The media plays a significant role in shaping the message content (Herring, 2001).

Finally, likely consequences on language use could arise from the co-occurrence of additional channels to text such as audio, video, or graphics (Yates & Graddol, 1996). Language use in computer-mediated environments is, thus, highly variable and linguistic choices are often contingent on social factors and situational context to express meaning.

2.4.1.2 Pragmatics in Computer-Mediated Communication

To communicate successfully, teams need to understand the context, any pre-existing knowledge of the situation involved, and the inferred intent of the sender to acquire the meaning of the utterances (Vieweg, 2012). Pragmatics, a subfield of linguistics, is concerned with the study of language use in real-world contexts (Samad, 2008). For both simple and complex tasks, teams rely heavily on linguistics pragmatics during their interplay of communication as its meaning relies on the mode, place, time and other factors (Samad, 2008; Mey, 1993). Although, developments in pragmatics have inspired research efforts in socio-technical systems, the importance of linguistics in team cognition is rare.

Language can make meaningful observations by cognitively stimulating when utterances imply the actions (Glenberg & Robertson, 1999, 2000). When teams communicate,

members combine semantic knowledge, the knowledge of the meaning of words, with other types of knowledge to comprehend what they hear or read. Pragmatics is therefore concerned with the inter-relation of language structure and principles of language use in context (Levinson, 1983). See Table 3 for an overview on types of pragmatics and cognitive knowledge paradigms, which are likely to occur in team communication.

Table 3. Pragmatics and Cognitive Knowledge Paradigms.

Types of Pragmatics/Cognitive Knowledge Paradigms	Description	Example
Mental and Context Models	Representations in episodic memory of situations, acts, spoken events, observations and thoughts or actions, which rest on the 'experiences.' (Ehrlich, Tardieu, & Cavazza, 1993)	<i>The fire spreads faster than last time.</i>
Prior Knowledge	Prior or background knowledge is information the speaker concludes other team members have beforehand or independently of, a prior conversation, featured in communication (Saeed, 2009, p. 201).	<i>Member 1: I need support from a unit. Member 2: I'll send you a helicopter</i>
Inferences	Conversational inferences are defined by the situation or context-bound process of team interpretation, which allow detailed exchange of information with limited communication volume in which the message receiver of the communication can overcome the lack of explicit detail by referring to the context (Gumperz, 1982; Samad, 2008).	<i>Out of water.</i>
Markedness (Inference)	Markedness is the neutralization of entities, locations and facts which are taken granted or presumed when referred to in more neutral terms (Trask, 1999; Vieweg, 2010).	<i>The fire is destroying the houses.</i>
Implicature (Inference)	Implicature is an implication drawn from an utterance based on expected conversational norms. Implicature is one of the most important sub-aspects in pragmatics that allows for coordination efficiency (Crystal, 1997; Levine, 1983).	<i>Help! Fire northeast.</i>
Anaphora (Inference)	Anaphora is an entity that derives its interpretation from previously expressed meaning and acts as a reference (Crystal, 1997).	<i>Try extinguishing the edges of the fire first. That way it cannot spread.</i>

2.4.1.3 Interpreting Computer-mediated Communication: An Example

To demonstrate the use of pragmatics and background knowledge in analyzing messages, the following example interpretations are considered. Examples are adapted and changed from Vieweg (2012). The team members who communicated these messages, staff stationed near the location:

1. “*No I have not. I am watching the fire’s direction of the wind speed.*” “*I am planning to wait here for unit support.*”
2. “*Can they extinguish it?*”
3. “*I just finished evacuating two people.*”

The communication receiver needs to be familiar with background knowledge of these situations as well as pragmatic knowledge of how communications work to understand what is happening in these messages, and how the information contained therein, contributes to SA and TMS. Moreover, an understanding is gained about how to identify SA and TMS cognitive behaviors from team communication. In the first message, the first phrase appears to be an answer to a question “*No, I haven’t.*” Next, the team member is watching the direction of the wind speed while at the same time the member planned to wait *here* for unit support. How is it known? To which question is the member responding? Why would the member watch the direction of the wind speed? Where is *here*? When analyzing in context, the phrase “*No, I haven’t*” is in response to a question that was asked from a team member who was likely asking if his comrade has started extinguishing the fires spread, which is known through the succeeding phrase about watching the direction of the wind speed. In addition, *here*, is the team member’s position. Waiting for unit support may consider situations in which the team member needs team support - cannot handle the situation him/herself (i.e., fire outbreak). Over all, the first message provides information that contributes SA and TMS by telling other team members that member is watching the direction of the wind speed, which indicates the need for support measures.

The second message includes references to “*they*” and “*it*.” Who are “*they*?” What is “*it*?” These two pronouns reference an anaphora. With knowledge of pragmatics, and with an understanding of the situational circumstances, inference suggests that *they* are members of the team, and in circumstances of a fire, *it* refers to fire. The second message contributes to SA by informing other team members that the mitigation efforts involve their team members. In the third message, team members learned about the evacuation of two people by one of their team member. Why are people evacuated? Once more, to understand the information, knowledge of the housing structure of the region inform members about why evacuations are taking place, due to an impending threat (i.e., fire). This message also indicates information about the status of the team member *who just finished evacuating*. This knowledge updates TMS information for further coordination purposes. The third message is similar to the first,

with this type of information upon which the team members may base further decision making.

While it is important to explicate the complexity involved when team members decode utterances to communicate successfully, the work does not necessarily create an understanding of utterances and or making sense of situations and relationships. The messages above serve an additional purpose in providing examples of the types of information that may lead to SA and TMS in complex socio-technical environments. The types of information contained in these messages are subject in later Chapters, and serve as a foundation for how SA and TMS cognitive behaviors are communicated.

2.4.1.4 Speech Act Behaviors

The prior example provides insight into pragmatics, but also shows team members to engage in speech act behaviors to convey their message. Parush, Kramer, et al., (2014) define the manner in which team members convey their messages as verbal-behavior, or speech act behavior (Parush, Kramer, et al., 2011). The common purpose of these behaviors is to share knowledge or information with others (Parush et al., 2014). These speech act behaviors are utterances that serve the communicative function of questioning, answering, or announcing information (Parush et al., 2011). In the healthcare domain, studies found different speech act behaviors occurring in different environments (Apker, Mallak, et al., 2010; Parush et al., 2014). For instance, a higher frequency of speech act behaviors of management (e.g., requesting or directing others to do something) and of dialogues were found in the surgical context, while in the handoff context a higher frequency of reporting and less dialogue was found (Parush et al., 2014). Different frequencies of speech act behaviors may, therefore also be present in the virtual team context and communications.

Given the sparsity in literature on speech act behaviors, this research explores the nature of speech act behaviors in virtual team communication and whether cognitive processes display certain speech act behaviors more than others. It is also of interest to see whether teams collaborate with their team members differently in the same context, or are the fundamental speech act behaviors similar, regardless of team performance. Questions and research hypothesis derived for this section are as followed:

Research Question 1.5: Which speech act behaviors are trivial within the virtual team context?

Research Question 1.6: Do cognitive behaviors display the same speech act behaviors?

Hypothesis 1.3: Different speech act behaviors are displayed in teams in regards to high versus low performance.

2.4.1.5 Verb, Verb Tense and Preposition

While speech act behaviors can provide insight on manner of sharing information, the content of what team members' communicate is the most relevant for observing cognitive behaviors in communication. The *verb* is the central element in a sentence, which conveys the meaning of events and organizes all other elements (Manning & Schütze, 1999; Palmer, Gilda, & Xue, 2010). The following example demonstrates the verbs key roles (Vieweg, 2012):

1. The helicopter *carries* water
2. The helicopter *gets* water
3. The helicopter *shoots* water

The sentences contain four words only, with three remaining the same. In each of the example, an event is in action that involves the helicopter and water. English speakers will understand the event described in each sentence is either a carrying event, a getting event, or a shooting event with the sentences relying upon the verb to convey each event meaning. In the examples above, the helicopter is the agent in the event (i.e. the doer), and water is the product or patient of each event. Here, the helicopter is the element that is in a particular state or undergoing a change of state. Yet, the meaning of the verb controls how the English speaker understands what each sentence describes. To classify text according to the utterance meaning, the events and the event participant must be recognized correctly (Palmer et al., 2010), because the verb generally conveys the main idea or event (Kipper-Schuler, 2006).

Verbs with a special attentional focus are viewed as foregrounded to the main sequence of events and are sensitive to grammatical markers such as verb-tense for establishing temporal relations between events (Carriers, Carried, Alonso, & Fernandez, 1997). The authors describe that verb-tense markers for instance may signal happenings, states, or events that are sequential or non-sequential. Further, these verb-tense markers can also indicate that events occur successively or simultaneously. On the other hand, secondary events do not have to be concurrent with the main events but might be part of a previous encountered, and therefore, indicate distortion or a break in the period of the text (Carriers et al., 1997). Tense is a major grammatical mechanism for expressing temporal relations in which time of occurrence of a referent event relates to the time of utterance (e.g., Cowrie,

1976, 1985). The following sentences are turned to (adapted and changed from Carriers et al., 1997):

1. Fire erupts.
2. Fire erupted.
3. Fire was erupting.

Based on Carriers and colleagues (1997), tense characterizes time (i.e., present, the past, and the future) as demonstrated in sentence 1 and 2. According to the authors, past tense describes events taking place to a temporally undifferentiated extent (i.e., moving away from present into an already known or completed). While present tense refers to events taking place simultaneous with the moment of communicating. The authors describe tense to order events in time by relying on anchoring events in relation to temporal reference points. Further, events can be extended or stretched in to a continuous event, even though it is still referred to the past as seen in Sentence 3. A simple change in tense might therefore affect the accessibility of information at very early stages of language processing (Carrieras et al., 1997).

The English language uses prepositions to express spatial, temporal relations, and mark semantic roles (Huddleston & Pullum, 2002). Out of one million English words, one in ten words is prepositional (Chengyu Fang, 2000). The most common monomorphemic prepositions are on, in, to, by, for, with, at, of, from as. Given that prepositions have multiple meanings and cross-linguistic characteristics, they are difficult to predict or analytically identify in text (Saint-Dizier, 2005). Yet, verb-preposition relation can help in predicting relationships between content and verbs (Kipper, Snyder, & Palmer, 2004). There is limited refereed literature that examines the functional make-up of cognitive behaviors in virtual team communication. This research analyzes how to identify cognitive behaviors in communication using verb relationships and prepositions. For analytics to successfully process and understand cognitive behaviors in natural language text, answering the research questions serve as the foundation for developing classifiers.

Research Question 1.7: Which verbs, verb tenses or prepositions support the identification of indicators?

Research Question 1.8: How are indicators linguistically constructed; and do they display the same functional make-up?

2.5 Communication Analysis Methods for Capturing Cognition

Part II, Section I. The second Part of this Chapter provides an overview of literature on methods to analyze cognition in virtual team communication. The critical review covers communication analysis, traditional methods of measuring SA und TMS, and natural language understanding, with the goal to derive requirements for analyzing cognitive behaviors in communications and to propose a method for the discourse analysis.

The increasing complexity of socio-technical systems led to a need for communication analysis methods to make sense of the richness of team communication data (e.g., Cooke, Gorman, & Kiegel, 2008). With the use of analytical communication tools, it becomes possible to study cognitive processes operating at the team level. Thus, with the team focusing on a cognitive task, the teams' communication can uncover the cognitive processes at the team level (Cooke, Gorman, & Winner, 2007). Though, traditional methods can recognize cognition at the team level, these methods are limited in their observation and do not observe the systems complexity of team interaction (Cooke & Gorman, 2009). In virtual teams, in which there are multiple team members, one of the main methods of analysis that prevails this problem is communication analysis. In line with the ITC theory, Cooke and colleagues (2013) broadly defined communication analysis as an enabler to study cognitive processes at the system level, including socio-technical systems. Analyzing communication data displays characteristics that are imperative for measuring team cognition (Cooke & Gorman, 2009):

1. Rich in data: data represents aggregated snapshots of behavior within a temporal window or over time.
2. Multidimensional: Includes content of what is said; the voice of how it is said; and the flow of who talks to whom.
3. Embedded in rich context.
4. Occurs naturally: Occurs in socio-technical systems naturally and constitutes in some systems all or most of the interaction.

Given the critical role that communication plays at the team level, measurement and analysis of communication have become a new approach in the team research community. In fact, various research fields apply communication analyses, which vary in their spectrum. While human factors communication analyses focus on performance indicators of dialogue

acts or the words used by novices and experts (e.g., Duchene & Jackson, 2010; Foltz, Bolstad, et al., 2008), other disciplines have their focus set on the messages and their meanings. For instance, in psychology, Tuscan, Simmer, et al., (2006) examined the manifestation of group coordination in conversations of emergency team members, while Keyton and Beck (2009) explored the intersection of task and relational needs messages of members of the Breast Cancer Support Groups. Because communication is reflective of the entire team interactivity, communication is found to be a better predictor of virtual team performance than other component-based measures (Gorman, Cooke, Winner et al, 2007).

Over time, different methods have evolved that are used to measure and analyze communication. Early approaches included the development and validation of rating scales for assessing the quality of communication behaviors in teams (Johnston, Smith-Jentsch, et al., 1997; Smith-Jentech, Zeisel, Acton, & McPherson, 1998) or the development of behavioral rating scales of communication behaviors tied to scenarios or events (Dwyer, Fowlkes, Osier, Salas & Lane, 1997). One of the most widely used analytical methods as a way to draw conclusions from the content within discourse about team cognition is the verbal protocol analysis (McNeese & Reddy, 2000; Walker, 2005). While verbal protocol analysis is a method for capturing cognition, it is also a way of analyzing data. According to the authors, McNeese and Reddy (2000), the content of team communication is transduced into a written transcript derived from team members' verbal interaction during a task. The content is then further assessed based on predefined categorization that may include rules being displayed in the conversation, the types of speech, or the actual meaning of the discussion (Contractor & Grant, 1996; Cook, Gorman, Kiekel, Foltz, & Martin, 2005). Researchers refer to this kind of data analysis as content analysis (e.g., McNeese and Reddy, 2000).

Most methods encompassing the categorization of communication by type are based on post hoc analysis (e.g., video, audio, or text records), or real-time categorization, which is carried out during experiments to assess relations between the types of communication and team performance (e.g., McMillan et al., 2004; Oarsman, 1990; Serrati, Entin, & Johnston, 1998). Cooke and Gorman (2009) suggested that at least some information about the behavior of a socio-technical system resides in the flow of communication from one member to another. The authors developed a test bed for uncovering patterns in communication flow data in which there were four different methods applied: Dominance statistic, communication required and passed scores, CHUMS, and Prone as displayed in Table 4.

Table 4. Communication Flow Measures of Team Cognition (after Cooke & Gorman, 2009).

Measures	Method	Team
Dominance Statistic	Involves analyzing cross-correlation among team members' speech quantities, which results in a ratio (flow quantity) that is indicative of the amount of speech to and from each team member.	No / Yes
Communication Required and Passed Score	A measure to indicate how far a team deviates from expectations in regards to relative speech ratio across the entire mission.	Yes
CHUMS	Analyzes the number of distinct patterns of relative speech quantity the team exhibits during the mission and is referred to be a measure of communication stability.	Yes
ProNet	Procedure describing the communication flow in which events are defined by each team members beginning or ending of a speech sequence. It is a measure of how much communication stability is found on average in a set of utterances.	Yes

The communication flow measures provided an analysis tool-set to evaluate communications involved in the Enron incident (Weil, Foster, Freeman, Carley, Denser, Franz, Cooke, Shoppe, & Gorman, 2008). The measures supported three-person teams in strategic planning tasks to discriminate high-performance teams from low-performance teams (Gorman, Cooke, Warner & Wroblewski, 2007), collocated versus virtual teams, or even to corresponds with unexpected changes in the scenario (Cooke et al, 2005). Besides the analysis of communications within teams that can uncover utterances types and patterns (e.g., Artman, 2000; Davis, 2005; Orasanu 1994; Parush et al, 2011), Parush and colleagues (2011) report on other approaches that analyze communication within healthcare. These methods provide analysis on the rhetorical framework (Heath & Luff, 1991), modified grounded theory (Lingard, Albert, & Levison, 2008), or activity framework to reveal distributed cognition and SA in the operating room (Hazlehurst & McMullen, & Gorman, 2007).

Common aspects of most of these approaches contain elements from a conversation analysis approach to analyze team communications in other command and control contexts (Pomerantz & Fehr, 1997; Schegloff, 1987, Salas & Cannon-Bowers, 2000). With the use of conversation analysis, key components of team verbal communication are segmented into meaningful sequences with each sequence made of utterances produced by at least two team members taking turns in the verbal interaction (Parush et al., 2011; Parush et al. 2014). Authors coded qualitatively by identifying meaningful sentence and communication patterns by two criteria: the speech act behavior and the task-specific-content. The objective of this

coding approach was to identify communications that reflect processes of building and maintaining cognition (Parush et al., 2011). Therefore, as Cooke and colleagues (2013) suggest, examining these communication aspects in discrete laboratory experiments may yield insight for understanding cognitive processes during temporal interactions.

2.5.1 Traditional Methods for Analysis of Situation Awareness

Most of situation awareness development across teams results in coordination activities and the transfer of information from one team member to another (Endsley, 1999). SA measures rely fundamentally on Endsley's three-level model that includes behavioral indicators of perception, comprehension, and projection, which can vary by degree of interest if the components are measured extensively or if a more general construct measure was of interest. Nevertheless, the most frequently applied method for measuring SA is the Situation Awareness Global Assessment Technique (SAGAT) (Endsley, Selcon, Hardiman, & Croft, 1998). SAGAT provides a direct, objective measure of situation awareness. A wide variety of operations, including command and control, use and validate SAGAT for measuring SA in both individuals and teams (Endsley et al., 1998). As a disadvantage, SAGAT requires a temporary "freeze" during the mission simulations in order to collect data. During the freeze, participants must rely on memory that might not provide an accurate reflection of their awareness of the situation (Endsley et al., 1998; Stanton, Salmon, Walker, Baber, & Jenkins, 2005). Therefore, many potential users view it as obtrusive to normal operations.

Other measures of SA are subjective by nature. While simple to use and primarily task friendly, many researchers believe subjective measures of SA have little validity (Stanton, et al., 2005). Research by Stanton and colleagues (2005) indicate that because SA is largely a cognitive construct, outside observers are often unable to assess accurate SA levels of other individuals, or team level SA. Their research also indicated minor support for subjective measures of SA because of a small to no correlation with objective measures of SA and no application for assessing team data. Communication analysis on the other hand addresses the need for an unobtrusive and objective measure of SA that can support both simulations and real-time operations to predict the level of SA of virtual teams through active, on-line team communication. However, communication measurements for SA are still scant, and, there is no effective model for SA communications analysis. A summary of originated SA measures are presented in Table 5 which extends the original Table by Stanton and colleagues (2005).

Table 5. Recent Measures of SA (after Stanton et al., 2005).

Measures	Methods	Type of Method	Domain	Team	Limitations
Objective Measures	<ul style="list-style-type: none"> SACRI (Hogg, Folleso, Strand-Volden, & Torralba, 1995) SAGAT (Endsley, 1995b) SALSA (Haus & Eyforth, 2003) SASHA (Jeanett, Kellt, & Thompson, 2003) 	Freeze-probe technique, Real-time probe, Post-trial Quest	Aviation (Military), Air Traffic Control, Nuclear Power	No	<ol style="list-style-type: none"> Requires expensive simulations Intrusive to primary task Limited validation
	<ul style="list-style-type: none"> CARS (McGuinness & Foy, 2000) MARS (Matthew & Beal, 2002) SARS (Waag & Houck, 1994) SART (Taylor, 1990) 	Self-rating technique	Aviation (military), Military (Infantry Operations)	No	<ol style="list-style-type: none"> Problems of gathering SA post-trial, e.g., correlation with performance, or forgetting low SA Limited validation
Behavioral Measures	<ul style="list-style-type: none"> SABARS (Meatthew & Beal, 2002) 	Observer-rating	Military (infantry operations)	No	<ol style="list-style-type: none"> Extent to which observer can accurately rate internal construct of SA is questionable Presence of observer might influence participant behavior
	<ul style="list-style-type: none"> Carreta, Perry, & Ree (1996) 	Peer-rating	Aviation (military)	No	<ol style="list-style-type: none"> Extent to which peers can accurately rate internal construct of SA is questionable
Inferred Measures	<ul style="list-style-type: none"> Hazard Perception Test (Grayson & Sexton, 2002) 	Task performance Analysis	Driving	No	<ol style="list-style-type: none"> The positive relation between SA and performance is probabilistic and not always direct and unequivocal Limited validation
	<ul style="list-style-type: none"> Communication/ Social Network Analysis (Bolstadt, Cuevas, Gonzales, & Schneider, 2005) 	Latent Semantic Analysis	Military (infantry operations)	Yes	<ol style="list-style-type: none"> Requires expensive and available speech recording systems and speech-to-text translation software
	<ul style="list-style-type: none"> Psycho-physiological Measures (French, Clarke, Pomeroy, Seymour & Clark, 2007) 	EEG and EOG	Gaming	No	<ol style="list-style-type: none"> Limited use and validation

Measurements are divided into four different measurements: objective, subjective, behavioral and inferred measures, and their methods as well as the type of method and domain. The presented method has mainly been applied, if it's applicable for teams and its limitations are defined.

2.5.2 Traditional Methods for Analysis of Transactive Memory System

TMS enables team members to store and retrieve information and knowledge efficiently (e.g., Lewis, 2003). Team communication is necessary to update, to complement, or to replace these memory directories with new entries (Wegner, 1986). For instance, team members must communicate to differentiate knowledge (i.e., specialize) between team members, evaluate knowledge credibility, and gain understanding of who knows what and

how knowledge fits together (i.e., coordinate) that ultimately leads to a functional TMS (Lewis, 2003). Like the measures of SA, TMS measures are fundamentally based on the TMS behavioral indicators of specialization, credibility, and coordination.

Most common methods of measuring the construct of TMS in dyads or groups are limited to recall observed behaviors, and self-report about members' expertise (Wegner, 1986). During the use of recall measures, the presence of TMS in dyads uses the quantity, content, and structure of what participants remembered individually or with their partners (e.g., Hollingshead, 1998, 2001; Wegner, 1987). Similar recall measures were studied in concordance with direct measures of a members' knowledge to understand group-level TMS and beliefs (Moreland, 1999; Moreland & Myaskosky, 2000). In addition, these measures were successful in experimental settings. However, the disadvantage of recall measures is that they depend on the task being identical across teams with a known solution (Lewis, 2003). The author also notes that disadvantages exist for outside observers that must evaluate specific behavior to the task requirements.

Table 6. Recent Measures of TMS.

Measures	Methods	Type of Method	Domain	Team	Limitations
Objective Measures	<ul style="list-style-type: none"> Recall (Hollingshead, 1998a, 1998b; Liang et al., 1995; Moreland, 1999; Wegner et al., 1991) 	Post- trial quest, semi- structured interview	Dyads, Production assembly	No/Y es	4) Extent to which participants can accurately remember information to respective domain areas is questionable 5) Tasks have to be identical across comparison teams
Subjective Measures	<ul style="list-style-type: none"> Expertise Identification Survey (Austin, 2003) Group Questionnaire (Liang et al., 1995) Transactive Memory System Scale (Lewis, 2003) Transactive Memory Index (Moreland, 1999) 	Self- rating technique	Management Consulting Merchandise, Production Assembly, Product Development	Yes	3) Measures of knowledge complexity, accuracy and agreement depend on information specific to the task and therefore are not practical in field contexts 4) Limited evidence of use and validation
Behavioral Measures	<ul style="list-style-type: none"> Liang et al., (1995) Moreland (1999) 	Observer- rating	Production Assembly	Yes	3) Extent to which observers can accurately rate internal construct is questionable 4) Observers must evaluate behaviors specific to the task

In general, these measures have not been constructed for controlled settings where tasks are well-understood or do not differ across comparison, and therefore do not transfer well to other settings (Lewis, 2003). Another measure, the TMS scale is subjective in nature (Lewis, 2003). While easy to administer and unobtrusive to the primary task, data is collected on the individual level and needs to be aggregated to the team level. Table 6 presents a summary of TMS methodologies. Communication analysis addresses the need for an

objective and aggregated measure of TMS that may predict the effectiveness of TMS development in virtual teams in both simulations and real-time operations.

2.5.3 Shortfalls of Recent Methods

The previous section presented different types of measurements which are applicable of measuring team cognition. Of particular relevance to this review are the recent methods and their limitations. The findings in the following are summarized for adopting a new approach to measuring cognitive behaviors.

While objective and subjective measures can be substitutes for each other (e.g., Kren and Tyson, 2009; Merchant, Theivananthampillai, & Stringer, 2010), they should be used as complementary (Rajan & Reichelstein, 2009). Objective measures are those measures that compare an individual's perception of the situation, or environment, to what is actually happening for scoring the accuracy of a given point in time (Merchant et al., 2009). Authors describe subjective measures to assess cognitive processes using self-rating data, their own data, or data observed and taken from an anchored scale. While subjective measures are attractive in that they are relatively straight forward and easy to administer, these measures are difficult to anticipate *ex ante*, are non-verifiable *ex post*, and therefore considered non-contractible (Merchant et al., 2010). Subjective estimates of an individual SA may also be given by trained observers (e.g., peers, commanders, or trained external expert).

Behavioral measures on the other hand infer cognitive processes based on actions individuals choose to take, and on the assumptions that cognitive processes interrelate with team action (e.g., Cooke et al., 2005; Gorman et al., 2007). These measures rely on observer ratings and are, therefore, somewhat subjective in nature (e.g., Dwyer et al., 1997; Stanton, et al., 2005). Judgments about behavioral indicators that are more readily observable (e.g., Merchant et al., 2010) mitigate the limitations of subjectivity. Other inferred measures include SA measurements of indirect evidence such as social network analysis, communication analysis, or physiological data (Cooke et al., 2005, Stanton, et al., 2005). These methods have been limited in their application. Also many studies do not implement the use of a communication analysis to derive measures of SA or TMS. Technology advancements make communications analyses possible, and with the modern workplace provide a wide range of digital communications channels (e.g., e-mail, chat, instant messaging, voice/over-IP (VoIP), and teleconferencing (Cook, Duchon, Gorman, Keyton, & Miller, 2012). To date there are still only a few methods for analyzing team communications. For instance, analyzing communications among members, larger than two, remains

cumbersome as the complexity of the communications and the possibility of parallel discourse streams increase (Cooke et al., 2005). In addition, even with the progress made to date, speech-to text software is capable of capturing one person's speech effectively, but capturing and transcribing conversation of two or more people is still very difficult (Hain et al., 2010).

Research of team communication is further shifting towards automated text processing technology, such as, Latent Semantic Analysis, which identifies sequential communications patterns, without the need for extensive hand coding of communication data (Kiekel, Coole, Foltz, & Shope, 2001). Latent Semantic Analysis is a fully automated mathematical method for representing and analyzing semantic information within a domain (Landauer, Foltz, and Laham, 1998). Such automated methods are very important tools for assessing the quality of team performance and offer a deeper understanding of factors necessary for effective training or design (cf. Gatica-Perez, 2009).

2.5.4 Communication Methods Employed in this Research

Computer-based applications are upgrading the capabilities for Social Sciences, and significantly improving the ability of researchers to develop and implement automatic routines that collate, categorize, and quantify research data. There is still a strong need for research literature, including new software tools and models that can further push the envelope into deeper research regarding cognitive behaviors in communications. It is the fundamental basis for capturing cognitive behaviors in complex systems. Based on the critical role to understand the underlying factors that make up the functioning of cognitive behaviors, this research explores cognitive behaviors in communications through the application of communication analysis including content and discourse analysis. The content analysis is used for developing a coding scheme to categorize cognitive behaviors and to run a qualitative coding process. The discourse analysis supports defining cognitive behavior classifiers and identifying turn taking. The richness of communication in virtual teams is the basis for using these analyses as an approach to uncover cognitive behaviors and similarities or differences of virtual teams in a laboratory experiment.

2.6 Team Information Processing Barriers and Failures

Part II, Section II. Team's information processing barriers and failures are discussed in this section of literature review. Emphasize is placed on cultural and language diversity to present theoretical ground.

During a team task, when time is limited, team members must act quickly to gather information and assess their situation (Kanawattanchai & Yoo, 2007). If team members turn to team communication to help him/her attain awareness about the situation, he or she must decide how best to locate useful and meaningful information. Often, several messages communicated over computer-mediated communication (Yoo & Kanawattanchai, 2001), making it sometimes difficult for a single team member to locate the right information in which he or she is interested.

Based on the key principles of pragmatics, communication is only as detailed as necessary to convey the meaning (Grice, 1975, 1978). Work by Grice supposes that this may lead to problems of miscommunication in teams in particular when team members assume that the other team member (listener) does not require additional elaboration. Often times, the listener interpreted the statement as incorrectly because he/ she lacked a vital piece of information. The author further notes that the use of ambiguous or illogical statements in order to convey some other meaning as what is said might not always correspond to what is meant. After Grice (1975, 1978), the implied meaning is therefore the most troublesome in the virtual team context. Given that, implied meanings are highly context-dependent interpretations; their interpretation requires high level of communication competence from the speaker for an accurate assessment of the context, prior knowledge, and socio-cultural norms (Thomas 1983, Blum-Kulka, House, & Kasper, 1989). However, virtual teams nowadays are composed of language diverse members, increasing the challenge for communicating effectively in a virtual team context (Jackson & Joshi, 2004; Majchrzak et al., 2007, Watson-Manheim & Belanger, 2002, Watson, Kumar, and Michaelson, 1993).

2.6.1 Cultural Diversity and Awareness

The increase in the number of cultural diverse team members, the ageing workforce, and other demographic changes mean that teams will become increasingly more heterogeneous (Triantis, Kurowski, & Gelfand, 1994). Culture, which consists of commonly held beliefs, norms, assumptions and values, provide a source of identity for people (Early, 2006; Hofstede, 1980). The values people possess often times influence modes and means of their activities, specify general preferences, and govern beliefs about what is right and wrong (Schwarz, 1999). Diversity describes a range of team member differences, but generally refers to the distribution of member attributes among members who work together interdependently (Jackson & Joshi, 2004). One challenge virtual teams' face is the interaction with team members from various cultural backgrounds (Baba, Gluesing, Ratner, & Wagner,

2004). Research by Anawati and Craig (2006) demonstrated that the majority of virtual team members' would like their colleagues to be aware of cultural differences. The authors point out that the longer virtual teams worked together, the more team members of different cultures want colleagues to know. Especially, if the existence of cultural differences stays unnoticed for a long period of time. Team members must be aware and show an understanding for other ethnic groups to change attitudes and values in cross-cultural working relations (Adams, 1995). Recognition of one's own and other team members' cultural backgrounds and values (i.e., cultural awareness) is hence of importance.

Team members, however, find themselves often newcomers in a particular cross-cultural interaction, which demands to adjust to the unknown context (Barba et al., 2004). Under conditions of high uncertainty (Gudykunst, 1998), effective interaction in cultural diverse teams involves reorganizing one's mental representation, adapting behavior to intercultural situation, and having the sensitivity to recognize when a specific set of behaviors is appropriate (see Chen & Starosta, 1996). Conclusively, team members adjust to different cultures based on cognitive adjustment (e.g., Barba et al., 2004).

While cultural diversity can have positive impacts on virtual teams and team outcomes, the negative seem to be outweighed (Shachaf, 2008). Research by Shachaf (2008) suggests that compared to collocated homogeneous teams, culturally heterogeneous teams can leverage diverse knowledge and skills and use constructive cultural conflict to improve overall outcomes of decision making and performance. Further, they can use concurrent engineering to reduce time to market that also leads to improved performance. The following Table 7, adapted from Shachaf (2008), describes both the positive and negative impacts of cultural diversity.

On the other hand, a comprehensive review of the literature indicates culturally diverse teams to exhibit lower levels of integration (Watson & Kumar, 1992), resulting in incomplete team cognition that inhibits common understanding. Six (6) different factors caused the failure to create mutual misunderstandings. The factors described by Barna (1985) are 1) false assumptions of similarity, 2) language, 3) non-verbal misunderstanding, 4) the presence of misconceptions and stereotypes, 5) the tendency to evaluate, and, 6) high anxiety. In addition, a study by Vignovic and Thompson (2010) reviewed existing literature on cue deprivation in computer mediated communication environments. They proposed that cue deprivation also hinders intercultural collaboration in virtual teams due to members' lower awareness of other team members' cultural background. As a result, team set-ups may not

include existing knowledge about the culture of team members, or consider behaviors accordingly (e.g., communicating in clearer and/or elaborative terms). Virtual team members may process information based on their own cultural backgrounds rather than on their other team members. The set-up might even perceive their team members to be working remotely as outgroup-members who could potentially facilitate distrust and interfere with cooperation within the virtual teams (Vignovic & Thompson, 2010; Tyler & Blader, 2003).

Table 7. Impacts of Cultural Diversity in Teams (adapted from Shachaf, 2008).

Impacts		Outcomes
Positive Impacts of cultural diversity	Leverage diverse knowledge and skills to improve outcomes of decision making	Improve outcomes of decision making and performance (compared with collocated homogeneous teams)
	Concurrent engineering to reduce time to market	Improve performance
	Constructive conflict	Improve outcome of decision making and performance (compared with collocated homogeneous teams), but reduce satisfaction
Negative impacts of cultural diversity	Differences in non-verbal styles create miscommunication	Problems with communication, satisfaction, and performance
	Difference in verbal style create miscommunication	Problems with communication, satisfaction, and performance
	Language differences create miscommunication due to lack of accuracy	Problems with communication, satisfaction, and performance

Contrary to previous findings, the social identity model proposes that in the absence of team members' anonymity, the awareness of cultural identities may become more salient, increasing the acquisition and application of knowledge about cultures (Postmes, Spears, & Lea, 2000). Further, research has found that computer-mediated communication can even lead to more cohesive teams, due to visible anonymity and sense of de-individuation, increasing group cohesiveness and adherence to group norms (Postmes, Spears, & Lea, 2000; Spears, Postmes, Lea, & Watt, 2001). Based on 1) the theoretical ground discussed 2) the increased acquisition of knowledge about cultures in computer-mediated communication in early team stages (Postmes, Spears, & Lea, 2000; Yoo & Kanawattanchai, 2001), 3) the

environment of the study in which team members cultural backgrounds were only visible to fellow team members by communicating, the following was hypothesized:

Hypothesis 2.1: There will be a significant awareness by team members of their homogeneous or heterogeneous team composition.

2.6.2 Language Diversity

One of a potential source of linguistic diversity in teams sprouts from team members from different countries, who speak different languages. Such diversity may be recognizable in the language that has shown to cause difficulties in communicating effectively. Indeed, difference in languages can lead to problems in understanding and sharing of information, which can isolate team members from their team if they are unable to communicate proficiently (for example in Lichacy & Bjørnstad, 2013; Marschan-Piekkari, Welch, & Welch, 1999). However, there are also apparent individual differences in communication elaboration, determined by individual's motivation and ability (Petty & Cacioppo, 1979). Since the main purpose of communication is creating an essential link between the meaning and action, (Donellon, Gray, & Bougon, 1986), language competencies and socio-cultural differences have to be considered given that language is closely connected with thought processes and interaction (Chen, Geluykens, & Choi, 2006).

Sometimes the differences in language use are subtle so that they can lead to misattribution errors, especially when the foreign language speaker is proficient in other areas (Chen et al, 2006). For instance, English speakers frequently describe German speakers as sounding rude because of their use of the English language (Byrnes 1986; Hymes 1972). This however, was found not to be caused by German speakers transferring cultural knowledge from the German culture into the non-native (English) culture, rather, it arises from differing linguistic competencies (Geluykens & Kraft, 2003). Differences to language structure do not relate to serious problems but can cause occasional misunderstandings to some individuals (Chen et al., 2006). According to Chen and colleagues, errors in syntax, particular in written communications, can result in misunderstandings or irritation by other team members. Therefore, major negative impacts of cultural diversity on virtual teams are reflecting differences in non-verbal/ verbal styles and language differences that can lead to miscommunication and poor team performance (e.g., Barna, 1985; Shachaf, 2008).

For instance in a study by Baba and colleagues (2004), Americans and Israelis stated that members from eastern cultures such as Japan or China, were not direct in their communications. The team members were confused while waiting for clarification and

clearer response from team members from the eastern culture. In addition, while eastern cultures focus on maintaining relationship and are process oriented, western cultures felt that this act creates conflict which intensified already existing misunderstandings. However, language may not only reflect socio-cultural context, it may also influence interactions within teams. In global teams, in which all team members share a common language, it is not too uncommon to find native speakers of one language to form closer relationships with each other (Nickerson, 2000); leaving non-native speakers out of the conversations. In addition, cue deprived environments may further hinder communication competencies due to lower awareness of team members' cultural background (Vignovic and Thomspson, 2010). Hence, members are more likely to process information based on their own cultural backgrounds which reflects in their communication (Vignovic & Thompson, 2010; Tyler & Blader, 2003). Other factors that create difficulties both written and spoken language, which contributes to misunderstandings and requires team members to invest more effort in encoding and decoding messages of senders was found to be accuracy, slower speech and translation problems (Shachaf, 2008). Therefore, the cost of interaction is higher for both the non-native and native speaker.

It is therefore of interest to understand how communication differs between native and non-native English speakers that are solely connected through computer-mediated communication technology; and what potential problems may arise from using automated machine to analyze the communication of team cognition. Further, it is of interest on whether ethnicity plays a part in the communication performance between team members. Thus, the context of communicating in culturally diverse virtual teams raises questions as to how diversity influences contribution and how teams can overcome the cultural conditions and constraints that define team operations, in order to facilitate effective communication. Moreover, it highlights that the impact of cultural diversity on computer-mediated communication requires a better understanding, for teams to develop skills to cope with such a challenging environment. Based on the literature review, the following research questions and hypotheses are proposed:

Hypothesis 2.2: Team members that are culturally aware show higher team performance.

Hypothesis 2.3: Significant differences in contribution of English native speakers and non-native speakers in virtual teams exist across time.

Hypothesis 2.4: Higher amount of cognitive behaviors are leveraged from team

communications in virtual low diversity teams compared to when team diversity is high.

Hypothesis 2.5: Patterns of speech act behaviors in virtual high diversity teams differ from teams low in diversity.

Hypothesis 2.6: Diverse teams show a significant higher amount of cognitive behavior of confusion and misunderstanding.

The types of diversity considered in this study are ethnic and language diversity. Although, according to Van Knippenberg, De Dreu, and Homan (2004) diversity dimensions can have positive or negative effects, depending on the situation and information differences which affect teams, the focus lies in assessing the diversity dimension affects separately (Schippers et al., 2003). Given the computer-mediated communication environment, a specific focus is language diversity.

2.6.3 Information-Processing Failures

One impediment amongst team members are the differentially held schemas for specific situational and task information (Rentsch, Delise, Salas & Letsky, 2010). For instance, experts conceptualize and present problems abstract and explain tasks in broad terms, whereas relative novices represent and explain tasks using concrete statements (Hinds, Patterson, & Pfeffer, 2001). Another impediment is the bias of favoring information known to individual members at the expense of discussing uniquely held information (Strasser and Titus, 1985). Particularly then, when the team desires conformity to reach group consensus or when teams believe in their teams invulnerability through collective rationalization without evaluating alternative or incomplete information sources (Strasser and Titus, 1985). Failing to appraise the risk of preferred solutions generally results in selective information processing (e.g., Janis, 1972). These combined factors are likely to result in extremely defective decision-making performance in teams (Turner & Pratkanis, 1998). Janish (1972, 1982) predicted this phenomenon and proposed it as *groupthink*. He suggested it is likely to surface in teams that are highly cohesive, insulated from experts, operate under direct leadership, and experience condition of high stress and learned helplessness.

Teams do appear to be vulnerable to information processing failures that are resulting from these factors, and other factors such as confusion, misinterpretation, or poor training that frequently causes a breakdown in interaction of communication (Schippers, et al., 2014; Tajfel, & Turner, 1986; Taylor & Brown, 1988). This also occur during the decision making process for solving complex and dynamic pronlems that can lead to cognitive biases and errors (e.g., Dörner, 1996). This research also verifies the findings of Hinsz et al. (1997) in

that poor or distorted communications show a direct effect to the quality or failures of information processing, usually in the form of more exaggerated team behavior. Important factors to minimize failure are: a) share relevant information, b) examining implications of shared information or c) update and adapt held information or behavior (Schippers et al. 2014). Overall, these and other team factors, differentially held schemas and biases, create communication barriers that may limit knowledge building, effectiveness of team interaction, and ultimately, result in poor team outcomes (see Janis, 1972; Janis 1982).

2.7 An Approach of Optimizing Team Cognitive Processes

Part III, Section I. In Part III, literature on approaches to optimize team cognitive processes, specifically reflexivity is reviewed. The goal of the third Part is firstly, to present a theoretical-based model that depicts relationships between reflexivity, communication, cognitive behaviors, influencing factors and team performance, and secondly, to derive hypotheses.

Externalization is an approach common in cognition literature that encourages minimizing barriers (e.g., Rentsch et al., 2010). According to Rentsch and colleagues, it is a useful approach for developing team cognition by using specific communication forms, schema-enriched communications through structured or strategy discussions, team interaction training, and/or briefings. These approaches support the development of building knowledge structures in teams by providing and eliciting structure, organization, justification, and interpretations (Rentsch et al., 2010). Another approach, for externalizing cognition, uses *lessons learned*, a process that facilitates team cognitive development by having team members review the team's purpose, team goals, member skills, and roles (Hackman and Wagemann (2005). Lessons learned, in form of *reflection* (i.e., *reflexivity*), may be an important element in any learning environment. Self-reflection, for example, is an exercise to reduce cognitive biases and errors for decision-makers in dynamic, complex problem solving environments (Dörner, 1996, Güss, Evans, Murray & Schaub, 2009). Decision makers that adjust strategies based on situational changes through self-reflection can discriminate between the effects of actions from an autonomous system; and trace an implemented decision that propagates through a system over time (Schaub, 2007). While reflection helps to evaluate outcomes, using their learning and alternative strategies, it is critical process for information processing activities (Schippers, 2014). Yet, the effectiveness and benefits of reflexivity as an approach for externalizing and improving cognitive behavior in virtual teams that are maneuvering in dynamic and time-constraint situations have to be studied.

2.7.1 Introduction to Team Reflexivity as an Approach

Team reflexivity, a group level construct is an approach in which team members manifest sharing information in actual team behaviors and communication (West, 2000). Team reflexivity has been defined as the degree to which team members reflect upon and communicate about the team’s objectives, strategies and team processes, and adapt to the team’s expected circumstances (West, 2000). Schön (1983), introduced the primary concept of reflection and distinguished between two types of reflection: Reflection on action and reflection in action. West (1996) adopted the reflection concept to the group entailing both aspects, the reflection in action concept, and the self-reflection aspect at the team level. The team construct compares reflexivity to an iterative process that consists of highly interrelated components of reflection, planning, and action/adaption (West, 2000; Widmer et al., 2009). In this process, planning is the bridge between reflection and action/ adaptation, since reflection itself does not lead to direct change (West, 1996; Widmer et al., 2009). According to Widmer and colleagues (2009) during the planning phase, goals are proposed and strategies formed, and implemented during the action phase. During the action/ adaptation phase, goal-directed behaviors are relevant for achieving the team’s objectives (West, 2000). Gained feedback, from the actions completed leads to further changes as well as further reflection, planning, and action. Hence, the action/ adaptation phase is an important aspect of the learning cycles to test assumptions (Widmer et al, 2009). Figure 4 illustrates the relationship between these three phases.

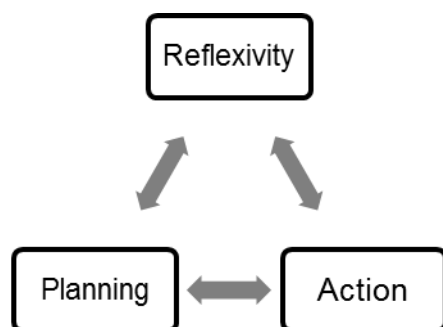


Figure 4. Aspects of Reflexivity (after West, 2000).

Recent work has studied team reflexivity as one construct, with information-processing as an essential part of team reflection (e.g., Carter & West, 1998; De Dreu, 2002; Pieterse, van Knippenberg, & van Ginkel, 2011; Schippers, Den Hartog, & Koopman, 2007; Schippers, Homan, & van Knippenberg, 2013; Schippers, Den Hartog, Koopman, & Wienk, 2003; Schippers, West, & Dawson, 2015; van Ginkel, Tindale, & van Knippenberg, 2009).

Schippers and colleagues (2014) conceptualize team reflexivity as an explicit information processing activity in teams that reduces potential information-processing failures.

Throughout the literature, reflexivity is an important factor for team efficiency in complex decision making teams (Carter & West, 1998); increased levels of team performance (Brahm, 2009; Carter & West, 1998; Schippers et al., 2013; Van Ginkel & Van Knippenberg, 2009); innovation (MacCurtain, Flood, Ramamoorthy, West, & Dawson, 2010); higher decision quality (Van Ginkel, Tindale, & Van Knippenberg, 2009); shared understanding (Pieterse et al., 2011; Van Ginkel et al., 2009); and learning (De Dreu, 2007; Schippers et al., 2013).

Teams that engage in reflexivity plan in more detail, respond to a larger set of environmental cues, and pay attention more extensively to long-term outcomes, than do non-reflexive teams (Widmer et al., 2009). Through collectively engaging in reflexivity about the task, team members become aware of their own or others' task schema and possible differences (Van Ginkel et al., 2009). Discussing differences and reconciling group members' task schemas during reflexivity, creates task appropriate cognitive representation (Van Ginkel et al., 2009). Even if differences in understanding task schemas stay unnoticed and have negative affects team processes, reflexivity can help team members to understand strategies and goals (Pieterse et al., 2011).

2.7.1.1 Reflexivity Interventions

With the fast pace in work environments, teams might not have the time to find cognitive, temporal, and physical space to reflect on the appropriateness of their objectives, the effectiveness of their processes, and awareness of their changing situation. Indeed, empirical studies demonstrated that individuals do not reflect spontaneously, but that teams could benefit from targeted reflexivity interventions (Badke-Schaub, Frankenberger & Dörner, 1997; Schippers et al., 2013). Several initial studies show that inducing reflexivity enhances performance and productivity (Widmer et al., 2009). The term "guided reflexivity," introduced by Gurtner, Tuscan, Semmer, and Naegele (2007) first tested the ability of guided reflexivity to provoke reflexivity within hierarchically structured teams. Gurtner and colleagues based guided reflexivity on a three-stage model. The first stage involves the team's consideration on how the team has performed up to a point. The second stage focuses on strategies for potential improvements, and during the final stage, teams develop plans on how to implement the new strategies. Between experiment scenarios, written instructions implement reflexivity either to the team members to reflect on the task individually or by communicating with other team members. Results showed that guided reflexivity has a

positive effect on team performance. Reflexivity completed by team members individually was superior to team reflexivity, perhaps because the team discussions of strategies were too general, as the authors speculated. Thus, Gurtner and colleagues (2007) suggested focusing on task adaptive strategies when implementing team reflexivity. For example, teams should rethink and revise early-adopted strategies to enhance team coordination.

Another study by Mueller, Herbig, and Petrovic (2009) examined students of mechanical engineering who worked on a product development task. The authors defined reflexivity in terms of discussing past actions and their outcomes on implicit team knowledge. Their results indicated that teams that were instructed to collaboratively reflect on their implicit individual knowledge or to communicate with their team members about the task, produced qualitatively better and more innovative products. However, for teams in highly dynamic and complex environments, a reflexivity intervention might be time-consuming. For that reason, it is important to illuminate the situations under which reflexivity is most profitable (Schippers et al., 2013). As proposed by Schippers and colleagues, induced reflexivity might be a practical intervention for team performance improvement after relatively poor or mediocre performance as judged by external evaluators. Consequently, reflexivity interventions might support initial team cognitive processes and thus enhance team performance in the initial stages of team development.

Any team can be trained to make good strategy decisions in a given situation or be trained in a specific task (e.g., work embedded training or hands-on practice; Gurtner et al., 2007; Kozlowski & Bell, 2008), but such training is limited to the task and the training environment. Specific training content for general training interventions would require extensive preparation in design and most likely be expensive and cost prohibitive. Gurtner et al. (2007) proposed that guided reflexivity is an intervention that would stimulate teams to develop and implement task-adaptive strategies on their own, in a way that time and effort are saved, while task performance flexibility increases. Hence, guided reflexivity interventions might be particularly applicable during team development stages, especially in low performing teams (Schippers et al., 2013), in highly innovative teams, and in complex decision-making teams that have extraneous cognitive burdens. Large multinational military coalitions could also profit from these guided reflexivity interventions where team members may have never worked together before, do not meet face-to-face, nor are they likely to see each other again after the mission has been accomplished (Schraagen, Veld, & De Koning, 2010).

Theoretical work on guided reflexivity interventions suggests that these interventions can occur at three different time stages: Before, during, or after the task has been completed (Schippers, Den Hartog, & Koopman, 2007). According to Schippers and colleagues (2007), an intervention before the task is characterized by the team goal, strategies, and processes. Identifying a reflexivity intervention occurring during the team's task is characterized by reviewing the team's process and correcting teams' action taking. Evaluations of achievement and the way things were done, characterizes reflexivity occurring after finishing the task. Placing guided reflexivity interventions at the midpoint of task performance might be most effective because team members have already received experience with the task and the working process (Hackman & Wagemann, 2005). Furthermore, according to Hackman and Wagemann, mid-point interventions encourage reflection on teamwork strategies, and show an increase in performance. In addition, it contributes to personal learning of individual team members. In contrast, a strategy intervention implemented prior to the team task stimulated teams to perform poorly compared to teams who had an obvious strategy at hand (Hackman & Wagemann, 2005). During any guided reflexivity intervention, the reflective processes must occur at a conscious level, because only then can one evaluate prior decision-making and adapt to changes (Boud, Koegh, & Walker, 1985; Brahm, 2009).

Recent literature suggests that simple, structured interventions will enhance reflexivity (Konradt, Schippers, Garbers & Steenfatt, 2015; Ellis, Carette, Anseel & Lievense, 2014; Schippers et al, 2014). For instance, Konradt and colleagues (2015) studied 98 teams that communicated virtual via chat or face-to-face while completing a collaborative task. Information was variously distributed so that team members had to rely on each other for task completion. After the teams completed the first task, randomly assigned teams received a team reflexivity intervention. Team members had instructions to reflect about expert knowledge, review performance, and reflect on alternative strategies using expert knowledge. Next members developed plans for an implementation strategy in the next phase of task completion. Teams in the team reflexivity group demonstrated higher levels of reflection than teams in the control group. Results showed that these teams were more likely to exhibit a shared mental model, had a greater adaptation rate and greater team performance improvements. Although there has been a substantial amount of research on reflexivity (e.g., Gurtner et al., 2007; Schippers et al., 2013), there is need for subsequent research on team reflexivity intervention that guides exploration about how these interventions might affect team cognition (i.e., cognitive behaviors), communication processes, and overall team

performance. Because virtual teams are more prone to information-processing failures this study introduces guided team reflexivity intervention that may be particularly beneficial for such teams (Andres, 2013; Hertel, Geister, & Konradt, 2005).

2.7.1.2 Traditional Methods of Analysis for Reflexivity

Most of reflexivity development in teams was a result of the discussion processes (Konradt, et al., 2015). The authors illustrate the diversity of reflexivity measures and propose a more fine-grained measure that takes diversity, quality, and quantity of information acquisition and processing activities into account in order to observe team success and failure more accurately. Prior measures have neglected the reflexivity construct as a whole and instead focused mainly on the reflecting aspect of reviewing objectives, working methods or the extent of reflection (Konradt et al., 2015; Schippers et al., 2007; West, 2000). This research addresses the limitation of current reflexivity measures, and the complexity and diversity of behaviors, constituting team reflexivity (Konradt et al., 2015). In order to grasp behaviors displayed, a communication-based approach was chosen to extract the exhibited reflexivity behavior. Since communication is reflective of team interaction and cognition (ITC-Theory by Cook et al., 2013) it may also be reflective of reflexivity. It is therefore of interest which of the types of reflexivity behavior are communicated and whether or not reflexivity exhibits other behaviors of cognition or speech act. Furthermore, to analyze reflexivity in team communication, classifiers need to be created that can tag observed indicators. Thus, it was of interest to understand the linguistic construction of reflexivity indicators. The following research and hypothesis questions were of interest to this study:

Research Question 1.9: Which types of reflexivity do teams communicate?

Research Question 1.10: Does the occurrence of individual reflexivity indicators differ?

Research Question 1.11: Does reflexivity also exhibit cognitive or speech act behaviors?

Hypothesis 1.4: Different reflexivity behaviors are displayed in teams in regards to high versus low performance.

2.7.1.3 Theoretical Model of Reflexivity and SA and TMS Cognitive Behaviors

Reflexivity applies to behaviors that are similar to those of cognitive activities such as „questioning, planning, exploratory learning, analysis, diversive exploration, making use of knowledge explicitly, planfulness, learning at a meta-level, reviewing past events with self-awareness, and coming to terms over time with a new awareness“ (West, 2000, p.4). Thus, team reflexivity may aid in stimulating the development of cognitive behaviors SA and TMS that might be observable in team communication.

Current research supports these propositions, as reflexivity was found to be a moderator on the development of TMS and better decision making (Van Ginkel & Van Knippenberg, 2009). The authors examined three person teams to function as an independent advisory committee and three stores in making a decision about four interrelated issues. The advisory committee manipulated reflexivity by means of written instructions that asked participants to think about the group task, and what would lead to high or low team performance because of their experience during their task. Results of the study identified building of knowledge of who knows what (i.e. TMS) and sharing distributed information is more likely to occur when team members engage in reflexivity. The study has shown the first positive effects of reflexivity on TMS development, which might also hold true for SA development. Particular as training interventions for passing on information and providing feedback on the outcome of an action where found to result in higher SA levels (Kaber & Endsley, 1998). As both SA and TMS cognitive behaviors during reflexivity communication reflect content between team members exchanged, the application of a communication based approach seems justified and promising. Especially, since recent research suggest that the fundamental construct of reflexivity lies on the communication content and is not inferable by the frequency of overall communication in teams (e.g., Ellis et al., 2014, Schippers et al., 2014). Hence, this research proposes a theoretical model focusing on the social interactive team processes in relation to the emergent states (cognitive constructs, Konradt et al., 2015).

These complex socio-technical environments bear situations which are novel and unpredictable to teams and in which no pre-existing rules are available to guide action (Rosen et al., 2008). Instead it involves the generation and adaptation of rules to these novel situations by combining, aggregating and visualizing information to support team members in handling uncertainty and building new knowledge and informational relationships (Letsky, Warner, Fiore, Rosen, & Salas, 2007; Rosen et al., 2008). Thus, both coordination regarding information acquisition as well as behavioral coordination is quintessential (e.g., Entin &

Serfaty, 1999; Rosen et al., 2008). During such phases, the externalization of these cognitive processes in form of cognitive behaviors in communication may generate new team understanding. Reflexivity may therefore develop SA and TMS cognitive processes, observable in form of cognitive behaviors in communication, in that reflexivity supports:

1. referring back to SA and TMS representations to reflect on the situation or team members' expertise and update their old representation with the newly attained information to either revise or continue with their strategy as planned,
2. developing SA based on data and viable information in the environment as well as about TMS on team members' role and specialization,
3. integrating individually held SA or TM in to team SA or TMS for a common team representation of the problem and the team,
4. projecting current team knowledge about the situation into the near future of team actions - SA - and coming to a team consensus on team members' specialization - TMS cognitive behavior - for further coordination,
5. gaining and updating SA for team understanding of the developed situation and retrieving updated knowledge from their TMS for locating valid information from other team members specialization or coordination efforts for adapting or implemented strategies.

Reflexivity can therefore catapult communication processes in teams, and then mitigate information-processing failures (e.g., caused by language diversity) for teams in complex socio-technical systems such as ad-hoc or virtual teams, or teams that designed for a short lifecycle (e.g., Alge, Wiethoff & Klein, 2003; Kirkman, Rosen, Tesluk & Gibson, 2004; Jarvenpaa & Leidner, 1999, Schippers et al., 2014). Thus, team reflexivity may increase the amount of cognitive behaviors in communication leading to higher team effectiveness. Examining whether reflexivity externalizes major cognitive processes and behaviors will provide major insight in describing the effectiveness of reflexivity on cognition and team processes. At the same time, reflexivity might minimize the effect caused by team diversity that too often leads to information- processing failures (Schippers et al., 2014). Hence, new questions are arising as to how reflexivity is changing or augmenting team cognitive behavior communication in complex socio-technical systems and to whether reflexivity improves cognitive behavior communication that lead to improved virtual team performance.

The theoretical model proposes reflexivity as one construct that is comprised of iterative processes of reflexivity transition and action phases (Schippers et al., 2007). Although, Konradt and colleagues (2015), considered one component ‘reflection’ during the transition phase, the theoretical model considers reflection as two separate indicators: review (e.g., review of prior task performance and mission analysis) and strategy development (e.g., planning and formulating strategies). Viewing the transition phase as two separate components not only aligns with the aforementioned reflexivity model by West (2000), but also, may provide a better understanding of the reflexivity transition phase and the reflexivity construct. The action phase of reflexivity will thus represent strategy implementation and adaptation of prior developed strategies and actions performed (Marks, Mathiue, & Zaccaro, 2001). Three indicators of review, strategy development and strategy implementation together present the reflexivity construct.

A theoretical model captures possible influences of team reflexivity intervention on cognitive constructs, team processes (i.e., communication and reflexivity), and performance. The underlying process relationships of the proposed constructs, which may elicit positive influence on team outcome, are also in the theoretical model. Moreover, relationships between individual constructs and performance gain better understanding of the interplay of the cognitive and team process variables. Further, possible negative influences of diversity, on communications, or team outcomes, reside within the proposed theoretical model. The theoretical model, displaying proposed relationships is illustrated in Figure 5.

Underlying the proposed relationships in the theoretical model, the model proposed the following effects of team reflexivity intervention on team communication, cognitive processes, and performance outcomes:

Hypothesis 3.1: Team reflexivity intervention exerts positively increases overall communication volume.

Hypothesis 3.2: Team reflexivity intervention positively influences reflexivity communication regarding review, strategy development, and strategy implementation.

Hypothesis 3.3: Team reflexivity intervention positively influences cognitive behaviors SA and TMS.

Hypothesis 3.4: Team reflexivity intervention decreases diversity in teams.

Hypothesis 3.5: Team reflexivity intervention positively increases performance.

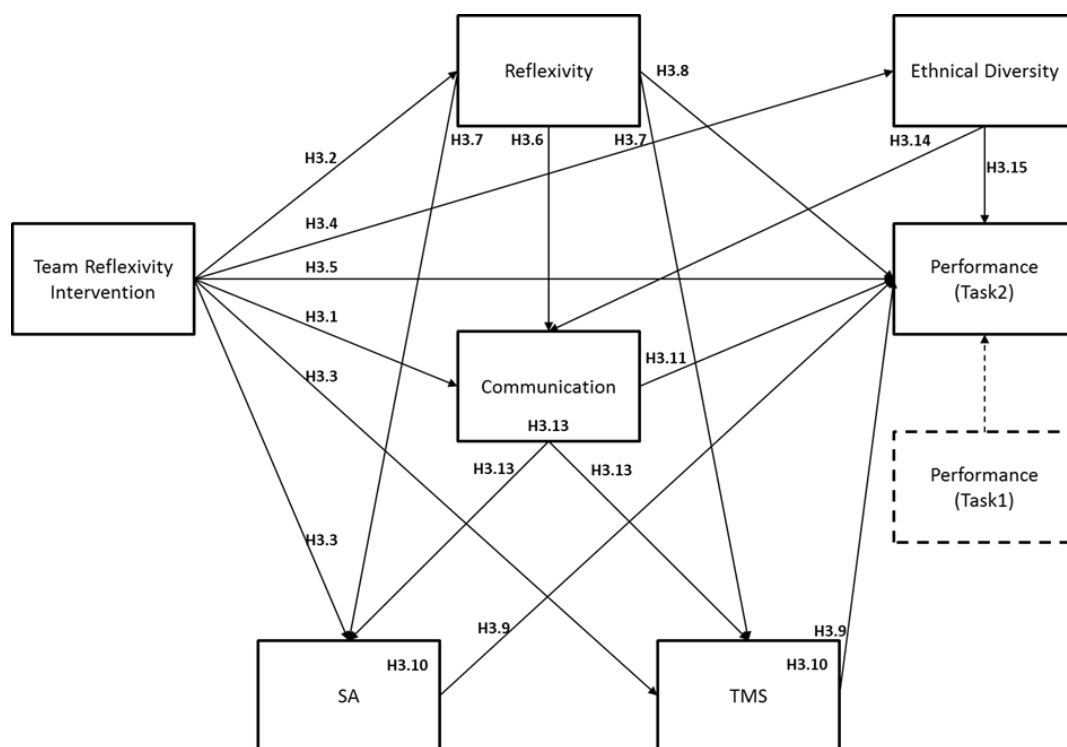


Figure 5. Proposed Theoretical Model and Sets of Hypotheses (H).

Given that, communication exhibits certain indicators regarding reflexivity phases such as review, strategy development, and strategy implementation that might direct task activities in teams leading to higher performance outcomes, the following is hypothesized in the theoretical model:

Hypothesis 3.6: Reflexivity exert a positive influence on communication volume; in that the volume of communication increases with an increase in communication regarding the reflexivity indicators review, strategy development and strategy implementation.

Hypothesis 3.7: Reflexivity positively influences cognitive behaviors SA and TMS, in that more cognitive behaviors are displayed with an increase in reflexivity.

Hypothesis 3.8: Reflexivity positively influences performance.

Based on previous reviewed literature on cognitive behaviors, SA, and TMS affect overall team outcomes, support the following hypothesis in the model:

Hypothesis 3.9: SA and TMS cognitive behaviors positively influence performance.

During reflexivity communication certain SA and TMS cognitive behaviors may be exhibited that are proposed to have a direct effect on performance. Although, reflexivity research argues direct relationships of reflexivity on team performance, it seems to limit the reflexivity construct, given that cognitive processes during reflexivity may affect or mediate the outcome (Konradt, et al., 2015; Salas, Fiore, & Letsky, 2012). Therefore, the effect of reflexivity on performance may be mediated through the exhibition of the cognitive behaviors in team communication. The following mediator effect is predicted in the theoretical model:

Hypothesis 3.10: SA and TMS cognitive behaviors mediate the influence of reflexivity on team performance.

Prior research identified high communication volumes to decrease performance, as the act of communication prohibits teams from taking action (see e.g., Yoo & Kanawattanachai, 2001). Therefore, the following was predicted regarding the effect of communication on other processes and outcomes within the theoretical model:

Hypothesis 3.11: Higher communications volume will negative impact performance.

Hypothesis 3.12: Communication increases the exhibition of SA and TMS cognitive behaviors.

Although, reflexivity communication will exhibit certain SA and TMS cognitive behavior, the exhibition of these SA and TMS cognitive behaviors in communication may be mediated by communication volume (i.e., how much team members communicated during reflexivity). Thus, the following mediator effect is proposed:

Hypothesis 3.13: Communication mediates the relationship reflexivity and the cognitive behaviors SA and TMS.

The theoretical model proposes negative influences of diversity on other constructs and outcomes, and predicts the following:

Hypothesis 3.14: Diversity negatively influences communication volume.

Hypothesis 3.15: Diversity negatively influences performance.

Although the theoretical model captures major theoretical propositions, additional investigations of the effect of team reflexivity intervention on individual constructs and

indicators can increase researchers understanding of 1) effectiveness of team reflexivity intervention, 2) occurrence of reflexivity indicators during team reflexivity intervention, and 3) identification of essential cognitive behavior indicators in reflexivity communication observed during the intervention. These results may fill the gap in research in providing understanding of how team reflexivity intervention drives communication regarding the reflexivity construct (review, strategy development, and strategy implementation). It further may provide understanding of which reflexivity indicators mark high performance teams. Based on the literature previewed, the following is hypothesized:

Hypothesis 4.1: Team reflexivity intervention will improve team performance.

Hypothesis 4.2: Teams engaging in the team reflexivity intervention will show more reflexivity in communication during the intervention.

Hypothesis 4.3: Teams engaging in the team reflexivity intervention will show more cognitive behaviors in reflexivity phases during the intervention.

2.7.1.4 Temporal Nature of Reflexivity

Reflexivity in teams is a transition phase that occurs between performance episodes (Marks et al., 2001, Konradt et al., 2015; Schippers et al., 2014). During the transition phases, team reflexivity entails an interaction process in form of communication to review current information, past or planned action, decisions or strategies with respect to team goals, processes or outcomes (e.g., Konradt et al., 2015; Schippers et al, 2014). For example, the team may strategize about current task goals and plan future action points. Thus, the aim of team reflexivity is to review the past and learn from experience to strategize these future activities (Ellis et al., 2014). After these strategies have been conceptualized, teams need to implement them in form of adaptation. However, adaptation may not follow team reflexivity. Yet, it must occur during the action phase for reflexivity to have positive effects on team processes (Gurtner et al., 2007; Marks et al., 2001; Schippers et al., 2014). Besides action phases being periods of strategy implementation; team members will also have monitoring, coordinating, or performing tasks to complete (Konradt et al., 2015; Schippers et al., 2014). As an example, the assigned team member may be responsible for tracking and reporting to their team counter parts. Marks and colleagues (2001) suggest a temporal pace while teams shift among transition and action phases during collaboration. Studies actually showed that teams shift focus on past, present and future events during process activities (Mohamed & Nadkarni, 2011; Shippers et al., 2009).

Research by Goh, Goodman, and Weingart (2013), examined the cycles of work-task processes in attaining team goals included planning, enacting, and reviewing. The cycles are patterns of team activities and interactions. Their findings suggested that the duration of the activity has an effect on team outcome. Better outcomes are attained through shorter testing cycles of plans or enactments, and still have longer cycles of reviewing. Even though this study lacked specificity about the timing benefit of processes or construction of process cycles that might be effective, it may need a more definitive approach for understanding the dynamics of processes to inform timing of interventions on team performance (Goh et al., 2013; Kennedy & McComb, 2014). A study by Kennedy and McComb (2014) examined the dynamics and timing of transition and action shifts in a teamwork simulation. Researchers based their method on tracking track-phase shifts by identifying the first transition shift, and then shifts of different transitions, as-well-as shifts to an action phase during team communication. Their findings add to the literature on timing of transition and action shifts by demonstrating that some interventions are likely to improve team performance. This outcome result is because of promoting process discussions and shifts during transition and action phases. The nature of reflexivity can be separated into transition phases and action phases of reflexivity that occur between performance episodes (Konradt et al., 2015).

To gain more understanding of reflexivity phase topics, both topic review and strategy development are attributed to the transition phase. Strategy implementation is attributed to the action phase. Both reflexivity phases constitute a cycle that consists of a sequence of events and states (i.e., cognitive behaviors). Given the scarcity of research about team reflexivity transition and action shifts in team communication, it was of interest to understand timing and its relationship to reflexivity. One focus of this research is placed on the temporal relationships among reflexivity transition and action phases and how they relate to performance. The hypotheses below are results of the research review:

Hypothesis 5.1: Proportion of communication shifts between reflexivity phases differ across time.

Hypothesis 5.2: Communication shifts between topics across collaboration over quartiles differs for teams who received the reflexivity intervention compared to those who did not.

Hypothesis 5.3: Communication progression of topics regarding reflexivity differs between high and low performing teams over time.

Research on team cognition has predominantly taken on static measures with cognitive constructs examined at a single point in time (Gevers et al., 2015). To fill this gap in research, the current research applies a communication-based approach to investigate the unfolding process of cognitive behaviors and reflexivity. This was of particular interest as teams adapt their cognitive structures to the changing demands of the task environment (Randall et al., 2011; Uitdewilligen et al., 2013). Thus, the emergence of cognitive behaviors and that of the reflexivity construct, especially concerning strategy implementation (i.e., adaption phase), may provide insight into how these emergent processes unfold over time. Given all the above, it was hypothesized:

Hypothesis 5.4: Volume of reflexivity in communication will differ across time for teams engaging in team reflexivity.

Hypothesis 5.5: Volume of SA and TMS cognitive behaviors in communication will differ across time for teams engaging in team reflexivity.

2.7.1.5 Reflexivity on Diversity

Situational complexity, team composition, team tasks, failures in information processes and diversity all challenge team collaboration and the development of cognitive processes (Schippers et al., 2014). According to the same authors, these challenges can lead to, but are not limited, to ineffective communication, information inaccuracy, create a common misunderstanding, wrongly held representations, ineffective strategy options, no projection of future situations development, or inadequate coordination efforts during exercises. Particularly, ethnical and language diversity may place tremendous burdens on computer-mediated communications in complex socio-technical systems. Team discussion and training may therefore provide team members with an opportunity to exhibit more efficiently SA and TMS cognitive behavior in computer-mediated communication. Schippers and colleagues (2014) also noted that through team reflexivity (e.g., in form of guided reflexivity, feedback, or learning from errors made by other teams') will enable teams to mitigate prior information-processing failures. Guided team reflexivity may therefore be a beneficial approach for ethnic or language diver's teams to communicate more efficiently about reflexivity, or SA and TMS cognitive behaviors that could result in better team performance. Given these findings, the following was hypothesized:

Hypothesis 2.7: Diverse teams engaging in the team reflexivity intervention will show more reflexivity during the intervention.

2.8 Summary

Chapter Two (2) contains three sectional parts to provide an elaborative literature review on theories, measurements, and constructs considered in this dissertation. Further, this Chapter proposed a theoretical model depicting constructs of reflexivity and cognitive behaviors for investigating relational effects on communication processes and team performance. Throughout the Chapter research questions, together with proposed hypotheses, highlight important research points (see Table 8 and 9 for a summary). The next Chapter focuses on the research design and method adopted.

3 Overview of Research Design

The preceding Chapters outlined literature and theoretical models of investigating team cognition specifically cognitive behaviors in communication to better understand how cognition is explicitly communicated and when it becomes important for team effectiveness. Understanding the role of leveraging cognitive behavior from team communication, as well as its potential relation with overall team effectiveness is an emergent area of study. The first questions to explore are:

1. How are SA and TMS cognitive behavior indicators constructed linguistically?
2. Do the effects of cognitive behavior indicators differ based on the implementation of team reflexivity or due to cultural diversity that relates to team effectiveness?

The key intent of Chapter Three (3) is to present a summary of the research questions and theoretical prepositions and hypotheses.

3.1 Purpose and Research Questions

The purpose of this research was to examine whether team communications contain team level cognition, and, how best to extract the cognition data from team communication. The specific interest was to understand linguistic composition within the computer-mediated communications, to identify how best to extract SA and TMS cognitive behavior indicators. The literature review described three gaps in research that the current studies address. First, research shows the importance of communications to the team cognitive processes - there are no systematic studies for assessing team cognition at the linguistic level. Similarly, research evidence suggests common approaches for automated machine processing, but studies do not reveal a classification system or statistical analysis process for resolving cognitive behavior indicators.

Second, several studies have shown that cultural diversity can affect team communications negativity by increasing team misunderstanding and frustration, but their effects remain unknown. While studies show the negative impact on overall team effectiveness in cultural diverse teams, there is no evidence that performance in virtual team's computer-mediated communications has a similar effect. However, team reflexivity interventions may mitigate these cultural-diversity related effects on computer-mediated communications.

Third, prior research highlights the role of team reflexivity in increasing overall team effectiveness - the research does not reveal how team reflexivity might affect computer-

mediated communication in relation to overall team effectiveness. Although experimental research suggest an increase in team communication, through team reflexivity components, there is no effectiveness study of single reflexivity components. Therefore, it was of interest to investigate reflexivity components in communication by creating classifiers to analysis the statistic of reflexivity in team communication. A summary of the research questions stated in the previous Chapter are listed in Table 8. The research questions are the fundamental basis which drives this study.

Table 8. Summary Research Questions

Number	Research Question
1.1	Which types of SA cognitive behaviors do teams communicate?
1.2	Does the occurrence of individual SA cognitive behaviors differ?
1.3	Which types of TMS cognitive behaviors do teams communicate?
1.4	Does the occurrence of individual TMS cognitive behaviors differ?
1.5	Which speech act behaviors are trivial within the virtual team context?
1.6	Do cognitive behaviors display the same speech act behaviors?
1.7	Which verbs, verb tense or prepositions support the identification of indicators?
1.8	How are indicators linguistically constructed, and do they display the same functional make-up?
1.9	Which types of reflexivity do teams communicate?
1.10	Does the occurrence of individual reflexivity indicators differ?
1.11	Does reflexivity exhibit cognitive behaviors and speech act behaviors?

3.2 Research Design

The research employed a true experimental design, case analyses, as well as a quasi-experiment design. The design adopted, enabled random allocation of members by the researcher to various conditions of interest. The present experiment used a two (2) (team reflexivity: reflexivity, control) x three scenario mixed factorial design. In the experimental design, team reflexivity was a between-subject variable while scenario was a repeated measure within-subjects variable. Team reflexivity consisted to commonly reflect on the team’s strategy, or control condition with no team reflexivity intervention. Teams measure performance during all three scenarios. The case analyses examined, selected high and low performance teams to assess variations in cognitive behavior indicators with respect to performance. The quasi-experiment tested the selected cultural diverse virtual teams (i.e., native vs. non-native English speakers) upon the variables (i.e., team reflexivity and scenario). This research design enabled the proposed model to be tested using a large sample of newly formed virtual teams in a microworld setting.

In addition, this research considered a quantitative approach as the most relevant methodological approach. This approach also used specific numerical measures representing the theoretical concept of interest for testing. The qualitative studies assessment describes the linguistic construct of SA and TMS cognitive behavior indicators and classifiers occurring in team communications. Quantitative data examined the impact team reflexivity had on these cognitive behaviors, as well as the cultural diversity in virtual teams. During the exercise, questionnaires provided quantitative data and communications activity logs saved any occurring communication between team members. A communication log was the most efficient method for gathering data in the research undertaken. It enabled data to be collected while teams were completing their tasks. The questionnaire considered the context methodology of the data collection. More specifically, it was essential that the scale used would provide a measure of the construct of interest. It was important to minimize the amount of missing data in the data set, so every run double-checked all team members' completion of the entire questionnaire. The questionnaire was an on-line questionnaire. This approach facilitated greater efficiencies with data collection and reduced the potential for errors in data entry. In a later section of this Chapter, the scale that comprises the questionnaire is described in detail (see Measures 3.8).

The first part of this study was to extract cognitive behavior and reflexivity indicators from communication through data analysis. Communication data was manually annotated and clustered into classifications to assess the linguistic construct of SA and TMS cognitive behavior and reflexivity indicators. This classification system provides a feature set that classifiers can use in automatically categorizing and labeling text. Besides the indicators, speech act and verb determined their use to analyze, to evaluate how, and, in which ways, SA and TMS cognitive behaviors and reflexivity are communicated. The second part of this study evaluates the influence of ethnic and language diverse teams on communication, cognitive behavior indicators, and their relationship to team performance. In addition, team reflexivity intervention was evaluated in connection with diversity as reflexivity may mitigate potential negative effects of diversity within virtual teams. The third part of this study was designed to test the effect of team reflexivity intervention, by randomly assigning virtual teams to either engage in team reflexivity or participate in a control discussion. The team reflexivity intervention was examined to test whether possible increases of the level of SA and TMS cognitive behaviors in team communication can be observed and how the overall effect may influence overall performance outcomes. Lastly, the temporal nature of reflexivity

phases in communication as well as the effect of team reflexivity across time was of research interest.

3.3 Research Hypotheses

A summary list of all hypothesized propositions is provided in Table 9.

Table 9. Summary of Hypotheses.

Number	Hypothesis
<i>Behavior Indicators</i>	
1.1	Different SA cognitive behaviors are displayed in teams in regards to high versus low team performance.
1.2	Different TMS cognitive behaviors are displayed in teams in regards to high versus low team performance.
1.3	Different speech act behaviors are displayed in teams in regards to high versus low performance.
1.4	Different reflexivity behaviors are displayed in teams in regards to high versus low performance.
<i>Cultural Awareness and Diversity</i>	
2.1	There will be a significant awareness by team members of their homogeneous or heterogeneous team composition.
2.2	Team members that are culturally aware show higher team performance.
2.3	Significant differences in contribution of English native speakers and non-native speakers in virtual teams exist across time.
2.4	Higher amount of cognitive behaviors are leveraged from team communication in virtual low diversity teams compared to when team diversity is high.
2.5	Patterns of speech act behaviors in virtual high diversity teams differ from teams low in diversity.
2.6	Diverse teams show a significant higher amount of cognitive behavior of confusion and misunderstanding.
2.7	Diverse teams engaging in the team reflexivity intervention will show more reflexivity during the intervention.
<i>Theoretical Model</i>	
3.1	Team reflexivity intervention positively increases overall communication volume
3.2	Team reflexivity intervention positively influences reflexivity communication regarding review, strategy development and strategy implementation.
3.3	Team reflexivity intervention positively influences cognitive behaviors SA and TMS
3.4	Team reflexivity intervention decreases diversity in teams
3.5	Team reflexivity intervention positively increases performance
3.6	Reflexivity exerts a positive influence on overall communication volume
3.7	Reflexivity positively influences the exhibition of cognitive behavior SA and TMS
3.8	Reflexivity positively influences performance
3.9	SA and TMS cognitive behaviors positively influence performance
3.10	SA and TMS cognitive behaviors mediate the influence of team reflexivity intervention on team performance.
3.11	Higher communication volume will negatively impact performance
3.12	Communication increases the exhibition of SA and TMS cognitive behaviors.
3.13	Communication mediates the relationship between reflexivity and the cognitive behaviors SA and TMS
3.14	Diversity negatively influences communication volume

Number	Hypothesis
3.15	Diversity negatively influences performance
<i>Effect of Team Reflexivity on Performance and Behavior Indicators</i>	
4.1	Team reflexivity intervention will improve team performance
4.2	Teams engaging in the team reflexivity intervention will show more reflexivity in communication during the intervention.
4.3	Teams engaging in the team reflexivity intervention will show more cognitive behaviors in reflexivity phases during the intervention.
<i>Reflexivity and Cognitive Behaviors Over Time</i>	
5.1	Proportion of communication shifts between reflexivity phases differed across times.
5.2	Communication shifts between topics across collaboration over quartiles differs for teams who received the reflexivity intervention compared to those who did not
5.3	Communication progression of topics regarding reflexivity differs between high and low performing teams over time.
5.4	Volume of reflexivity in communication will differ across time for teams engaging in team reflexivity.
5.5	Volume of SA and TMS cognitive behaviors in communication will differ across time for teams engaging in team reflexivity.

3.4 Methods

The data supporting this dissertation represents one point in time. The method section, describes the study participants, followed by a discussion of the team structure. The section also describes the tasks employed and instruments used to measure the variables of interest as well as the procedures devised for the recruitment of the sample and data-collection. Lastly, it discusses the coding scheme and preparation of data for statistical analysis.

3.4.1 Sample

The sample consisted of university students and employees (N = 304) who were randomly assigned to four member teams. Of the 62 intact teams (N = 248), the mean age of participants was 22.2 years ($SD = 5.7$), and women comprised 56% of the sample. Team composition was to 82% ethnically diverse and participants self-identified as 68.5% Caucasian. English was the native language 90% of the team members. Students participated to earn additional credit in their psychology class. Three of the initial 76 teams dropped from the exercise due to network problems that led to loss of data. Inspection of the communication log revealed that 11 teams neither followed instructions, nor discussed the provided exercise questions. The data they submitted were about unrelated topics; therefore, these eleven 11 teams did not provide an input and the data had to be excluded. The analysis includes data submitted by 62 intact teams (248 team members) in the analyses.

3.4.2 Materials and Apparatus

This section outlines the materials and the apparatus of the simulation environment used to study cognitive behaviors in virtual team communication.

3.4.2.1 NetOpFeuer 2.0 Simulation

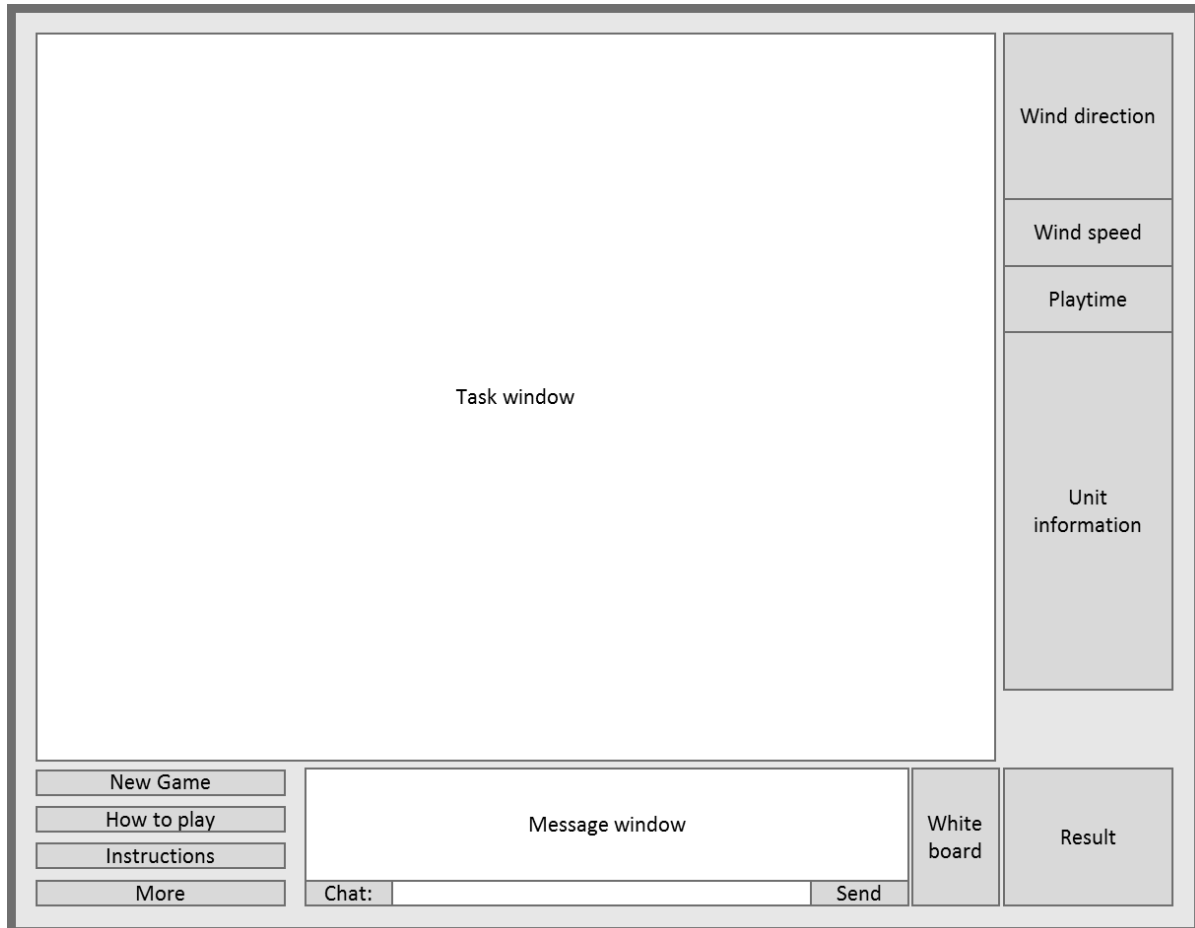
The *NetOpFeuer 2.0*⁴ was the computer simulation for this investigation. *NetOpFeuer 2.0* (Network Operation Fire) is a computer simulated, team-based fire-rescue simulation (see Figure 6 for a screenshot of the simulation). *NetOpFeuer 2.0* specifically designed as a microworld for both empirical studies and training to develop skills in the area of network-centric command and control operations. Therefore, the intended design of the simulation was optimal for research involving complex and dynamic environments, transactive memory system, and situation awareness development. The simulation challenged team members to collectively complete tasks through role interdependency, different team member resources, and lack of, or partial information availability, to individual team members. The simulation also confronted team members with complex, but unusual, and uncertain situations. DiFonzo and colleagues (1998) stated that microworlds like *NetOpFeuer 2.0* provide high levels of experimental control and offer experimental realism. The *NetOpFeuer 2.0* microworld puts a team of people in charge of an emergency response unit during a major fire event in a populated area. The fire model in the simulation generates forest and building fires that have characteristics of complex adaptive systems (i.e., self-organization and non-linear growth). The situation evolves over time as a function of human interaction.

NetOpFeuer 2.0 had two initial explicit goals for the team members, to save as many buildings and as much forest from fire as possible. The evaluation of these two variables automatically measured and appeared in the status column to the right of the simulation window, after the simulation was over. Besides these two simulation goals, there were a number of other intrinsic goals that team members accomplished: a) finding water towers, observing water levels, setting priorities in fighting fire, and making team agreements b) exchanging specific information about a fire unit's characteristics such as water supply, speed, fuel consumption, but also setting priorities, notice team members positions and make agreements. The fire extinguishing forces were specific to each unit. Virtual teams in complex dynamic systems continuously engage in processes of knowledge acquisition and knowledge application. Thus, team members had to share information through the chat

⁴ NetOpFeuer 2.0 Simulation was developed by IABG in cooperation with the Chair of Cognitive Systems at the University of Bamberg.

system in order for team members to understand the entire team situation. See Appendix A for more information on installing and starting the NetOpFeuer 2.0 Simulation.

Figure 6. NetOpFeuer 2.0 Interface.



3.4.2.2 Scenarios

The stimuli consisted of three simulation-based scenarios that were equal in complexity and difficulty. The simulation used all three scenarios to generate dynamic situations that included changing conditions, time constraints, and incomplete solutions that create a need for team coordination and communication. The first scenario was a training scenario of 10 min that familiarized the teams with their task and the microworld simulation. The training scenario consisted of the lowest difficulty level of the scenarios. Both main scenarios (i.e., task 1 and task 2) were data sources for both research conditions and congruency in complexity and difficulty (Berggren, Alfredson, Andersson, & Granlund, 2004). To create a new simulation environment for the second main scenario the simulation map had been turned 180 degrees. Congruent complexity and difficulty of scenarios were important to allow for observation of the effect of team reflexivity on cognitive behaviors,

and team performance. In addition, it excluded the possibility that the performance results represented only the difficulty level or complexity of the final scenario. The potential for an effect of experience/ learning was determined in the control condition. The two main scenarios lasted 15 min each.

3.4.3 Team Structure

Prior to experimental research, responsibilities are often allocated to the task. Yet, the dynamic and uncertain nature of team environments requires flexibility in sharing responsibility to ensure mission success. The contingency theory suggest, that there is not one superior team structure for all positively tasks or conditions and instead that teams have to adapt its structure to meet the imposed complexity of their task environment (Pennings, 1992; Alberts & Nissen, 2009). For the reason that most virtual team members are experts drawn from different organizations or coalition partners, conceptualized of a fluid membership per assignment, with a short life-cycle, cultural diverse team members with the situation at hand leaving them no time to prepare (Alge et al., 2003; Jarvenpaa & Leidner, 1999; Kirkman et al., 2004); virtual teams examined were exposed to the same condition as actual virtual teams (N = 248). While individual role tasks⁵ and mission goals were predefined, the team structure was not defined, challenging teams during early team stage by external and internal team factors (Majchrzak et al., 2007). No leader was determined prior to experimental phase.

3.4.4 Team Task

The task employed for the virtual team activity in this research represents complex socio-technical systems common in today's environment. The team task was a virtual fire-rescue task that involved team coordination and collaboration to extinguish emerging fires. Selection of each of the team members to one of cross-functional roles was a random assignment. The teams' task was to coordinate actions among team members and to collaborate to understand where fire emerges, to and reach the fire. During coordination, team members observed a terrain composed of villages and forests. Further, the team task entailed team members to protect villages and forests from fire and reduce fire eruptions as quickly as possible. This required continuous observation of the terrain, team members' information exchange, and integration of information concerning erupting fires. Team members exclusively exchanged information and discussed procedure and strategies via a chat system that allowed sending and receiving typed text messages. The resources that could be

⁵ Individual role tasks were randomly assigned to each team member. The team was not made aware of other team members assigned role tasks.

integrated in the simulation were units such as fire-engines and helicopters with different assigned unit capabilities (e.g., speed, limited water etc.). Each team member was provided with one fire rescue unit (i.e., a fire truck or helicopter). The task used for this study was comparable to the Berggren and colleagues (2004) task. This task design provided good data collection capabilities and had low resource demands, can be easily administered, and allowed manipulation of the complexity levels.

Given that team members worked on different computers connected via network, each team member was provided with instructions on how the task was to be completed. For example, teams were instructed that all team members were required to participate in the task; they were free to discuss the task with team members throughout the simulation via chat, what strategy teams implemented and how they went about completing the task was up to each team. Teams were expected to exhibit communication about cognitive behavior indicators as well as team activities. For instance communication about, how they would approach the task; strategies team members would employ to result in good team performance; coordination activities they would put in place to increase team activity; consensus or disagreement about ideas recommended to the team; and words of encouragement to support the team. Instructions were provided for all phases of the experiment.

3.4.5 Team Reflexivity Intervention

Teams were assigned to either a team reflexivity intervention, which instructed the team members to reflect on the fire-rescue task or a control condition. As structural outlines have been found to enable teams to effectively cope with complex virtual environments (i.e., information overload; Ellwart, Happ, Gurtner & Rack., 2015), teams received instructions that described in three steps on how to engage in reflection on the task (Gurtner et al., 2007). Step one suggested reviewing task performance: “How did you ask for unit information? How did you pass on information? How was the team organized?” Step two instructed participants to consider potential improvements in performing the task: “Are there alternatives to your chosen task performance procedures, and if so, what are they?” Step three asked participants to develop suggestions for task improvement for the future scenario. This form of reflexivity is also known as guided team reflexivity that induces reflection in teams through given instructions (Gurtner et al., 2007; Konradt et al., 2015; Schippers et al., 2014). The instructions did not suggest specific strategies for the task. The team members discussed the questions as a team via the chat. Teams in the control condition were asked to discuss via

chat “the conditions to professional success in the workplace.” This topic was unrelated to the fire-rescue task as implemented by Gurtner and colleagues (2007). The reflexivity and the control conditions were implemented before the second task, which was the midpoint of the two tasks performed. Based on research by Hackman and Wageman (2005), this was an optimal point in time to reflect on performance strategies. Teams were provided with 10 minutes for discussing.

3.5 Measures

This section describes the measures of interest that were used to collect data on virtual team demographics, performance, diversity, linguistics and reflexivity.

3.5.1 Demographics

Basic demographic questionnaire regarding information of age, sex, and ethnicity were collected. The demographic questionnaire was administered at the end of the experiment (see Appendix B).

3.5.2 Team Performance

The NetOpFeuer 2.0 System measured performance automatically by evaluating how many buildings and how much of the forest were saved from fire. Performance was indicated as a percent of the saved surface displayed in the status information column. Performance measures were taken at each task. To facilitate statistical computations, performance measure scores were standardized (i.e. z – score transformed for proportional data). Performance was represented as a latent variable of task 2, by controlling for performance of task 1 as a covariate for the evaluation of the theoretical model.

3.5.3 Diversity Measure

Teachman (1980) suggested that a research-computed-diversity is generally the same as an entropy-based index. The diversity category measures how group members are distributed across the native language diversity variable $H = -\sum (P_i \ln P_i)$, where P_i represents the proportion of the team members that possess the certain diversity characteristic. The index ranges from 0 to 1 with the higher score indicating a greater diversity distribution of the characteristics within the team. If, however, $H = 0$ the team characteristics are uniform and thus diversity is not existing; if the characteristic is evenly distributed within the team, then the value equals 1. The formula H is the sum of the product of the proportion of the diversity characteristic with its natural log of its proportion for a given diversity characteristic within the team. For instance, a team comprised of one non-native English speakers’ and three

native English speakers, the language diversity is .35 for the non-native English speaker ($H = -(1/4) \times \text{natural log}(1/4)$) and .21 for the native English speakers ($H = -(3/4) \times \text{natural log}(3/4)$). Primary language diversity scores for Team 1 results in 0.56. The diversity values of 62 teams were computed in Excel by using the entropy index (e.g., Harrison and Klein, 2007, Schippers et al., 2003; Teachman, 1980) and transferred into SPSS. For sample, for teams of this study, overall language diversity ranged from 0.00 to 0.91 ($M = .17$, $SD = .29$). To represent ethnical and language diversity two dummy variables (ethnic diverse 0 = no, 1 = yes; language diverse 0 = no, 1 = yes) were created for assessing the theoretical model. The dummy variables were employed to control for any additional effects of diversity while testing different hypotheses (Lowry and Gaskin, 2014).

3.5.4 Cultural Awareness Measure

Cultural awareness was measured using a two item questionnaire. The items are: “Where you aware that one or more of your virtual team members’ were from a different ethnicity than you?” “Where you aware that one or more of your virtual team members’ primary language was not English?”(yes, no). Correctness of cultural awareness was attained by comparing subjective answers of team members’ to answers provided in the demographic questionnaire (e.g., items include “What is your ethnic heritage” and “What is your native language”). Correct answers were indicated as 1 for diversity present, 2 for diversity not present, and incorrect answers were indicated as 0. Proportions of cultural awareness were calculated at the team level. The cultural awareness items were administered at the end of the experiment.

3.5.5 Linguistic Measure

This measure provides communicative information about defined indicators in the primary data. The identification of the indicator properties may be combined to identify word segments as an utterance. Indicator volume regarding cognitive behavior and reflexivity were estimated by the number of tagged utterances (i.e., chat messages) team members exchanged (Yoo & Kanawattanachai, 2001). The depth of communication of an indicator was examined by the number of words tagged in the utterance (i.e., words written; e.g., Anseel, Lievens, & Schollaert, 2009; Konradt et al., 2015).

3.5.6 Manipulation Check

Before testing the research questions and hypotheses, a manipulation check was performed to ensure that treatment was successful. Participants completed a four item

reflexivity scale (Schippers et al., 2013). The four items were adjusted from Schippers, Den Hartog, and Koopman (2007) to fit the context of the task already performed. Sample items are: “The team reviewed its objective” and “the method used by the team to get the job done was discussed” (1 = strongly disagree; 5 = strongly agree), $\alpha = .73$ (Schippers et al., 2013). Schippers and colleagues (2007) found good discriminant validity for reflexivity as a measure of the construct. The reflexivity scale served as an indicator for whether teams have actually reflected upon their task performance and developed an alternative performance procedure for the final task (Appendix B reflexivity scale items).

3.6 Questionnaire Administration

Questionnaires were completed by participants on the computer using Survey Monkey after Scenario 2 took place. The questionnaire set included the Reflexivity scale, Cultural Awareness items and Demographics (see Appendix B). For direct access, the questionnaire links showed on participants’ computer taskbar that by mouse click opened to the assigned set of questionnaire. Participant responses to questionnaires were collected directly via Survey Monkey to allow high accuracy and efficiency in the data-collection procedures (DiFonzo, Hantula, & Bordia, 1998).

3.7 Procedure

On arrival, participants were seated in front of a personal computer with a range of 4-20 participants per session and a Median of 16 participants per session. After informed consent was obtained, participants received their participant number, were randomly assigned to a virtual team and to one of the guided reflexivity conditions. The general procedure was explained and the standardized training procedure began. After the 20 min training that included the 10 min practice task, teams began task 1 lasting 15 min. Immediately after completing task 1, participants “chatted” during a 10 min discussion phase. Directly after, teams started their task 2 for 15 min. Upon completion, participants filled out a questionnaire set. Neither performance goals nor performance rewards were given to individuals or to the teams. Participants were then debriefed, assigned activity points for their classes, and dismissed. The entire session lasted approximately 120 minutes. Data on the behavior of team members during the scenarios were collected through a computerized protocol that recorded all actions and communication exchange.

3.8 Preparation of Data Analyses

This section outlines how the collected data was prepared for hypothesis testing and further analysis.

3.8.1 Software for Data Analyses

Data Analyses is performed with SPSS software (version 11.0 for Windows; SPSS Inc., Chicago, IL). The theoretical model is tested with SmartPLS 3 (Ringle, Wende, & Becker, 2015).

3.8.2 Data Cleaning

All data were checked for logical inconsistencies with no inconsistencies identified. There were no missing values and no missing average self-rated reflexivity scores.

3.8.3 Data Distribution

The distributional shape of all variables was examined to determine the extent to which the assumption of normality was met. The Shapiro-Wilk's test ($p > .05$) (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of the histograms, normal Q-Q plots and box plots were used to assess distribution at both the individual and team level. While performance scores indicated to be distributed normally, variables regarding communication, cognitive behavior, and reflexivity indicators had a positive skewed distribution and thus did not meet the assumption of normality.

3.8.4 Reliability Statistics

Prior to analyses, Cronbach's alpha was calculated for the reflexivity scale to verify that the internal consistency of the scale was adequate for the obtained sample. The internal reliability for the reflexivity scale $\alpha = .87$ was found to be acceptable.

3.8.5 Aggregation of Data

To justify aggregation of reflexivity variables from individual team members to the team level, Interrater Agreement Index (r_{WG}) and Interrater Correlation Coefficient (ICC) values were computed (Bliese, 2000). For the reflexivity measure, $r_{WG(j)}$ was .84 suggesting that the team-level analysis is appropriate. The ICC(1) values were above the threshold of .17 and ICC(k) values ranged from .46 to .65 indicating that mean ratings reliably distinguish the teams. Thus, given the pattern of $r_{WG(j)}$ along with the sizeable ICC values, aggregation to the team level is realistic (Bliese, 200; Brown and Hauenstein, 2005).

3.8.6 Manipulation Check

The effectiveness of the manipulation check for the reflexivity manipulation was evaluated by performing an independent sample t-test. Team members in the guided

reflexivity condition had significantly higher reflexivity scores ($M = 4.29, SD = .38$) than team members in the control condition ($M = 3.89, SD = .55$), $t(60) = 3.31, p = .002, d = 0.84$, resulting in evidence of an effective manipulation.

3.11 Summary

Chapter Three (3) has provided an overview of the methodology adopted to achieve the research aims. First, it discusses the purpose and value of the research guiding the research methodology. In this dissertation, the use of quantitative methodology, with the research questions of interest guiding the research design proved to be most appropriate. In addition, explanation of the research design fully supports the research hypotheses. Further, this Chapter provided an outline of the procedure used for data collection. The procedure discusses the collection of the dissertation data for this research and describes the approaches adopted to prepare the data for analyses. The next Chapter focuses on the requirements for the discourse analysis and presents the approach to the data analysis. Specifically, it describes development of the coding scheme, together with the discourse analysis process that leads to the identification and assessment of cognitive behavior indicators and reflexivity.

4 Requirements of a Communication-Based Measurement Model

In Chapter Four (4) requirements for a communication-based measurement model are presented. While this measurement model bases its description on team cognition and the cognitive behaviors in team communication, the underlying requirements were the basis for creating a coding scheme to analyze cognitive behaviors and reflexivity in communication.

4.1 Deriving Cognitive Behaviors from Computer-Mediated Environments

The explanation of how information is communicated via computer-mediated communication in complex socio-technical systems and the potential for that information to lead to team cognition creates the core of this dissertation. Team members use computer-mediated communications during operation to communicate timely, useful information. During these operations team members also seek information from multiple sources in an attempt to make optimal decisions within given time constraints (Palen, Vieweg, Liu, & Hughes, 2009; Vieweg et al., 2010). The first objective is to identify what messages contribute to team cognition, specifically to SA and TMS, and what specific cognitive behavior indicators they contain. This leads to the second objective, which is to identify how to communicate cognitive information at a linguistic level. This process generates the foundation for tools that can automatically extract pertinent, valuable information. Such automated tools need to be trained to correctly “understand” human language which involves the identification of the words team members use to communicate in computer-mediated communication.

In natural language understanding, data coding is an integral component of identifying words. Methods for data coding and language understanding incorporate named entity recognition (Bikel, Schwartz, & Weischedel, 1999), semantic role labeling (Hovy, Marcus, Palmer, Ramshaw, & Weischedel, 2006; Hwang, Bahtia, Bonial, Mansouri, Vaidya, Xue, & Palmer, 2010) or syntactic parsing (Gabbard, Markus, & Kulick, 2006), which employ a supervised machine learning approach that relies on annotated corpora. For a machine to successfully locate utterances in computer-mediated communication that contain information about team cognition, it needs to be trained to identify computer-mediated communication text that is most like to present such information (e.g., Palmer, Glidea, & Xue, 2010). This process will require identifying behaviors of information team members communicate (cf. Verma et al., 2011); for example, of information about the social, built, and physical mission environment or more specifically, information about team members’ positions related to other

team members and their coordinated effort. Computer-mediated communication are annotated with various categories with further analyses revealing how information leading to team cognition and specifically how SA and TMS cognitive behavior are constructed linguistically. In the research presented here, this further analysis involves an examination of the speech act, as well as verb and verb tense used to convey team cognitive information. Particular given that in the English language, the verb is generally the central element in a sentence which organizes all other elements (Manning & Schütze, 1999), and which conveys the meaning of the events taking place (Palmer et al., 2010).

While existing measures of SA and TMS provide a theoretical ground for developing measures of cognitive behaviors, in which cognitive behavior indicators may group and form into classifications to enable an automated driven analysis; a model can determine how the cognitive behavior indicators from participant's messages are derived. The various reviewed measurements of team cognition present different approaches taken (i.e., phenomenological, causal or actionable) to measure cognitive processes (e.g., Cook et al., 2005; Dwyer et al., 1997; Johnston et al., 1997; McNeese & Reddy, 2000; McMillan et al., 2004; Orasanu, 1990; Serfaty, Entin, & Johnston, 1998; Smith-Jentsch et al., 1998; Walker, 2005). Fundamentally, cognitive behavior indicators are construct factors used for measurement. In a first step, Figure 7 depicts the formalization of the description of these cognitive behavior indicators and factors.

All relevant aspects of the models dimensions such as cognitive processes, behavioral indicators, and data coding are displayed. Data coding of message utterances, specifically of verbs, the cognitive behavior indicators are classified and are the lowest level of analysis. Thereon, an attribution of the cognitive behavior indicators means that one of the cognitive behavior indicators results because of data coding. These behavior indicators then identify the corresponding cognitive process. To understand the pattern of cognitive behaviors in team communication, speech acts (e.g., request, announcement, question, reply, confirmation, read-back) are identified by means of data coding of communication patterns and utterances (Parush et al., 2011). The behavior indicators map out according to the occurring speech act as seen in the following example:

Team Member 1: *“Is there any fire?”*

Speech-act: Questions; Cognitive behavior indicator: Perception.

The objective of such a sound data coding process is to identify communications that reflect cognitive behavior indicators of developing and maintaining cognitive behavior in communication.

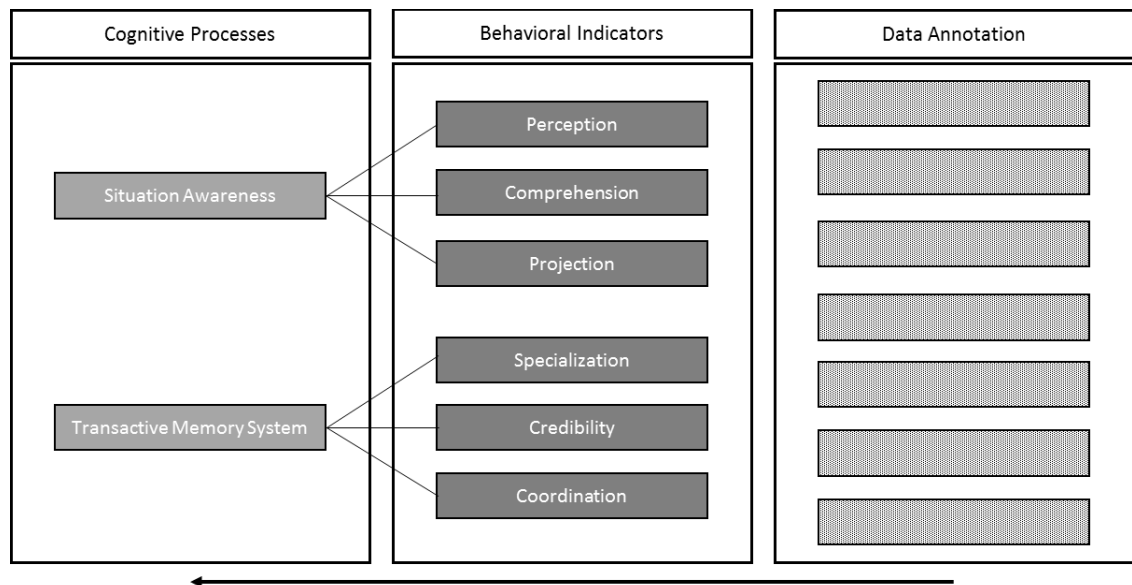


Figure 7. Data Coding Process Model.

This model is capable of examining team communication to assess the degree of SA cognitive behavior to which team members are sharing perceived data (level 1), interpreting data to understand the current situation (level 2), and project what will happen in the near future (level 3; Endsley, 1998). In addition, TMS cognitive behavior indicators will also examine the areas of specialization expertise, credibility of others’ knowledge, and coordination of procedures using this model. An ongoing assessment will provide a running indicator of SA/ TMS cognitive behaviors that could, if not addressed, lead to reduction of team effectiveness or failure. Each occurring event in complex socio-technical systems is unique; however, regularities exist as to how events transpire. Previous experience with these types of situations (e.g., when a wildfire ignites) provides team with background knowledge necessary to predict future states as the event unfolds. Correspondingly, by uncovering, understanding, and describing regularities of cognitive behavior indicators in team communication, automatic methods can locate vital information that we can expect team members to communicate, in complex event driven situations. By creating background

measurement techniques that can collect data from team members' communications in the background, cognitive process measurement can be more easily included in a wide variety of system development and exercises. It can significantly extend the ability to detect shortfalls in cognitive processes during early team development phases, or prior to significant problems occurring in the field. For analysts and trainers to gain knowledge about cognitive behavior, transmitted via computer-mediated communication, automated text analysis must be able to identify these pertinent cognitive behavior indicators. A fundamental step in this process is the creation of classifiers to locate cognitive behavior indicators, often described by particular verbs (Verma et al., 2011; Vieweg et al., 2010).

4.2 Requirements for the Measurement Model

The above sections discussed the need and design for a model to collect measurement of behavioral cognitive communications, which derive from the behavior indicators spawned by the data coding. To derive a measure of indicators that represents data coding of team communications several factors must be considered:

1. Descriptive requirements for the information to be extracted
2. Development requirements for the structure of data and analysis
3. Measurement requirements for the expected knowledge gain through the analysis

4.2.1 Example of SA and TMS Requirements of Information to be Extracted

Cognitive behavior indicators are derived from data through coding from team members' utterances. Therefore, the requirement analysis for both SA and TMS cognitive behavior revealed additional indicators relevant for gaining and maintaining SA and TMS. The identified cognitive behavior indicators were not part of the prior construct based measures. The analysis was the product of an extensive research literature of SA and TMS models review and prior measurement methods. A summary of all cognitive behavior indicators is provided in Table 10.

Table 10. Requirements for Extracting Information from Virtual Communication.

Indicators	Requirements
Specification to SA	
Perception	The perception of current situations and states of objects, events, people, systems, environmental factors
Comprehension	Relationships and locations of / and between objects, events, people and places to provide an understanding of the situation
Projection	The possibility of likely occurring future events
Action	Actions that are taken in relation to objects, events, people, systems, environmental factors
Specification to TMS	
Specialization	The qualification of a team member to complete a task (e.g., status, mode and condition of expertise)
Coordination	Interaction by team members to coordinate and prioritize the team tasks for action
Confusion	Any misunderstanding or confusion in regards to the task and team (e.g., roles, current situation)
Credibility	Team members accepting procedural suggestions and cross checking information (e.g., confirming, question assumptions)
Feedback	Feedback regarding task accomplishment

4.2.2 Requirements for the Structure of Data and Analysis

Messages need to be available in a certain way to be useful for the continuous assessment process. These requirements are as follows:

1. *Qualitative communication data*: An essential requirement of the data is the provision for the various indicators and their variance in utterances such as through pragmatics (e.g., inference), individual (e.g., cultural diversity, background knowledge etc.) and situation factors (e.g., improvising for lost social cues - emoticons). Thus, the automated text analysis and data coding processes must take into account these variances regarding the possibility of influencing factors. An appropriate approach in the identification of communications variances is mandatory for the identification process of indicators.
2. *Quantitative information of communication data*: The need for probabilistic analysis of indicators in communication, is an additional requirement to the qualitative statements on indicators in team communications.
3. *Level of analysis*: This is the analysis through which indicators need to be functional at the level of team utterances and language sequences. A different level of analysis will provide further language decompositions to leverage verbs from team utterances in order to screen for key words that relate to the indicators.

4. *Method for assessing indicators in communication*: The method must be able to figure out similarities in utterances to stimulate appropriate statistical analysis. The similarities need to reference the key parameters in each of the indicators and/or according to speech acts. The assumption is that each derived indicator from utterances must display variability due to complexity of socio-technical systems. Therefore, to reproduce the actual state in complex events, there must be a highly flexible analysis.

4.2.3 Requirements for the Expected Knowledge Gain through the Analysis

The requirements summarized in the previous section point out the importance of the validation of indicators in team communication data.

1. Establishment of requirements for realistic illustration of the cognitive indicator's complexity and the linguistics variability: Prior to extraction of realistic linguistic indicators, mapping pragmatics is necessary for identifying classes of indicators in regards to variance of individual and/or situation conditions. Further, conclusions about the linguistic variability of the indicators need clear definitions for classifiers to automatically categorize and label indicators. This also includes conclusions developed using speech acts and verbs.
2. Data coding of indicators assess cognitive behaviors and/or reflexivity in communication: It is equally important in building a solid basis for knowledge expectancy. Newly developed theoretical approaches for measuring indicators include the requirement to measure or capture previously unrecognized indicators. This establishes the need to research and define overall levels in communications, and then determine their relationship to team performance. Because of the potential influence of data coding, in form of team reflexivity or cultural diversity on indicators, it may be possible to summarize qualitative conclusions based on the analysis. Furthermore, the conclusions must identify the magnitude of the influence on reflexivity and/or cultural diversity, and how both cognitive behavior and reflexivity in communications relate to overall team performance.

4.3 Coding Scheme

Based on the requirements for analysis, a clearly defined coding scheme was developed, which describes all cognitive behavior indicators of interest and projects conditions under which language, or speech, occur. The requirement analysis determined the level of development using prior language knowledge to review, relative to existing models of SA and TMS. Once, researchers finished identifying and evaluating all the cognitive behavior, the coding scheme was complete.

Based on the requirement analysis, the coding scheme identified and annotated SA and TMS cognitive behaviors in team communications. When SA and TMS cognitive behaviors in communications were present, data was collected and speech act behaviors displayed by team members reviewed. The coding scheme, thus, forms clear separation of the indicator content to provide linguistic information of the annotation for the development of the classification system.

4.3.1 Task Related Communication Scheme

A coding scheme for task-related communication and non-task related communications assessed cognitive behavior indicators specific to the task (Table 11 presents the coding scheme). Non-task related communications referred to communications not related to the task that could contain aspects or relate to cognitive behaviors discrete to the team mission. For this analysis, the primary focus relied on task-related communication while task non-related communication was still part of the development of the cognitive behavior classification system.

4.3.2 SA Cognitive Behavior Scheme

Defined SA cognitive behavior indicators align with the measurement model by Richter and Lechners' (2011) of SA by applying Endsley's theoretical SA model (Endsley & Jones, 1997). Richter and Lechner (2011) distinguished between perceiving the environment (perception), comprehending relevant facts perceived (comprehension), exchanging relevant projections of future environmental states (projection), and exchanging information about behaviors (actions) to understand how and when team members become aware of their situational environment. For a team to use their resources, SA must be established for both situation factors in the environment as well as for changes in team factors. Viewing both SA applications as a higher level SA construct may thus allow teams to be resilient and adaptive to arising changes in complex socio-technical situations. The ability for the coding scheme to

concern SA regarding situation factors of the environment and team factors was therefore of great importance. The application of the developed SA cognitive behavior coding scheme consists of two separate constructs a) the scheme focuses on the Situation Awareness of task Environment (external, SAE) and b) focuses on the Situation Awareness of task in Teams (internal, SAT). The task is defined by the situation encountered during which virtual teams operate to complete mission goals. Refer to Table 13 for the coding scheme of SAE and Table 14 for the coding scheme of SAT.

4.3.3 TMS Cognitive Behavior Scheme

The defined TMS cognitive behavior indicators use the Transactive Memory System Scale by Lewis (2003) assessing communication about the team members' specialization, credibility, and coordination. Items of the Transactive Memory System Scale subcomponent (i.e., specialization, credibility, and coordination) were adapted (Lewis, 2003). Because credibility included items of confusion and feedback, the code set added two additional indicators for confusion and feedback. The application of the TMS cognitive behavior-coding scheme reveals behaviors responsible for developing a TMS within communication of specific virtual team environments. Refer to Table 15 for the coding scheme of TMS.

4.3.4 Speech Act Behavior Scheme

To identify and quantify SA and TMS cognitive behavior, the analysis focused on speech acts in which cognitive behaviors are shared among team members. Speech-acts, which are verbal communication behaviors, were defined as utterances that serve a function in virtual team communication (Parush et al., 2011; Parush et al., 2014). Based on Parish and colleagues (2011), these speech acts served various functions enabling sharing SA and TMS cognitive behavior related information among team members. The speech act scheme was adopted and changed to fit the virtual team environment by adding *comment* as a category, see Table 19. Data coding identified speech acts as utterances and categorized the content related to cognitive behavior indicators.

4.4 General Coding Approach

The next step in the coding procedure involved determining SA and TMS cognitive behaviors, task or non-task related communications and speech acts in team members' communication activity. The communication data were coded applying the data coding method employed by two coders. This approach classified communication activity of team members according to pre-established categories. Communications were segmented into

utterances. Here, the sentential construction that referred to a distinct cognitive process. Each utterance was given a separate code. The central purpose via this method was to annotate the communication accordingly, mapping the utterances according to categories and examine the frequency of each requisite indicator.

4.4.1 Coder Training

The coders trained as a group on understanding the coding scheme, their definitions, and application on how to code communication using the data coding method. The coders practiced using the coding system during the pilot testing phase of data coding. During training, the two coders coded team communication data from two-three member teams not included in the present data set. Also, coders practiced individually by coding communication of an excluded four-member team. Coders discussed their respective coding with one another to calibrate frequency annotated for all categories. The team assigned two coders to do all team coding of communication utterances. Coders defined each utterance as the message sent by a particular team member. Following the training period, coders independently coded the communication data, subsequently reviewed their coding, calculated the percent agreement, and resolved any differences in data coding.

4.4.2 Coding Procedure

The communication data between team members were time-stamped chat logs. The resulting transcripts provide a realistic example of an inter-collaborative team response to a simulated emergency. Two coders then coded all messages that the system automatically logged to establish the reliability of the coding method. Coders also included chat message utterances in the coding scheme. Coders first categorized task communication for task-related and not-task related communication. If utterances were identified as not-task related, utterances were not coded further. If utterances were identified as task-related, the coding included identification and classification of speech act and cognitive behavior indicator in utterances. Coders had first to classify utterances according to the speech act scheme. Next, coders distinguished between two main cognitive behavior indicators SA and TMS with their cognitive behavior sub-codes. A single utterance could involve multiple, code-time classifications if the message utterance content contained these speech act or cognitive behavior aspects. Where multiple codes applied, a code identified each part of the utterance (Kennedy and McComb, 2014). One sub-code of cognitive or speech act behaviors was applied per utterance to have independence of codes between sub-codes. In cases in which two utterances referred to the same cognitive process (i.e., sub-codes), the coder had to

weight the content and assign the most applicable in that certain context to retain independence of observations. Figure 8 presents a flowchart of the process applied.

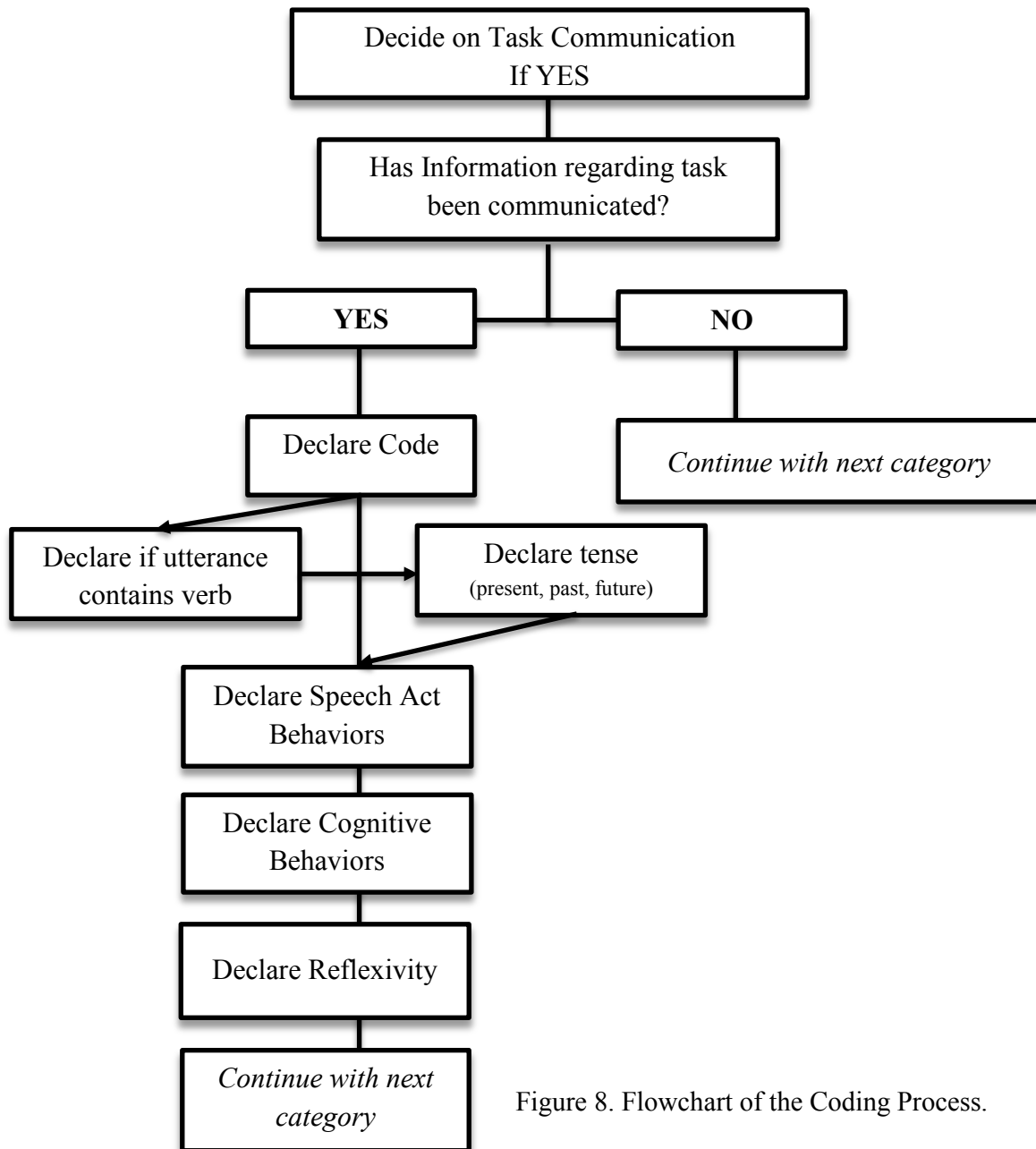


Figure 8. Flowchart of the Coding Process.

4.4.3 Interrater Reliability

After coder assigned codes, their agreement and overall reliability was calculated. To determine the overall agreement between the two coders, the qualitative categorical statistic Cohen's Kappa was used. Cohen's Kappa accounts for the fact that each coder may agree by chance and not strictly, because coders chose the same selection of codes. Therefore, Cohen's Kappa was chosen as the preferred statistic over Chi-square as kappa tests for agreement whereas Chi-square tests for association (Thomas & Hersen, 2003). Because Kappa has its limitation, Krippendorff's alpha (α ; 2004) was computed as it is referred to as standard reliability statistic for content analysis and similar data making efforts (Hayes & Krippendorff, 2007). Krippendorff's alpha counts category pairs coders assigned to utterances and lets coders be unaffected by their numbers. It bootstraps the distribution of a sample from the reliability data to avoid assuming approximations. The bootstrap sample of 10,000 was chosen to gain accurate inferential statistics. A bootstrap sample larger than 10,000 was found to add little additional precision to the data (Hayes & Krippendorff, 2007). After inter-rater reliability was computed and variations identified, both coders discussed differences and came to a complete agreement. This step was necessary for further analysis.

4.4.4 Pilot Testing

Before launching the full-scale content analysis with the newly developed coding scheme, test coding of a sample of the communication to be analyzed was conducted to reveal inconsistencies and inadequacies in the category construction. It also helped in establishing the reliability of the coding scheme. For the pilot testing percent agreement of the ratio between the number which was agreed upon (agree + disagree) of codes were computed (De Wevers, Schellens, Valcke, & Van Keer, 2005). Coders had 27.76% variation in their agreement for coding 2809 chat messages (i.e., training, scenario 1, discussion phase, and scenario 2). Coder 1 had 27.94% variation in agreement from coder 2 for 1121 chat messages of 10 teams; coder 3 had 32.95% variation in agreement from coder 1 for 926 chat messages of five teams; and coder 4 had 22.40% variation in agreement from coder 1 for 762 chat messages of five teams. After test coding was conducted, category construction of the coding scheme was refined to improve reliability.

4.5 Linguistic Analysis Focusing on Verbs

This phase of research focuses on building the foundation for computational linguistic methods that can predict whether computer-mediated communication contains team cognitive information. During this phase, messages that included information relevant to team cognition from all datasets were examined to determine how that information is linguistically constructed. This phase addresses the second research question. The specific linguistic aspect of computer-mediated communication that focused on how to identify which verbs team members use to express team cognitive behavior. In addition to identifying the verb construction, verb tense was analyzed and mapped in relation to the annotated classifications.

4.6 Tagging Verbs and Preposition, Verb Tense and other Characteristics

The focus of this phase of research lied on verbs, which communicate the events taking place and organize all elements of the sentence (Manning & Schütze, 1999). The goal of this phase of research is to identify verbs with high representation in messages that contain cognitive behavior indicators. To achieve this, VerbNet (Kipper-Schuler, 2006; Kipper, Dang, Schuler, & Palmer, 2000; Kipper, Dang, & Palmer, 2000), a lexical resource based on verb classes originally devised by Levin (1993), provides detailed semantic and syntactic information for English verbs. VerbNet includes 8,537 verbs distributed across 273 classes⁶ which have similar meaning, and which exhibit similarity in semantic and syntactic behavior. Therefore, each verb is grouped into verb classes that include the verb in context, and descriptions of semantic and syntactic attributes (Palmer, Hwang, Brown, Kipper-Schuler, & Lanffranchi, 2009), for example:

- A list of each verb in the class
- Semantic roles (e.g., describing conceptual relationship elements have with the verb or restrictions)
- Syntactic frames (e.g., behavior of sentence elements by providing a description of their ordering in a sentence such as noun phrase, verb, noun phrase, prepositional phrase instrument)

With VerbNet a set of verbs in the same class behave in much the same way and have similar underlying semantic components while appearing in a similar context (Vieweg, 2012). The VerbNet classes also provide a list of verbs that may not be present in any of the data examined, but might describe similar information in unseen data. In other words, if a

⁶ <http://verbs.colorado.edu/verb-index/index.php>

particular class is of relevance to a specific cognitive behavior indicator, and a verb in a class that identifies a previous unseen message, then, that message could predict or forecast the probability of cognitive behavior. See Appendix C for a more detailed description on the use of VerbNet. Using VerbNet verb classes in this research is to exhibit verbs from the same classes in team communications that are pertaining to cognitive behavior indicators.

For analytics to successfully process and understand cognitive behavior indicators in natural language text, events and event participants have to be detected (Palmer et al., 2009). The purpose of VerbNet for this research was to identify these verbs that convey particular event (e.g. past, present, and future) and event participants (Palmer et al., 2009). Particularly as the tense markers are representation of a product of knowledge about the objects and actions, to which the text refers (Carreiras et al., 1997). The temporal relationship of events enabled by verbal tense-markers, allow posting of parts that are also the most dominant points of comprehension. Thus, tense-markers demonstrate whether situation occur at, prior to, or after the communication. Therefore, besides looking at verbs falling into the same classes, of interest was also to analyze verb tense, as cognitive behavior might be elicited for past, present and future events.

There are some limitations in tagging verbs by VerbNet Guidelines⁷, which are for the identification of cognitive behavior indicators. During verb tagging, instances can occur in which the predicate is not a verb. Particularly the progressive *-ing* form of a verb often functions as a noun. In addition, the past participle form of a verb can appear similar to a predicate adjective. Under the following circumstances the verb is not a verb, and should not be tagged. The verb is a noun, if

- Followed by “be”
- “to” + bare form of a verb at the beginning of a sentence
- Preceded by a preposition
- Preceded by a determiner, such as the, a, an, that, those, this, or these
The verb is an adjective, if
- Occurring between a determiner (the, a, an, that, those, this, or these) and a noun
- Presence of verbs like seem, feel, become, look before the questionable predicate
- Presence of degree adverbs (quite, rather, very or less)
- Reduced relative clauses might let the predicate seem as past tense verb but may be a predicate adjective.

During the coding and determination phase of verbs, these guidelines were used to leverage the “real” verbs for further analysis.

⁷ Source http://verbs.colorado.edu/verb-index/VerbNet_Guidelines.pdf

4.9.2 Tagging Prepositions

Verb-preposition relation can help in predicting semantic content of a verb-frame (Kipper et al, 2004). According to Kipper and colleagues (2004), matching these relationships both entails matching of exact verb-frame where the encountered preposition is explicit and listed in the frame, as well as matches of verb frames with alternative prepositions. VerbNet includes a hierarchy of prepositions (Kipper et al., 2004), with 57 entries based on Jones and Boguraev (1987). Generally, membership is taken to range from 50-60 members as found in traditional English grammar (Warringer & Griffith, 1977; Pollock et al., 1961) to 248 as found in a corpora study by Fang (2000). VerbNet classes specifically include and explicitly label prepositions that certain arguments or sentential complements require (Kipper et al, 2004); e.g., preposition are denoted by curly brackets {}, with possible prepositions defined inside it. For example:

NP V NP PP.DESTINATION⁸

Example "The helicopter carried enough water to the City."

Syntax AGENT V THEME {TO TOWARDS} DESTINATION

The frame for carry-11.4 class allows for either Agent Verb Theme TO Destination or Agent Verb Theme TOWARDS Destination. Figure 9 shows a partial hierarchy of prepositions divided into path and locative prepositions (e.g., Kipper et al, 2004), with path prepositions further subdivided into source, direction, and destinations. In this research, preposition classes of team communication that are pertaining to cognitive behavior indicators are exhibited. For analytics to successfully process and understand cognitive behavior indicators in natural language text, spatial and temporal-relation preposition have to be identified. VerbNet allowed identifying these preposition in relation to the verb classes that served as the foundation for future research involving the development of classifiers that can detect if messages contain cognitive behavior indicators based on features providing identification of the verb and verb class. Refer to Figure 9 to receive an overview of the preposition partial hierarchy of the VerbNet.

⁸ NP = Noun Phrase, V = Verb, PP = Preposition, ADV = Adverb

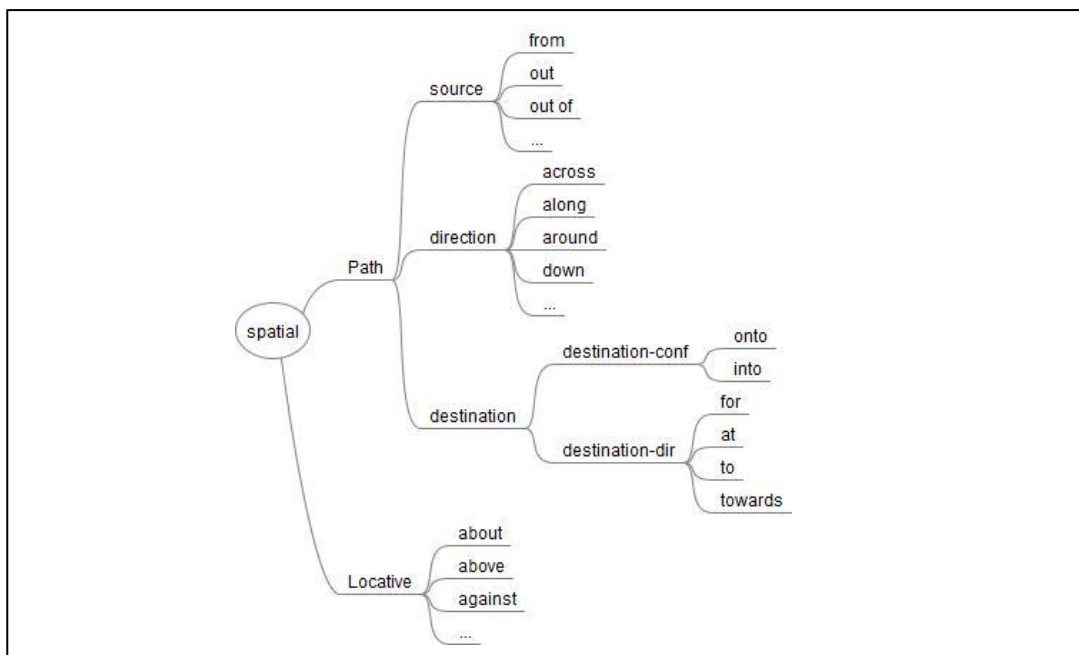


Figure 9. Preposition Partial Hierarchy of VerbNet (after Kipper, Snyder, & Palmer, 2004).

4.10 Summary

Chapter Four (4) focused on the requirements for the discourse analysis and presented approaches to the data analysis. Specifically, the development of the coding scheme together with the discourse analytical process that leads to the identification of cognitive behavior indicators and reflexivity was described. The next Chapter presents results on the identification of cognitive behavior and reflexivity indicators that team members communicate in highly complex socio-technical environments.

5 Development of a Classification System

The aim of the first part of research was to investigate the extent to which SA and TMS are linguistically represented in team communication. This Chapter describes the study findings as they relate to the research aims. The first phase of the research focused on identifying SA and TMS cognitive behaviors which addresses the first research question. To identify the specific types of cognitive behavior indicators⁹ that team members communicate in highly complex socio-technical environments, a content analysis was performed on messages to reveal their meaning. The second part of this section presents the results of the identification of reflexivity indicators in communication. A content analysis was performed on messages to reveal types of reflexivity indicators exhibited in the computer-mediated teams. A deductive content analysis was chosen that would enable retesting of existing data in a new context.

5.1 Cognitive and Speech Act Behaviors in Team Communication

The current phase of research focuses on identifying team cognitive behavior addresses the first research questions. This phase of research determined what cognitive and speech act behavior team members communicate and whether occurrences differ between one another. This was assessed in three separate coding steps. The initial step in the qualitative coding procedure was to annotate data by assigning a code to each utterance for every team. In the second step, the interrater reliability was calculated and presented. In the third step, results of identified task related communication, cognitive behavior indicators and speech acts are presented in form of team communication volume¹⁰. During all coding passes communication volume was estimated by classifying and counting the number of chat messages according to SA and TMS cognitive behavioral indicators and speech act behaviors.

⁹ The word indicator is used interchangeable with the word classifiers, expressing the same meaning. However, in the first phase of the development of the classifier system, it is to majority referred to as indicator.

¹⁰ Communication volume was estimated after annotates finished the qualitative coding process similar to the procedure done by Yoo & Kanawattanachai (2001).

5.1.1 Phase I: Determine if Communication is Task and Non-Task Related

The purpose of the first pass of qualitative coding for coders was to read every communication message of each team and determine if message utterances contained information related to the task. Coders read utterances, and determined if the utterance contained information relevant to the task based on their knowledge of the scenario and task event. Utterances that did not mention task events or task related information were considered non-task related and were therefore coded as off-task. Utterances might contain information relevant to the task, in which they were considered task-related communication and coded further in a next step for cognitive behavior indicators. The two mutually exclusive codes used during this pass of analysis are presented in Table 11.

Table 11. Coding Scheme of Non-/ Task- related Communication.

Non-/ Task- related Communication			
Coding	Definition	Examples	Data annotated code
Non-task related communication	Information not referring to the task in any sense	"Everyone here from their psychology class?"	0
Task-related communication	Any information pertaining to the task, procedure or coordination	1

5.1.2 Phase I: Coding Kappa Calculation Task or Non-Task Related Communication

After coders assigned the first pass codes, Cohen's κ and Krippendorff's α were computed to determine the agreement between the coders on whether communication was task or non-task related. There was almost perfect agreement between coders, $\kappa = .985$ (95% CI, .979 - .990), $p < .001$ and $\alpha = .985$ (95% CI, .942 - 1.0), $p < .001$ for coding 8844 utterances¹¹.

5.1.3 Phase I: Coding Results of Task or Non-Task related Communication

The results of the first pass coding for the dataset are shown in Table 12. This table compares the proportion of messages that were non-task and task-related communication. Of the entire dataset, 7498, or 84.8% contained information relevant to the task and were thus subject to further analysis. The dataset also included contextual streams, i.e., every message team members sent during the data collection period that was specific to the scenario events. Only communication related to the task (7498 utterances) were used for further analysis.

¹¹ An inter-rater agreement above .8 for Kappa (Manning, Raghavan, & Schütze, 2008) and for Krippendorff's α (Hayes & Krippendorff, 2007) is considered the norm for a good reliability test.

Table 12. Results of Non-/ Task- related Communication.

Non-/ Task- related Communication		
Category	Number of Utterances	Percentage of Dataset
Non-task related	1346	15.2%
Task related	7498	84.8%

5.1.4 Phase II: Determine if Communication contains SA and TMS Cognitive Behaviors

The purpose of the second coding pass of qualitative coding was to determine whether utterances contain SA and TMS cognitive behavior indicator. It also assessed whether differences of occurrences between cognitive behavior indicators were present. During this phase of data coding, coders read all messages within each team that contained task-related communication. For a better understanding of SA cognitive behavior indicators, reviewers divided situation awareness code categories into environmental and team situation awareness coding schemes. This allowed for making distinguishments between the awareness that centered solely on environmental factors versus team factors.

Table 13. Coding Scheme of Situation Awareness of the Environment (SAE).

Awareness Environment (SAE) Cognitive Behavior Indicators			
Coding	Definition	Examples	Data annotated code
Perception	Information about objects, events, people, system, environmental factors and their current state such as condition, modes, action. Only task related <u>no</u> information related to own team.	"The houses are burned"	3
Comprehension	Information about task related occurrences that help understand location and relations among events, places. This includes task related comprehension.	"Fire is breaking out in the top left corner"	4
Projection	Communication of possible future actions with regards to the task and <u>not</u> in relation to the team	"The fire will move the direction of the wind"	5
Action	Action of the team with regard to the task	"Everyone go where the fire is burning"	6

The coding schemes in this pass of analysis for identifying cognitive behavior indicators of situation awareness of the environment (SAE), situation awareness of the team (SAT) and transactive memory system (TMS) are presented in Table 13, 14, and 15 accordingly. Each coding scheme presents the annotated category (Coding), a definition of the category, an example utterance and the code used to classify the utterance. The results of

the coders agreement for the first pass codes using Cohen’s κ and Krippendorff’s α can be found in Appendix D.

Table 14. Coding Scheme of Situation Awareness of the Team (SAT).

Situation Awareness Team (SAT) Cognitive Behavior Indicators			
Coding	Definition	Examples	Data annotated code
Perception	Information about objects, events, people, system, team factors and their current state such as condition, modes, action. Task related to own team.	“My helicopter broke down”	3
Comprehension	Information about task related occurrences within the team that help other team members understand team relations among events, places. This includes task related comprehension to own team.	“Our helicopters seem to work better than our trucks”	4
Projection	Communication of possible future actions regards to the team	“Our trucks will have to split up”	5
Action	Action of the team with regard to own team	“Park your vehicle parallel to my helicopter”	6

Table 15. Coding Scheme of Transactive Memory System.

Transactive Memory System Cognitive Behavior Indicators			
Coding	Definition	Examples	Data annotated code
Specialization	Information regarding expertise and status, condition, mode of expertise	“I’m a helicopter”	7
Coordination	Information regarding coordinating task or prioritization of tasks	Who wants to take what? Divide in 4ths?”	8
Confusion	Information regarding confusion or misunderstandings	“I misunderstood you, I will take bottom left.”	9
Credibility	Information regarding accepting procedural suggestions, confirming, questions assumptions, cross checking information.	“So one helicopter and one fire engines pair up?” “Correct”	10
Feedback	Information regarding task accomplishment	“60% forest was saved”	11

5.1.5 Phase II: Coding Results of SA

The results of the second pass coding for the dataset SAE are shown in Table 16. To identify significant difference in occurrence of the cognitive behaviors across indicators, chi square analysis was performed to assess goodness of fit. A significant effect of difference of cognitive behavior occurrences in communication was found between indicators $\chi^2(3, N = 2501) = 959.2, p < .001$, with a large effect size ($\phi = 0.62$). Residual analysis revealed that the cognitive behavior indicators perception and comprehension accounted for this effect. Hence, SAE cognitive behavior indicators were comprised to majority of the indicator perception with 1012 utterances followed by comprehension with 954 utterances. SAE cognitive behavior indicators action and projection were present the least in communication.

Table 16. Number of Utterances, Means, Standard Deviations and Percent of SAE.

Situation Awareness Environment Cognitive Behavior Indicators			
Category	Number of Utterances	M(SD)	Percentage of Dataset
Perception	1012	16.3(10.9)	13.5%
Comprehension	954	15.4(13.0)	12.7%
Projection	60	1.0(1.4)	0.8%
Action	475	7.7(8.1)	6.3%

The results of the second pass coding for the dataset SAT are shown in Table 17.

A significant difference of SAT cognitive behavior occurrences in communication was found between indicators $\chi^2(3, N = 2478) = 863.9, p < .001$, with a large effect size ($\phi = .59$). Residual analysis revealed that the cognitive behavior indicators action and comprehension accounted for this effect. Thus, SAT cognitive behavior indicators were comprised to majority of the indicator action with 1095 utterances followed by the SAT indicator comprehension with 753 utterances. SAT cognitive behavior indicators perception and projection were present the least in communication. Although differences in volume of individual cognitive behaviors were found, cognitive behaviors of SAT were identified in team communication.

Table 17. Number of Utterances, Means, Standard Deviations and Percent of SAT.

Situation Awareness Team Cognitive Behavior Indicators			
Category	Number of Utterances	M(SD)	Percentage of Dataset
Perception	545	8.8(5.9)	7.3%
Comprehension	753	12.2(7.9)	10.0%
Projection	85	1.4(2.6)	1.1%
Action	1095	17.7(10.5)	14.6%

5.1.6 Phase II: Coding Results of TMS

The results of the second phase coding for the dataset of TMS are shown in Table 18. This table presents the proportion of messages that contained TMS cognitive behavior indicators. To identify significant differences in occurrences of the TMS cognitive behaviors across indicators, chi square goodness of fit test was conducted. A significant difference of TMS cognitive behavior occurrences in communication was found between indicators $\chi^2(4, N = 4075) = 2736.0, p < .001$, with a medium effect size ($\phi_c = .41$). Residual analysis revealed that the cognitive behavior indicators specialization and coordination accounted for this effect. Therefore, TMS cognitive behavior indicators were comprised to majority of the indicator specialization with 2004 utterances followed by the indicator coordination with 1039 utterances. TMS cognitive behavior indicators credibility, feedback and confusion were the least present.

Table 18. Number of Utterances, Means, Standard Deviations and Percent of TMS.

Transactive Memory System Cognitive Behavior Indicators			
Category	Number of Utterances	M(SD)	Percentage of Dataset
Specialization	2004	32.3(14.7)	26.7%
Coordination	1039	16.8(10.2)	13.86%
Confusion	118	1.9(3.2)	1.6%
Credibility	566	9.1(7.1)	7.5%
Feedback	348	5.6(3.7)	4.6%

5.1.7 Phase II: Key Findings: Cognitive Behaviors.

The purpose of the second phase of qualitative coding was to determine whether utterances contain SA and TMS cognitive behavior indicator and whether differences of occurrences between cognitive behavior indicators are present. The assessment results provided answers to stated research questions (i.e., research questions 1.1, 1.2, 1.3, 1.4). Overall, results demonstrate that proposed cognitive behaviors were located in team communication with differences of behavior indicators. Some cognitive behavior indicators were located to higher extent in team communication compared to others, concluding that those may play major factors in team processes.

Communication about SA demonstrated further a unique pattern of cognitive behaviors in regards to the environment or internal team factors. Results of team communication illustrates, whether team members are centered externally (i.e. in the environment) or internally (i.e., within the team) by displaying different sets of cognitive behaviors. For teams that communicated about external events, SAE cognitive behavior indicators perception and comprehension were represented. Here, team cognitive behaviors

were characterized in sharing information regarding objects, events, people, systems in the environment and their current state. While for teams that communicated about SA internal events, SAT cognitive behavior indicators action and comprehension were to majority represented in team communication. The cognitive behavior action was characterized through sharing information about action in the team. For both internal and external SA, comprehension played a major role for understanding events or team relationships in congruence to the task. Communication about TMS illustrated differences of cognitive behavior indicators with the primary indicator specialization and coordination. Here, the indicators were characterized by teams displaying behavior regarding their expertise or status as well as coordinating and prioritizing their tasks. Conclusively, the coding process revealed types of cognitive behaviors displayed in communication during team interaction. The overall cognitive behaviors reflect similarities within each category but also differences across indicators.

5.1.8 Phase II: Key Findings: Case Analysis of Cognitive Behaviors in High vs. Low Performing Teams

Case analysis was used to answer the hypotheses questions whether SA and TMS cognitive behaviors in team communication vary in regard to team performance (Hypotheses 1.1 and 1.2). For a detailed description of method, statistical procedure, results and key findings refer to Appendix E, Section 1.1.

Overall findings indicated team performance to vary by volume of cognitive behaviors. High and low performance teams varied to some extent in displaying cognitive behaviors but also showed similarities for all three cognitive behaviors (i.e., SAE, SAT and TMS). While high performance teams displayed cognitive behavior SAE projection and action, no difference in team performance was found for SAE perception and comprehension. This result indicates that high performing teams are more likely to verbalize higher SA levels by projecting environmental events into the near future (Endsley, 1995b). Results were different for SAT cognitive behaviors where high performance teams showed behavior of perception (e.g., being highly aware of their team states) more than low performance teams; cognitive behaviors of understanding teams relationships to their task (i.e., comprehension) and projecting team states into the near future were not observed differently. Instead, even though not significantly different, teams of low performance are more likely to center their cognitive behavior on projecting events of their team into the near future. Yet, both SAE and SAT cognitive behavior indicator action was displayed in higher performance teams,

indicating those teams to be more likely to verbalize action taking among their team members aiding overall SA and coordination.

Although, no significant difference between high versus low performance teams was found for TMS cognitive behavior specialization, confusion or feedback, high performance teams did show higher levels of cognitive behaviors of coordination and credibility. Hence, high performance teams seem to share information regarding task coordination and prioritization more extensively leading to coordinated team processes and better performance. Further, this coordination behavior is supported through cognitive behavior of credibility by accepting procedural suggestions, confirming or questioning assumptions as well as cross checking information resulting in higher levels of team uniformity to task completion and then team performance.

Overall, team performance varied by volume of cognitive behaviors. High performance teams displayed cognitive behaviors of SAE projection and action in regards to the environment, SAT perception and action in regards to the team and TMS coordination and credibility. Low performance teams seemed to focus more internally (i.e. regards to own team), such as projecting team events to the near future in contrast to projection how external events may unfold. Hence, low performance teams might not be as adaptable to external changing situations compared to high performance teams. Conclusively, the case analysis revealed types of cognitive behaviors displayed in high versus low performance teams, similarities of cognitive behaviors between teams and significant differences, supporting Hypothesis 1.1 and 1.2 partially.

5.1.9 Phase III: Determine if Communication contains Speech Act Behaviors

The purpose of the third coding pass of qualitative coding was to determine which speech act behaviors are trivial in the virtual team context, and whether cognitive behaviors display the same speech act behaviors. For the third phase of qualitative coding, coders read the same messages they coded in phase two, and assigned up to seven “speech act behaviors” identified in the utterances (see Table 19; Parush 2011). The results of the coders agreement for the first pass codes using Cohen’s κ and Krippendorff’s α can be found in Appendix D.

Table 19. Coding Scheme of Speech Act Behavior.

Speech Act Behavior			
Coding	Definition	Examples	Data annotated code
Request	Directing, instructing, or requesting someone to do or report something	“Help” “Send a helicopter to west village”	1
Announcement	Information on an action taken, condition, state, mode etc.	“West village is saved”	2
Question	Asking about an action, condition, state, mode etc.	“How many helicopters do we have?”	3
Reply	Providing information about an action, state, mode as a response to a question	“Is south-west area covered?” “Yes, I cover south-west area”	4
Comment	Comments on requests, announcements, questions, replies or about action, condition, state, mode etc.	“Dang” “That is not fair at all” “Sorry”	5
Confirmation	Assuring that a request was acted upon	“Can you cover the small towns?” “Yes”	6
Read-back	Repeat of a request, announcement, reply, or confirmation	“Move to left town now” “Move to left town”	7

5.1.10 Phase III: Coding Results Speech Act Behaviors

The results of the third phase coding for the dataset of speech act behaviors are displayed in Table 20. The table presents the proportion of speech act behaviors found in team communication. The dataset consisted of only four utterances regarding read-back. Because of the low number of utterances, read-back was excluded in further analysis as it seemed for this context of no relevance. To identify significant differences in occurrences of the other six speech act behaviors across speech act categories, a chi square analysis was performed to assess goodness of fit. A significant difference of speech act behaviors in communication was found between indicators $\chi^2(5, N = 7365) = 3182.2, p < .001$, with a small effect size ($\phi_c = .29$). Residual analysis revealed that the speech act behaviors announcement and reply accounted for this effect. Hence, majority of team members are making announcements to other team members with 2965 utterances, replying to other team members with 1279 utterances and asking questions with 1003 utterances. Speech act behaviors comment, request for information or confirming are less dominant in the dataset.

Table 20. Number of Utterances, Means, Standard Deviations and Percent of Speech Acts.

Speech Act Behavior Indicators			
Category	Number of Utterances	M(SD)	Percentage of Dataset
Request	726	11.7(8.1)	9.7%
Announcement	2965	47.8(25.5)	39.5%
Question	1003	16.2(7.7)	13.4%
Reply	1279	20.6(10.2)	17.1%
Comment	790	12.7(11.7)	10.5%
Confirmation	602	9.7(6.6)	8.0%
Read-back	4	0.0(0.4)	0.1%

5.1.11 Phase III: Cross-tabulating Cognitive Behaviors with Speech Act Behaviors

In order to develop an analytics of cognitive behaviors it was of importance to understand the linguistic construction of cognitive behavior indicators in communication. This section answers the research question 1.5 on which speech act behaviors are trivial and whether cognitive behaviors display the same speech act behaviors (research question, 1.6). In a first step, the cognitive behavior indicators were cross-tabulated with speech act behaviors. This allowed for an understanding of how cognitive behavior indicators occur in communication. It also provided valuable information for the foundational elements of text analytics. Count of total cognitive behavior utterances in relation to speech act behaviors varied to initial count which can be attributed to the coding process (i.e., assigning one or more than one code per utterance). To identify significant differences in occurrences of cognitive behaviors across speech act behaviors, chi square analysis was performed to assess goodness of fit.

5.1.11.1 Cross-tabulating SAE Cognitive Behavior with Speech Act Behaviors

None of the numerical data presented in the cross-tabulation section could undergo a statistical analysis. First, the sample size was small. Second, there was an inability to assign team members either randomly or by counter balancing to speech act behavior observations, which resulted in the same sample pool participating in some of the observations but not all. This violated the independence of observation assumptions critical for statistical analysis (see, Parush et al., 2014). Descriptive results indicate SAE cognitive behavior perception (utterances 637) and comprehension (utterances 694) to occur to majority during announcements see Table 21. Cognitive behavior perception was further displayed in questions and replies while comprehension was present in requests and replies. Further, descriptive results show SAE projection to be identified to majority in announcements

(utterances 36). SAE cognitive behavior indicator action was presented to majority in requests (utterances 248) and further in announcements.

Examples¹² of SAE Cognitive Behavior Indicators by Speech Act Behavior:

<i>Perception</i>	<i>Announcement</i>	<i>“Our forest is dead”</i>
	<i>Question</i>	<i>“What is that in the center?”</i>
	<i>Reply</i>	<i>“I have not looked over there”</i>
<i>Comprehension</i>	<i>Announcement</i>	<i>“Our weakest area seems to be by the northeast”</i>
	<i>Request</i>	<i>“If it looks like its heading for an already burnt out area just leave it.”</i>
	<i>Reply</i>	<i>“Not until these people in town are save Jim.”</i>
<i>Projection</i>	<i>Announcement</i>	<i>“It will catch the town on fire”</i>
<i>Action</i>	<i>Requests</i>	<i>“Bail on small ones protect big ones”</i>
	<i>Announcement</i>	<i>“Helicopters should handle forest fires and trucks should handle villages”</i>

Table 21. Results of Cognitive Behavior SAE by Speech Act Behaviors.

<i>Category</i>	Cognitive Behavior SAE by Speech Act Behavior					
	Request	Announcement	Question	Reply	Comment	Confirmation
	<i>M(SD)</i> <i>n</i>	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>n</i>	<i>M(SD)</i> <i>n</i>
Perception	0.6(0.8) 35	10.3(8.0) 637	2.8(2.3) 171	2.1(3.0) 131	0.6(1.0) 35	0.4(0.6) 24
Comprehension	1.8(2.5) 114	11.2(10.1) 694	0.9(1.1) 58	1.2(2.1) 77	0.2(0.5) 13	0.4(0.9) 25
Projection	0.2(0.4) 9	0.6(0.9) 36	0.1(0.2) 4	0.1(0.3) 5	0.0(0.2) 2	0.0(0.0) 0
Action	4.0(4.1) 248	2.2(3.5) 138	0.6(0.9) 38	0.6(1.2) 34	0.1(0.3) 7	0.2(0.7) 15

5.1.11.2 Cross-tabulating SAT Cognitive Behavior with Speech Act Behaviors

The cognitive behavior indicators of SAT displayed a similar pattern as SAE in the cross-tabulation with speech act behaviors, see Table 22. Descriptive results indicate that perception differs by speech act behaviors and to majority displayed announcement (utterances 246). SAT cognitive behavior comprehension was to majority displayed in announcements (utterances 400). Perception behaviors were further displayed in questions and replies while comprehension was present in replies and requests. Descriptive results show SAT projection (utterance 59) and action (utterance 409) to be identified to majority in announcements (utterances 59). Action behaviors were further displayed in request and replies. The results illustrate that both SAE and SAT cognitive behavior indicators display the

¹²The following utterance examples of all cognitive behaviors for speech act behaviors are based on communication that took place between team members. Some utterances were altered for the purpose of the example.

same speech act behaviors within team communication. This result aids in the development of computerized analytics.

Table 22. Results of Cognitive Behavior SAT by Speech Act Behaviors.

Category	Cognitive Behavior SAT by Speech Act Behavior					
	Request	Announcement	Question	Reply	Comment	Confirmation
	<i>M(SD)</i> <i>n</i>	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>n</i>	<i>M(SD)</i> <i>N</i>
Perception	0.3(0.6) 18	4.0(3.2) 247	2.7(2.4) 164	1.9(2.1) 118	0.2(0.5) 13	0.3(0.5) 16
Comprehension	2.1(2.5) 131	6.5(4.7) 400	1.5(1.6) 95	2.5(2.5) 152	0.1(0.3) 5	0.3(0.5) 17
Projection	0.1(0.3) 6	1.0(2.0) 59	0.1(0.3) 6	0.2(0.5) 10	0.0(0.0) 0	0.1(0.2) 3
Action	5.3(4.3) 331	6.6(4.8) 409	2.3(2.0) 144	3.3(3.6) 205	0.1(0.3) 5	0.5(0.8) 33

Examples of SAT Cognitive Behavior Indicators and Speech Act Behavior can be found on the next page:

<i>Perception</i>	<i>Announcement</i>	<i>“Someone has two vehicles”</i>
	<i>Question</i>	<i>“So we have 2 trucks and 2 birds?”</i>
	<i>Reply</i>	<i>“yeah I got it”</i>
<i>Comprehension</i>	<i>Announcement</i>	<i>“I get the top trees/villages”</i>
	<i>Request</i>	<i>“whoever is on the bottom half with me just communicate with me to tell me where you are going”</i>
	<i>Reply</i>	<i>“I don’t know. I just know that my helicopter does hardly anything for huge fires in the forest.”</i>
<i>Projection</i>	<i>Announcement</i>	<i>“I will take the helicopter”</i>
<i>Action</i>	<i>Announcement</i>	<i>“We can double up in area ...”</i>
	<i>Request</i>	<i>“Keep an eye out for anyone who may need help”</i>
	<i>Reply</i>	<i>“I can help”</i>

5.1.11.3 Cross-tabulating TMS Cognitive Behavior with Speech Act Behaviors

The cognitive behaviors of TMS were also cross-tabulated with speech act behaviors, see Table 23. Examination of potential differences of TMS cognitive behavior by speech act behavior category revealed that occurrence of TMS cognitive behavior specialization was primarily presented in announcement (utterances 1059). The cognitive behavior specialization was further apparent in replies and questions. Descriptive results also indicate TMS cognitive behavior coordination to majority be represented in requests (utterances 265). Moreover, coordination was also identified in announcements and questions. Descriptive

results demonstrate cognitive behavior TMS confusion (utterances 82) to be identified to majority in questions while TMS cognitive behavior credibility was primarily presented in confirmation (utterances 292). TMS cognitive behavior credibility was also found in replies. Descriptive results demonstrate TMS cognitive behavior feedback to be mainly identified in announcements (utterances 221). Thus, speech act behaviors contribute to the understanding of how cognitive behaviors are communicated by team members. Examples of TMS Cognitive Behavior Indicators and Speech Act Behavior:

<i>Specialization</i>	<i>Announcement</i>	<i>“I have a heli, I will cover the bottom right”</i>
	<i>Reply</i>	<i>“I think there are only 4 helicopters.</i>
	<i>Question</i>	<i>“How long is the heli water lasting?”</i>
<i>Coordination</i>	<i>Request</i>	<i>“Pay attention to your corners”</i>
	<i>Announcement</i>	<i>“Each get a primary section group up for the big ones”</i>
	<i>Question</i>	<i>“Are we going to assign regions?”</i>
<i>Confusion</i>	<i>Question</i>	<i>“ ... do you mean the trees or the houses?”</i>
<i>Credibility</i>	<i>Confirmations</i>	<i>“ I agree”</i>
	<i>Reply</i>	<i>“that might be a good idea but the trucks are slow”</i>
<i>Feedback</i>	<i>Announcement</i>	<i>“I think we’re doing a lot better this time around.”</i>

Table 23. Results of Cognitive Behavior TMS by Speech Act Behaviors.

Cognitive Behavior TMS by Speech Act Behavior						
	Request	Announcement	Question	Reply	Comment	Confirmation
<i>Category</i>	<i>M(SD) n</i>	<i>M(SD) N</i>	<i>M(SD) n</i>	<i>M(SD) N</i>	<i>M(SD) N</i>	<i>M(SD) n</i>
Specialization	1.7(2.0) 106	17.1(9.0) 1059	5.1(4.0) 313	7.8(4.7) 485	0.8(1.4) 48	1.3(1.5) 79
Coordination	6.9(5.7) 425	4.3(3.8) 265	4.0(2.7) 250	1.8(1.7) 109	0.2(0.6) 12	0.5(0.9) 33
Confusion	0.0(0.1) 1	0.4(1.1) 24	1.3(2.5) 82	0.1(0.4) 7	0.1(0.3) 4	0.1(0.2) 4
Credibility	0.1(0.3) 6	1.0(1.4) 65	0.2(0.6) 11	3.1(3.6) 190	0.3(0.7) 24	4.7(3.7) 292
Feedback	0.1(0.4) 8	3.6(2.7) 221	0.2(0.4) 12	0.9(1.5) 54	0.9(1.3) 53	0.3(0.6) 17

5.1.12 Phase III: Key Findings: Speech Act Behaviors and Cognitive Behaviors

The purpose of the third phase of qualitative coding was to determine which speech act behaviors are of importance in team communication and whether cognitive behavior indicators display the same speech act behaviors (research question 1.5, and 1.6). Overall, results show speech act behavior announcement, question and replies to be most relevant in team communication context of virtual teams. Both speech act behavior question and replies regard normal exchange of information between team members while announcement concerns proactive information sharing by providing information to other team members (see Parush et al., 2014). Cross-tabulation of cognitive behaviors and speech act behaviors was conducted to examine whether cognitive behaviors display the same speech act behaviors. Results indicated that the same speech act behavior announcement (i.e. announcing information regarding the environment to other team members) was primarily exhibited while displaying SAE cognitive behaviors of perception, comprehension and projection. On the other hand speech act behavior request (i.e. requesting information in regard to action in the environment) was observed in SAE cognitive behavior action.

The same patterns were found for SAT cognitive behaviors in which the speech act behaviors entailed information regarding the team. However, the speech act behavior announcement was also exhibited from the SAT cognitive behavior action in addition to the speech act behavior request. This finding indicates teams to announce action being taken by team members (i.e. internal) while for action occurring in the environment (i.e. external), team members may request others to take action. The behavior elicits coordination for directing or instructing to perform actions (Parush et al., 2014). SA cognitive behaviors speech act behaviors relates to active information sharing by providing information to other team members. Thus, during the action phase (i.e., SA action) speech act behavior of managing to direct for performing actions are exhibited.

Different patterns of speech act behaviors emerged for TMS cognitive behaviors. Speech act behavior announcement was observed in TMS cognitive behaviors specialization and feedback. Hence, team members primarily announced their expertise status or their feedback. On the other hand, speech act behavior request was elicited in TMS cognitive behavior coordination, as well as speech act behaviors announcement and question. These speech act behaviors suggest that the coordination behavior is a dynamic form of verbal interaction to exchanging information between team members, provide proactive information to other team members and direct others to perform actions (Parush et al., 2014). The speech

act behavior question, which relates to exchanging information between team members', was primarily observed in the cognitive behavior confusion. That is team members asked question if they were unsure or did not understand. Lastly, speech act behavior confirmation was exhibited in TMS cognitive behavior credibility regarding accepting procedural suggestions or confirming.

General, results of speech act behavior provide an understanding on which speech act behaviors seem most important in virtual team processes. Further, results indicated SA cognitive behaviors to display similar patterns of speech act behaviors, still major differences were found for TMS cognitive behaviors. These findings provide insight of cognitive behavior construction in team communication. The results contribute to the understanding of how cognitive behaviors occur in communication. For analytics to successfully locate communication that contain cognitive behavior indicators, it needs to be trained to identify text that is most likely to convey such information. In the next step, verbs used that convey cognitive behavior information are leveraged.

5.1.13 Phase III: Key Findings: Case Analysis of Speech Act Behaviors in High vs. Low Performing Teams

Case analysis was conducted to determine whether speech act behaviors differ in regard to team performance (Hypothesis 1.3). For the detailed description of statistical procedure, results and key findings refer to Appendix E, Section 1.2. Case analysis was conducted to determine whether speech act behaviors differ in regard to team performance. Results of high and low performance teams indicated no significant difference of speech act behaviors request, announcement, question, reply, comment and confirmation, rejecting hypothesis 1.3. Yet, even though the results were not significant different, high performance teams seem to exhibit speech act behavior confirmation more often in comparison to low performance teams. Moreover, high performance teams show more behavior of requesting information from other team members as opposed to low performance teams. Even though majority of speech act behaviors were not observed to be different in regard to team performance, the speech act behavior requests were present in high performance teams. Also high performance teams seem to exchange more information between team members and give directives or instructions to perform actions (Parush et al., 2014).

5.2 Linguistic Analysis Focusing on Verbs

This phase of research focuses on building the foundation for computational linguistic methods that can predict whether computer-mediated communication contains team cognitive

information. During this phase, messages that included information relevant to team cognition from all datasets were examined to determine how that information is linguistically constructed: this phase addresses the next research questions (1.7 and 1.8). The specific linguistic aspect in team communication which was focused on was to identify verbs, verb tense and preposition team members use to express team cognitive behavior. In addition to identifying the indicator construction, verbs and verb characteristics were analyzed and mapped in relation to the annotated classifications.

5.2.1 Coding Process of Verb and Verb Tense

This coding process determined which verb and verb tense in utterances are indicative of cognitive behavior indicators. As in the above section, the process needed three separate coding steps. The initial step was to annotate data displaying cognitive behaviors by leveraging verbs and verb tense. Here messages identified in the prior coding as containing information of SA and TMS cognitive behavioral indicators were used for this phase of analysis. In the second step, the interrater reliability was calculated and presented. In the third step, results of identified verbs together with its verb classes from VerbNet, preposition and verb tense are presented accordingly.

5.2.2 Phase IV: Determine Verb and Verb Tense

The purpose of the fourth phase of qualitative coding is for coders to select identified messages in prior coding that contained SA and TMS cognitive behavior indicators. For determining verbs, utterances were selected based on the following criteria: Messages included a verb, and the verb had to be meaning-bearing. Messages that included no verb, e.g., were not eligible for this phase of the research. Exceptions were made for light or copula verbs¹³, e.g., ‘I am in the line of fire’ (Vieweg, 2012). For such events, an additional verb class for copula verbs was created. While ‘am’ links the subject ‘I’ and the prepositional phase ‘in the line of fire;’ the verb ‘am’ does not provide any semantic meaning on its own but instead conveys the event time (verb tense).

The copular verbs fell into two broader groups a) describing a kind of state that a thing/ person referred to by the subject (e.g., *be remain, seem, appear*) or b) describing a result of change affecting a thing/person referred to by the subject (e.g., *become, turn, grow, get*; Hurford, 1994). If a message contained a meaning-bearing or copula verb, then the utterance was copied into the verb analysis classification of that specific cognitive behavioral

¹³ In linguistics, a copula verb is a word used to link the subject of a sentence with a predicate (a subject complement).

indicator. This coding process continued for all messages containing verbs indicative of information relevant to SA or TMS cognitive behaviors.

For determining verb tense, the meaning-bearing and copula verbs that were already identified during the verb determination process were marked for their verb tense. Three tense-classifications were created for the tense markers that included present, past and future tense. The tense-classification system was applied for each cognitive behavioral indicator, see Table 24. The results of the coders agreement for the first pass codes using Cohen's κ and Krippendorff's α can be found in Appendix D. No substantial difference in agreement scores between Cohen's κ and Krippendorff's α were found.

Table 24. Data Annotation of Verbs and Verb Tense.

Verbs			
Coding	Definition	Examples	Data annotated code
Verb	Utterance contains a verb	I'm driving west	0
No verb	Utterance did not contain a verb	how great in the right corner	1
Verb Tense			
Coding	Definition	Examples	Data annotated code
Past	The verbs (e.g., to be) are all in past and adverbs indicate action has occurred	"There was low wind" "Fire had broken out in the top left corner" "We extinguished all fires"	1
Present	The verbs are all in present	"Everyone go where the fire is burning" "I'm a helicopter"	2
Future	The verbs indicate action that has not yet begun (e.g. to be)	"How many helicopters will we need?" "The fire will move the direction of the wind" " I will take the top again"	3

5.2.3 Phase IV: Coding Results for Verbs

For the results of the fourth phase coding, 5444 utterances, or 72.6% of the data set contained verbs. Of the total 7498 utterances, 25.3% of the data set contain cognitive behavior verbs related to SAE, 35.9% related to SAT and 54.1% related to TMS, see Table 25. Difference between number of identified utterances of cognitive behavior indicator and verbs existed which can be attributed to no verbs or more verbs being communicated that contain cognitive behaviors. For instance SAE cognitive behavior utterances coded for perception and comprehension entailed fewer verbs with the annotated indicators. Other major examples are TMS cognitive behavior confusion and credibility. On the other hand more verbs depicting indicators were SAT cognitive behavior action and comprehension, and

TMS cognitive behavior specialization. Variation in language use when referring to external, internal versus actionable events may be a factor contributing to less or more verb use.

Example:

<p><i>SAE perception:</i></p> <p style="padding-left: 20px;"><i>“House fire!”</i></p> <p style="padding-left: 20px;"><i>“New wind direction”</i></p> <p style="padding-left: 20px;"><i>“Too much of it”</i></p>	<p><i>SAE comprehension:</i></p> <p style="padding-left: 20px;"><i>“Town fire north east”</i></p> <p style="padding-left: 20px;"><i>“2 groups in forest”</i></p> <p style="padding-left: 20px;"><i>“South right in the forest”</i></p>
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To identify significant difference in occurrence of the cognitive behavior verbs between indicators, chi square analysis was performed to assess goodness of fit. A significant difference of cognitive behavior verbs in communication between SAE indicators ($\chi^2 (3, N = 1896) = 527.6, p < .001$), with a large effect size $\phi = .53$) and SAT indicators ($\chi^2 (3, N = 2698) = 1018.7, p < .001$), with a large effect size $\phi = .61$) was found. Residual analysis revealed SAE cognitive behavior perception and SAT cognitive behavior action to account for this effect. Results also indicated a significant difference of TMS cognitive behaviors in communication between indicators ($\chi^2 (4, N = 3759) = 3512.8, p < .001$, with a medium effect size $\phi_c = 0.48$). Cognitive behavior coordination accounts for this effect. Results of these findings demonstrated that cognitive behaviors can be identified through verbs. Some cognitive behaviors are more represented as verbs than others, still they aid in the development of automated classifiers.

5.2.4 Phase IV: Coding Results Verb Tense and Characteristics

For cognitive behavior indicators to be successfully located within communication, verbs need to be identified that are most likely to convey such information. This process also required identifying the tense of verbs that contain cognitive behaviors. In this step, cognitive behavior indicators were cross-tabulated with verb tense. This sheds light on understanding how to construct cognitive behavior indicators on the linguistic levels and in which verb form they occur in communications. The results of the third pass coding for the dataset of verb tense are shown in Table 25. The Table presents Mean, Standard Deviation and Sum of utterances for each cognitive behavior indicator and verb tense. An additional in text analysis was conducted for the discrimination of meaning-bearing verbs, copula verbs and characteristics that are essential for the identification of cognitive behavior indicators.

Table 25. Number of Verbs identified to Represent Cognitive Behaviors.

Category	Number of Verb Utterances	Cognitive Behavior Utterances	M (SD)	Percentage of Dataset
Verb	5444¹⁴	-	87.8 (34.7)	72.6%
SAE	1896	2501	30.6(22.0)	25.3%
Perception	777	1012	12.5(8.5)	10.4%
Comprehension	552	954	8.9(9.5)	7.4%
Projection	84	60	1.4(1.9)	1.1%
Action	483	475	7.8(8.1)	6.4%
SAT	2698	2478	43.5(21.7)	35.9%
Perception	565	545	9.1(5.7)	7.5%
Comprehension	801	753	12.9(8.7)	10.7%
Projection	92	85	1.5(3.0)	1.2%
Action	1240	1095	20(13.0)	16.5%
TMS	3829	4075	61.8(26.6)	51.1%
Specialization	2060	2004	33.2(16.5)	27.5%
Coordination	1020	1039	16.5(9.9)	13.6%
Confusion	104	118	1.7(2.9)	1.4%
Credibility	299	566	4.8(4.3)	4.0%
Feedback	346	348	5.6(4.0)	4.6%

5.2.4.1 Cross-tabulating Cognitive Behaviors with Verb Tense

None of the numerical data presented in the cross-tabulation section could undergo a statistical analysis. Besides the small sample size, the same sample pool participated in the observations of verb tense. This violated the independence of observation assumptions critical for statistical analysis (see, Parush et al., 2014). Hence, a descriptive analysis was undergone to determine primary use of verb tense of cognitive behaviors.

The cognitive behaviors of SAE were cross-tabulated with verb tense, see Table 26. Examination of potential differences of SAE cognitive behavior by verb tense revealed that occurrence of SAE cognitive behavior perception was to majority communicated in verb tense present. Also a difference for SAE comprehension and projection between verb tenses existed, with the majority identified in verb tense present. Further, the cognitive behavior projection is also being displayed in team communication in future tense, see Table 26. Descriptive results of the SAE cognitive behavior action also showed to be primarily occurring in present tense. Cross-tabulation was also conducted for cognitive behaviors of SAT with verb tense, see Table 26.

¹⁴ Number of verbs and number of verbs of cognitive behaviors differ due to the fact that coders could assign one or more cognitive behavior to an utterance.

Table 26. Means and Standard Deviation of Verb Tense by Cognitive Behaviors.

Category	Tense of Cognitive Behaviors		
	Past Tense	Present Tense	Future Tense
	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>n</i>
Tense SAE			
Perception	3.4(3.3) 213	8.7(6.0) 538	0.4(0.7) 26
Comprehension	1.3(1.4) 79	6.2(6.5) 382	1.5(3.7) 91
Projection	0.1(0.4) 7	0.7(1.1) 40	0.6(0.9) 37
Action	0.3(0.6) 18	6.23(5.9) 386	1.3(3.3) 79
Tense SAT			
Perception	1.65(1.5) 102	7.1(4.6) 442	0.3(0.7) 21
Comprehension	1.3(1.5) 80	8.7(6.6) 536	3.0(3.1) 185
Projection	0.0(0.1) 1	0.3(0.9) 20	1.2(2.3) 71
Action	01.9(1.8) 117	14.9(9.5) 924	3.2(3.8) 199
Tense TMS			
Specialization	5.65(4.1) 350	22.7(11.7) 1405	4.9(4.0) 305
Coordination	1.4(1.7) 84	13.5(8.7) 838	1.6(1.7) 98
Confusion	0.3(0.6) 69	1.3(2.4) 83	0.1(0.2) 4
Credibility	1.1(1.4) 69	3.6(3.3) 221	0.2(0.4) 9
Feedback	3.0(2.6) 185	2.5(2.1) 156	0.1(0.3) 5

Descriptive results indicate a difference of SAT cognitive behavior perception between verb tense, the cognitive behavior was found to occur to majority in present tense. Also the SAT cognitive behaviors comprehension and action were found to majority being communicated in present tense. Descriptive results of cognitive behavior SAT projection demonstrate to occur to majority as future tense. Also TMS cognitive behaviors were cross-tabulated with verb tense, refer to Table 26. Descriptive results show difference of TMS cognitive behavior specialization and coordination in verb tense use. Both cognitive behaviors were primarily communicated in present tense. Descriptive results also indicate TMS confusion and credibility to be identified to majority as present tense. On the other hand, TMS cognitive behavior feedback was primarily communicated in past tense. Verb tense contributes to the identification of cognitive behaviors, and how team members communicate them. Therefore,

results contribute to the general understanding of cognitive behaviors and aid in the development for leveraging cognitive behaviors automatically. In the next step, an in text analysis was conducted to shed further light on how cognitive behaviors are constructed linguistics by focusing on verb tense.

5.2.4.2 Verb Tense and Characteristics of SAE Cognitive Behavior Indicators

SAE cognitive behavior indicator verbs of perception were identified to majority as appearing as present tense (or also past tense) in communication (example a). An in text analysis revealed that the cognitive indicator was identified by copular verbs (e.g., *be - is, are, was, were*), also referred to as linking verbs, in communication (Galasso, 2002). While the copular verb *be* cannot stand along with the predicate, it must be supported by other adverbs to supply additional information to the verb (Galasso, 2002). Such supporting adverbial complements to the copular verb provide information regarding places such as of objects, events, people, system; time of environmental factors or their current state such as condition, modes, action (example b). As the analysis continued, auxiliaries (*is, was, are, were, have, had + meaning-bearing verb*) in connection with meaning-bearing verbs were found to be indicative of the cognitive behavior perception. As auxiliary verbs bear no meaning on their own, they provide temporal and aspectual information such as relating action or a state to the passage of time (see example c; Falk, 2003; Kuiper & Allan, 2010).

Example¹⁵: a) ...wind comes from the side
found a fire
b) There are so many fires
c) well that forest is getting burned

SAE cognitive behavior indicator verbs of comprehension are mainly occurring as present tense in team communication (see example a.). These indicators is also constructed through copula verbs in relation with prepositions (e.g., directional) to depict location and relations among events and places (example b.). The identification of auxiliary verbs *is, are, was, were, have + meaning-bearing verb* are also found within utterances (example c).

Example: a) ...larger fires in the forest require more people to extinguish...
b) it is right next to the town
c) the forest is getting burned next to the house

¹⁵ The following utterance examples of all cognitive behaviors are based on communication that took place between team members. In some instances the utterance was changed to fit the category.

SAE cognitive behavior indicator projection occurred present and future tense. In the English language there are no inflected forms for the future tense (example a; Kuiper & Allan, 2010). The auxiliary verb *will/ shall* or *going to* with the base form of the verb are employed to express future tense (Falk, 2003; Kuiper & Allan, 2010). Different from the auxiliary verbs *have*, *be* or *do*, these modal auxiliary verbs (e.g., *will/shall*, *would*, *can/ could*, *may/ might*, *should*, *must*, *ought*, *dare* and *need*) have no verb-like properties and are generally analyzed as lexical items (Falk, 2003). Thus, the cognitive behavior indicator is presented in the form of *will/shall/going to* + meaning-bearing verb. As seen in the example this construction expresses possible future actions in the environment. Informal contractions of the form “going to” were considered in the content analysis (example b.).

Example: a) *The other will extinguish*
 The wind really tells us where the next fires will start
 b) *things are gonna get bad...haha*

SAE cognitive behavior indicator verb action was to majority identified as occurring as present tense (example a). Further, auxiliary verbs of *can*, *should*, *do*, *need* were identified to express the ability to do something or action going on at a particular point in time (example b; SAE action; Kuiper & Allan, 2010).

Example: a) *bail on small ones protect big ones*
 Watch the houses please!! We don't want anymore to burn down!!...
 b) *You should get ahead of the fire to prevent spread of fire.*

The results present information on how SAE cognitive behavior indicators are constructed on the linguistic level. This information will aid in the development of text analytics to identify SAE cognitive behavior within communication.

5.2.4.3 Verb Tense and Characteristics of SAT Cognitive Behavior Indicators

Verbs of SAT cognitive behaviors were cross-tabulated to verb tense. Verbs of SAT cognitive behavior indicator perception were identified to majority as present and some degree to past tense in communication (example a). The study showed that these indicators spawned copular verbs. Therefore, copular verbs (e.g. *be*, *is*, *am*, *are*, *was*, *were*) identify SAT cognitive behavior to provide information about objects, events, people, systems, team factors and their current state such as condition, modes, action that are related to the own team (example b; e.g., Galasso, 2002). Also auxiliary verbs *be*, *have* were identified that connect to meaning-bearing verbs to express the time of the event (example, c; Kuiper &

Allan, 2010). The indicator is characterized by personal pronouns (*I*) and possessive adjectives (*my, yours, ours*).

Example: a) *I don't have a wind thing*
 b) *my fuel is low*
 c) *my helicopter is going home.*

SAT cognitive behavior indicator verbs of comprehension are mainly occurring as present tense in team communication (see Example a.). These indicators are also constructed through copular verbs in relation with prepositions (e.g., directional) to depict location and relations among events and places (Example b.) and/ or auxiliary verbs (e.g., *be, have*). The indicator was also characterized by personal pronouns (*I*) and possessive adjectives (*my, yours, ours*).

Example: a) *Somehow I got 2 helicopters in the bottom*
 b) *I'm at the bottom left in a truck.*

SAT cognitive behavior indicator projection occurred in mainly future tense. The auxiliary verb *will* and *shall* or *going to* with the base form of the meaning-bearing verb are employed to express future tense (Kuiper & Allan, 2010). As seen in the example, this construction expresses possible future actions of the team. The indicator was also identified by personal pronouns (*I*) and possessive adjectives (*my, yours, ours*).

Example: *I will get... northeast*

SAT cognitive behavior indicator verb action was to majority identified as occurring as present tense (example a). Further, auxiliary verbs of *can, should, do, need* were identified to express the ability for team members do something or taking action at a particular point in time (example b; Kuiper & Allan, 2010) that identified SAT cognitive behavior indicator action.

Example: a) *Split the areas the helicopters are assigned to*
 b) *We need to assign sections to each team member*

The results present information on how SAT cognitive behavior indicators are constructed on the linguistic level. This information will aid in the development of text analytics to identify SAT cognitive behavior within communication.

5.2.4.4 Verb Tense and Characteristics of TMS Cognitive Behavior Indicators

Verbs of TMS cognitive behaviors were cross-tabulated to verb tense. TMS cognitive behavior indicator specialization was identified to majority as present tense. The indicator is constructed of auxiliary verbs + meaning-bearing verbs to indicate the state of a team member or condition (e.g., *can, should, do, need*; see example a; Kuiper & Allan, 2010). Further copular verbs were identified to provide information regarding team member expertise, status, condition, and mode of expertise (example b; Galasso, 2002). Specialization could also be displayed as future or past tense (example c).

- Example
- a) *I'm giving up*
We need bigger tanks
 - b) *I am down here*
 - c) *I will take the top but just beware of the scale of the map...*

TMS cognitive behavior indicator verbs of coordination are mainly occurring as present tense in team communication (see example a.). These indicators are constructed in relation with prepositions (e.g., directional) to depict location and relations among team members and events (example b). These prepositions are useful to depict coordination activity. Also, auxiliary verbs of *be, can, should, do, need* are identified to express the coordination activity (example c).

- Example:
- a) *be sure to return to your position after helping out in other locations.*
 - b) *All hang out above the center city?*
 - c) *We can all cover the middle section.*

TMS cognitive behavior indicator confusion occurs mainly in past and present tense (example a). The indicators is also characterized by the auxiliary verb *do* to express the negative or to ask questions (example b, Kuiper & Allan, 2010).

- Example:
- a) *I understand your viewpoint.*
 - b) *I don't understand. ...*
Do you mean the trees or the houses?

TMS cognitive behavior indicator credibility occurs to majority in present tense with auxiliary verbs characterizing the indicator.

- Example: *yeah I'm checking for information.*

The TMS cognitive behavior indicator feedback is to majority identified in form of past and can also occur in present tense (see example a) accordingly). The cognitive behavior indicator is identified by auxiliary verbs that appear in the past tense within communication. The use of auxiliary verbs in past tense (e.g., *could*, *should*, and *did*) provide information to express past possibilities or abilities in the contingent circumstances of the team (example b; e.g., Kuiper & Allan, 2010).

Example: a) *we saved a lot of the buildings*
 I think we are doing a lot better
 b) *We could have been more organized...*
 well we asked if anyone needed help and we went on to help each other

The results provided present information on how TMS cognitive behavior indicators are constructed on the linguistic level. This information will aid in the development of text analytics to identify TMS cognitive behavior within communication.

In order to locate these cognitive behavior indicators through analytics, rules and exception of indicators have to be established. A detailed analysis of utterances in which the cognitive behavior indicators appear in form of verbs has to be conducted. This involved matching identified cognitive behavior verbs to VerbNet classes and defines verb frames, which is described in the second pass coding.

5.2.5 Phase IV: Mapping Verbs to Verb Classes

During the coding process of phase four, coders observed that the same or similar verbs and prepositions occurred repeatedly. To insure a detailed communication analysis, coders evaluated the frequency of verbs related to cognitive behavior indicators within the messages. With particular verbs, from all messages, coders matched the verbs manually to the VerbNet classes (Kipper-Schuler, 2005; Kipper-Schuler, 2006). This classifying process involved using the VerbNet website to locate verb classed associated with each verb. To demonstrate identified verb classes that are representing verbs used by all teams that related to cognitive behavioral indicators. The following is an example of the process; *returning the helicopter to the small village*.

In the example, the message focused on the verbal, *returning*, and the preposition, *to*, for their relationship to SA and TMS cognitive behavior indicators. In this case, the event was the result of a team member using a concrete theme, *returning* to a destination. The segment of the message that indicates cognitive behavior in the first example pertains to the verb *return*. Specifically the verb *return* is associated with cognitive behavior SAT

(comprehension) and TMS (specialization). The ending of the verb *-ing*, identifies it as a verbal that provides additional participant information in that a team member is returning the helicopter and not somebody else (e.g., Kipper-Schuler, 2005). The verb *return* belongs to the VerbNet Class Escape-51.1, which shows the relationship of the observed verb with its other class members being for example, *advance*, *approach*, *fall*, and *go or retreat* (Kipper-Schuler, 2005). All of the verbs in the Escape-51.1 Class have similar meanings, and exhibit similar semantic and syntactic behavior (Kipper-Schuler, 2005; Palmer et al., 2009). The verb-analysis of messages that contain cognitive behavioral indicators reveals that if a verb is in the escape-51.1 class, it is used in communication about SA behavior (i.e., perception, comprehension, projection, and action) to elicit TMS behavior (i.e., specialization, coordination, and feedback). In the following VerbNet classes that elicit information regarding team cognitive behavioral indicators are outlined.

Therefore, VerbNet classes might be associated with more than one cognitive behavior indicator. Table 27 displays verbs from the VerbNet classes of the cognitive behavior SAE as well as copular verbs identifying each cognitive behavior indicator. The verbs *appearance*, *'become'*, and *'seem'* are represented as both a verb and a verb class. Although, as a verb these verbs function as a copular verb, the verb class does not. Instead the verb class contains other verb members that have the same syntactic features. The identified verbs were attributed to 80 different verb classes, 79 verbs of the cognitive behavior SAE, 101 verbs of SAT, 105 of the cognitive behavior TMS were identified. Verbs were mapped to each cognitive behavior indicator. Similarities of verb use for individual cognitive behavior indicator exist thereof. It also suggests that team communications included a specific set of vocabulary that closely related to the mission environment and task goal.

Because of the limitation of verb use variety, the entire verb class was considered as each class presents member verbs that function in the same or similar way as the verb mapped to the cognitive behavior indicator. This provides greater generalizability for text analytics. As the highest class in each verb hierarchy shares all features with each verb in the entire class, the main focus was laid on the parent class. The parent class of the verb allowed identifying syntax and semantics of the cognitive behavior indicator (Kipper-Schuler, 2005). As not all syntax and semantic cases were identifiable with VerbNet¹⁶, new forms of syntax and semantic were added to the specific verb class.

¹⁶ See also http://verbs.colorado.edu/verb-index/VerbNet_Guidelines.pdf

Table 27. Mapping Cognitive Behaviors with VerbNet Classes.

Cognitive Behavioral Indicator	VerbNet Class	Copular Verbs
SAE – Perception	appear- 48.1.1, become-109.1, begin – 55., contribute-13.2, convert-26.6.2, defend-85, destroy-44, disappearance-48.2, discover-84, enforce - 63 escape- 51.1, exist – 47., get-13.5.1, light_emission-43.1, murder-42-1, other_cos-45.4, roll – 51.3.1, see-30.1, sight-30.2, stop-55.4	appear, become, get, run, look
SAE – Comprehension	appear- 48.1.1, begin – 55.1, bring-11.3, contiguous_location- 47.8, contribute- 13.2, convert-26.6.2, defend-85, escape- 51.1, exist – 47.1, fill-9.8, focus-87.1, get-13.5.1, help-72, keep – 15.2, leave – 51.2, light_emission-43.1, lodge-46, murder-42-1, put_direction 9.4, put_spatial-9.2, put-9.1, roll – 51.3.1, separate-23.1, spatial_location-47.6, split-23.2	appear, get, keep, look
SAE – Projection	appear- 48.1.1, begin – 55.1, build – 26.1, destroy-44, escape- 51.1, fill-9.8, future_having-13.3, get-13.5.1, hit- 18.1, light_emission-43.1, reach – 51.8, remove – 10.1, roll – 51.3.1	appear, get, keep, look
SAE – Action	appear- 48.1.1, become-109.1, bring-11.3, cooperate-73.3, defend-85, escape- 51.1, exist – 47., fill-9.8, forbid-67, get-13.5.1, help-72, keep – 15.2, leave – 51.2, lodge-46, murder-42-1, obtain -13.5, push-12.1, put-9.1, reach – 51.8, roll – 51.3.1, run – 51.3, rush – 53.2, search-35.2, see-30.1, sight-30.2, tell-37.2, try – 61, use – 105, want – 32.1	appear, become, get, keep, run

Syntax displays different frames of verb construction through prepositions or sentential complements in which the verb generally appears in (Kipper- Schuler, 2005; Kipper, Korhonen, Ryant, and Palmer, 2006, Palmer et al., 2010). Syntax may therefore help in determining which cognitive behavior indicator should be tagged. Illustration of syntactic structure of cognitive behavior indicator perception and comprehension are shown in examples a and b accordingly.

- a. The forest is burning NP V¹⁷
b. The fire jumped over to the houses NP V PP.Destination NP

Whereas perception exhibits a simple syntax structure NP V comprehension features the syntactic construction NP V PP.Location NP specifying the necessary (e.g., over, to) preposition to introduce the location (e.g., Kipper, Snyder, and Palmer, 2006). Classifying the syntactic structure allows the identification of a cognitive behavior indicator, yet the structures are not mutually exclusive for each cognitive behavior indicator. By identifying, other characteristics of the syntactic frame might create a more accurate result in text analytics of the cognitive behavior indicators. For instance, the depiction of semantic roles,

¹⁷ NP = Noun Phrase, V = Verb, PP = Preposition

conceptual relations among information pieces, and the information (who, what, when, where, and how) contained in an utterance can be depicted (Kipper, 2005; Palmer et al., 2010). The authors suggest semantic roles to present the semantics of main information pieces in a sentence so that changes in syntax would not influence their roles. For example:

- a. The fire destroyed the city.
- b. The city is destroyed.

The first utterance presents the fire as the subject and the city as the direct object, whereas in the second utterance the city is the subject. Through the application of semantic roles such as agent and patient to the utterances (e.g., the fire as the agent and the city as the patient) semantic roles stay consistent despite changes in syntax (Kipper- Schuler, 2005).

- a. [The fire] [agent] destroyed [the city] [patient]
- b. [The city][patient] is destroyed.

The semantic roles are not specific to one verb instead apply to several verb classes (e.g., Kipper- Schuler, 2005). The semantic role stimulus for example can be found in see-30.1 and amuse-31.3 class.

NP V NP	Example "I don't see any fires"	Syntax	Experiencer V Stimulus
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See-30.1 class: "fires" is the stimulus in this construction

NP V NP	Example "I'm confused with this wind thing"	Syntax	Stimulus V Experiencer
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amuse-31.1 class: "I'm" is the stimulus in this construction.

The roles that are instantiated in cognitive behavior indicators are specific roles possible for the given verbs. See Appendix F for the main semantic roles of cognitive behavior indicators (and reflexivity; Kipper- Schuler, 2006; Palmer et al., 2009; Palmer et al., 2010). The cognitive behavior indicators demonstrate the use of semantic roles that help to distinguish between each one. For instance the verb *take* belongs to the cognitive behavior indicator perception, comprehension, action and others. Semantic roles help to distinguish membership to one cognitive behavior indicator over another. In the example, *take* has distinct semantic roles (e.g., agent, theme, destination, instrument or source), that is displayed

different for each indicator (Kipper- Schuler, 2005; Kipper et al., 2006). VerbNet annotation guidelines suggest while some verbs require two arguments for example the verb see – the seer and the stimulus, other verbs such as run only require one argument – the entity that is running (Kipper- Schuler, 2005; VerbNet Guidelines). Semantic roles and syntax could therefore help to distinguish correct mapping of verbs to cognitive behavior indicators, see Table 28. In sum or one feature alone could be a more useful indicator than just the verb by itself (see VerbNet Guidelines). The syntactical frames of verb construction in which the verb of cognitive behavior indicator appears in were identified (e.g., Palmer et al, 2010). In the following prepositions encountered in cognitive behavior communication are turned to as they make up the syntactic frame.

Table 28. Example of Semantic Roles of Cognitive Behaviors.

Cognitive Behavior Indicator	Example	Semantic Role
Perception	<i>Each of us is taking one helicopter</i>	Agent, Theme
Comprehension	<i>I'm taking the helicopter to the next town</i>	Agent, Theme, Destination
Action	<i>Take the heli</i>	Theme

5.2.6 Phase IV: Determining Prepositions

Preposition classes of team communication that may pertain to cognitive behavior indicators are examined. After verbs were matched to cognitive behavior indicator, VerbNet allowed identifying preposition congruent with the verb that represents a cognitive behavior indicator (Kipper et al, 2004). Preposition based on the preposition class hierarchy are shown in Table 29. The prepositions are divided into path and locative prepositions (after Kipper et al, 2004). Prepositions are explicitly labeled in the syntax and denoted by a curly bracket {}, with one or more possible prepositions defined inside (Kipper- Schuler, 2005; Kipper et al, 2004). Other prepositions that were identified include time expressions (*on, in, at, from to, past, till/ until, by, since, during, for, ago, before/prior to*), relational expressions (*with, without, together*) single-word prepositions (*astride, athwart, atop, concerning, excluding, and regarding*) and phrasal prepositions (*along with, because of, in addition, in favor of, in place of, instead of, next to, together with, up to*; e.g., Kuiper & Allan, 2010). As VerbNet did not contain these prepositions, they were added to classes to allow for concrete identification of cognitive behavior indicators. The verbs encountered with prepositions for each cognitive behavior indicator will aid in the development of text analytics to identify cognitive behavior within team communication.

Table 29. Extraction Prepositions in Computer-Mediated Communication.

Path- Preposition		Locative Preposition	
Source	Destination	Direction	Location
From, out, out_of, off, off_of	For, at, to, towards, into, onto	Across, along, around, down, over, past, round, through, towards, up	About, above, against, along, alongside, amid, among, amongst, astride, at, athwart, before, behind, below, beneath, beside, between, beyond, by, from, in, in_front, inside, near, next_to, off, on, opposite, out_of, outside, over, round, throughout, under, underneath, upon, within
get-13.5.1, obtain -13.5, remove – 10.1	bring-11.3, carry-11.4 contribute- 13.2 convert-26.6.2 escape- 51.1, Fill-9.8 force-59 put_direction 9.4 put_spatial-9.2 put-9.1 reach – 51.8	carry-11.4, rush – 53.2, put-9.1	butter – 9.9, appear- 48.1.1, begin – 55.1, carry-11.4, contiguous_location- 47.8, contribute- 13.2, defend-85, enforce – 63, escape- 51.1, focus-87.1, get-13.5.1, help-72, keep – 15.2, leave – 51.2, light_emission-43.1, lodge-46, murder-42-1, occurrence-48.3, put-9.1, roll – 51.3.1, run – 51.3, rush – 53.2, search-35.2, seem-109-1, spatial_location-47.6,

5.2.7 Key findings of Leveraging Verbs, Verb Tense and other Characteristics

The purpose of the fourth phase of qualitative coding was to determine which verbs, verb tense or prepositions support the identification of cognitive behaviors. Particularly, for determining team communications, and whether cognitive behaviors display the same functional make-up. Results demonstrate that verbs can identify or represent cognitive behaviors. A broad range of verbs, which also included copular and auxiliary verbs identified the cognitive behaviors. Between individual cognitive behaviors similarities, but also differences were found for verbs, verb syntax and prepositional relations. Hence, cognitive behaviors SAE perception, SAT action and TMS coordination exhibited the highest verb volume in team communication.

The cross-tabulation of cognitive behaviors with verb tense revealed cognitive behaviors SAE/ SAT (i.e., perception, comprehension, and action) mainly being constructed of present tense in communication. Yet, different pattern of verb tenses existed for each individual cognitive behavior. Therefore, teams are talking mainly in present tense and past tense about their awareness (perception) while to understand the situation or to take action

they rely on present and future tense. To project the situation in to the near future teams to majority communicate in present or future tense when referring future events to environmental factors (i.e., SAE) or future tense when referring to their own team (i.e., SAT). TMS cognitive behaviors of specialization, coordination, confusion and credibility were also communicated in present tense.

Hence, teams communicate in present tense to represent their state of expertise to other team members, verbalize their coordination efforts, stating their confusion, and confirming or cross checking information of other team members. The team displayed feedback behavior by communicating in past tense to their team (i.e., TMS feedback). Hence, even though the primary tense of cognitive behaviors is present tense, possible variance of each cognitive behavior indicator exists. The result of a detailed in text analysis shed further light on to how verbs of each cognitive behavior indicator are constructed and which cognitive behaviors displays other characteristics such as copular or auxiliary verbs, prepositions and use of personal pronouns. With the mapping of identified verbs to verb classes and determining prepositional relationship, findings show which verbs, verb tense and prepositions support the identification of cognitive behaviors in team communication. Hence, even though similarities of individual cognitive behaviors are present, findings also indicate distinct variances in the functional make-up of cognitive behaviors. The findings thus aided in answering the research questions (1.7 and 1.8) by identifying characteristics (e.g., verbs, verb tense or preposition) of cognitive behaviors in communication and differences in its functional make-up. The results of the mapped verbs, verb tense and prepositions to the given cognitive behavior indicators will aid classifiers that are using VerbNet classes membership to have a higher chance of categorizing cognitive behavior information correctly rather than a classifier without the VerbNet information (e.g., Verma et al., 2010; Vieweg et al., 2010).

5.3 Creation of Linguistic Classifiers of Cognitive Behavior Indicators

Cognitive behavior indicators were mapped to generate linguistic classifiers that are functional for automated communication analytics. Although, some cognitive indicators were less represented in team communication, the classification system was developed for each individual cognitive behavior. To generate the classification system, verb frame, semantic role, prepositions, verb class, verb tense, speech act behavior and identifiable copular, auxiliary verb or other specifics were mapped out for each cognitive behavior indicator. For analytics to identify a cognitive behavior, the utterance has to match with the classification system of the cognitive behavior indicators. The classification system of each cognitive

behavior indicator was generated to be distinct from one another. Yet, a similar structure for some of the cognitive behaviors exists. Therefore, one or more cognitive behavior indicators might be identified within one communications utterances. This represents a more realistic picture, as one or more cognitive behaviors might be present in one utterance. Already during the manual coding process was this aspect taken into consideration during which one to possible four different behaviors were assigned to an utterance. Additionally, the tagging of several cognitive behavior indicators in team communication was dependent upon the syntactic construction of the utterance.

Results of the classification system illustrate a distinct syntactic construct of the cognitive behavior indicators communicated. The cognitive behavior SAE perception centers on communication content about external events in that the indicator is characterized by a simple syntactic frame (e.g., NP V, NP V NP or NP V S_ING), semantic roles specific to perception, as a verb occurring as past tense or present in announcements, questions and replies. On the other hand, a syntactic frame and semantic roles that mirror location and relations among places or events (e.g., NP V PP.Location, NP V PP.Location, NP, and NP V PP.Destination) characterize the cognitive behavior SAE comprehension that centers also on external events. Thus, path and locative prepositions identifies comprehension, as a verb occurs as present tense in announcements, requests and replies. The cognitive behavior SAT comprehension centers on communication content about internal team-related events. Similar to SAE comprehension, the indicator is characterized by a syntactic frame and semantic roles that mirror location and relations, but of the team (e.g., NP V PP.Location, NP V PP.Location NP, NP V PP.Destination). Comprehension is identified by path, locative and connective prepositions, as a verb occurs as present tense in announcements, requests and replies. Directional descriptive words (e.g., right, left, top, middle, bottom, upper, lower, north, south, east, west, corner, edge, center, area, part, portion, section, zone) characterize the SAE comprehension indicator. This characteristic is also present in the SAT comprehension indicator.

Overall the SAE and SAT behavior indicators show a similar classification characteristic. For instance, the cognitive behaviors SAE action and SAT action are almost indistinct, except that SAE is centered in the environment and SAT within the team. Both classifiers differ in that the SAT indicator features personal pronouns (e.g., I, you, we, us) and possessive adjectives (my, your, our) whereas the indicator SAE does not. In addition, as

a verb occurs as present tense in announcements, requests, and replies, a syntactic frame and semantic role of action taking (e.g. V NP, VC NP Destination) characterizes SAT action.

The cognitive behavior TMS specialization focuses on communication content about team members' expertise, their status and/or condition. The indicator illustrates a more diverse syntactic frame (e.g., NP V NP PP.Theme, NP V NP.Topic) and semantic roles featuring path, locative and connective preposition. As a verb it occurs as present tense in announcements, replies and questions. The other most communicated TMS cognitive behavior was coordination. The indicator coordination centers on communication content about coordinating and prioritizing tasks which is represented in the syntactic frame (e.g., NP V NP.Co-Agent, NP V NP.Location), the semantic roles featuring path, locative and connective prepositions, as a verb occurs as mainly present tense in request, announcements and questions. Both specialization and coordination feature the appearance of personal pronouns (e.g., I, you, we, us) and possessive adjectives (my, your, our). Also other cognitive behaviors indicators display a distinct syntactic construct that allows for correct identification of these cognitive behavior indicators. For instance the TMS indicator confusion indicates descriptive words of questions (e.g., what, where, who), which are also featured within the syntactic frame (e.g., NP How/What S). Other indicators that also feature descriptive words to better locate the indicators are credibility (e.g., yes, yeah, good idea, true) and feedback (e.g., effectively, good job, performance, teamwork). Even though some indicators display a similar classifier structure, they feature distinct characteristics that enable automated analytics to use these classifiers for identification of cognitive behavior indicators. The Table 30 illustrates an example classifier of the cognitive behavior perception, its syntactic construct and characteristics. All classifiers are presented in Appendix G.

Even though limitation might exists in identifying classifiers in that a) the indicative verbs might not be contained within the verb classes b) a verb exhibits a different syntactic construct and is therefore not tagged as a cognitive behavior indicator. However, this study presents a first approach to identifying cognitive behaviors in team communications. Further, the classifier model can be used in natural language processing to automatically identify cognitive behaviors. In using automated natural language processing, communication of themes can be analyzed to identify the occurrence of cognitive behaviors. Future research needs to further train and develop classifiers for various team environments (e.g., virtual teams employed in the medical, military or industry). The following Chapter identifies whether these cognitive behavior indicators show effects on communication and

performance. In addition, it examines the effect of reflexivity on team communication and overall team performance. Before turning to results of the proposed theoretical model, the second part of this Chapter presents results regarding leveraging reflexivity indicators.

Table 30. Classification of Cognitive Behavior SAE Perception.

SAE – Perception		
Syntactic Structure	Frames	Semantic Roles
	NP V NP V ADJ NP V ADV NP V NP NP V S NP V S_INF NP V S_ING	Actor V Theme Agent V Patient Agent V Result Agent V Theme Agent V Theme {+SC_TO_INF} Agent V Theme {+Be_SC_ING} Agent V Theme {with} Instrument Experiencer V Stimulus Patient V Patient V Result Theme V
Verb Class	appear- 48.1.1, become-109.1, begin – 55., contribute- 13.2, convert-26.6.2, defend-85, destroy-44, disappearance-48.2, discover-84, enforce - 63 escape- 51.1, exist – 47., get-13.5.1, light_emission-43.1, murder-42-1, other_cos-45.4, roll – 51.3.1, see-30.1, sight-30.2, stop-55.4	
Verb Tense	Past, Present	
Speech Act Behavior	Announcement, Question, Reply	
Copular verbs	is, are, was, were, appear, become, get, run, look	
Auxiliary verbs	is, are, was, were, have, had	
Others	-	

5.4 Reflexivity in Team Communication

According to West (2000, p. 4) reflection includes behaviors such as questioning, planning, exploratory learning, analysis, diversive exploration, making use of knowledge explicitly, planfulness, learning at a meta-level, reviewing past events with self-awareness, and coming to terms over time with a new awareness. The same or different cognitive behaviors might be observable in communications during the different stages of reflexivity (i.e., reflection, planning, and action). The planning phase, which presents goals and ways to achieve these aims, (West, 2000) might elicit cognitive behaviors for understanding the situation (e.g., SA comprehension) and planning the coordination of team tasks to achieve the goals (e.g., TMS coordination). On the other hand, the action phase, which refers to goal-directed behaviors relevant to achieving the desired changes (West, 2000, p. 3), might instead elicit cognitive behaviors of action (e.g., SA action) and assigning concrete tasks to team members (e.g., TMS specialization).

Understanding whether cognitive behaviors are elicited during reflexivity, light would also be shed on the differentiation of cognitive behaviors for reflexivity phases. It was therefore proposed that reflexivity elicits speech act behaviors and cognitive behaviors (research question 1.9). The appearance of these behaviors in communications and the underlying contextual structure, reflexivity phases and reflexivity pattern might result in a range of different team outcomes. Knowing what phases of reflexivity are more efficient in evolving cognitive behaviors would allow to specifically target team interventions. Team diagnostics in form of communication analytics could allow for identifying teams that are either low performing or do not benefit from reflexivity (see, hypothesis 1.4 and research question 1.10).

5.4.1 Reflexivity Coding Scheme

The reflexivity phases need to be derived via data coding from team members' utterance in form of indicators. The requirements for the structure of data and analysis described on page apply also for reflexivity to develop a clearly defined model (i.e., coding scheme). To identify reflexivity in communication, the reflexivity model by West (2000) was used as basis for the coding scheme. Compared to other measures of reflexivity, the coding scheme was comprised of the three phases of reflexivity, team review, strategy development and strategy implementation. See Table 31 for each reflexivity indicator, code definition and example. Since planning can be described as the bridge between reflection and action/adaption (Widmer et al., 2009) a clear distinction between indicators had to be established. For the purpose of this study, the definition of the codes include:

- a) Review is defined as the review of team objectives, tasks and work procedures; team interaction, structure and performance; capability and use of instruments (e.g., devices, tools,) or other means used for task activities.
- b) Strategy development defines the development of suggestions, plans, and strategies for improving performance or completing tasks, and ends with a definite strategy or plan in consensus with the team.
- c) Adaptation or realization of a prior strategies, defines strategy implementation. Starts with goal directed behavior of team coordination shortly before taking action (if applicable; e.g., (re-)stating individual task assignments, positions, instruments or other means in use).

Refer back to the general coding approach, coder training, coding procedure, interrater reliability and pilot testing for further information on the coding process.

5.4.2 Content Analysis of Reflexivity Communication

The next phase of research focusing on identifying team cognitive behavior addresses the research question on whether reflexivity can be identified in team communication. This phase of research determined whether team members communicated reflexivity, which was assessed in three separate coding steps. The initial step, in the qualitative coding procedure, was to code the data by assigning a reflexivity code to each utterance for every team. In the second step, the interrater reliability was calculated and presented. In the third step, results of identified reflexivity behavior indicator are presented in form of team communication volume¹⁸. During all coding passes, communication volume was estimated by classifying and counting the number of chat messages according to reflexivity behavioral indicators.

5.4.3 Phase I: Determine if Communication contains Reflexivity

The purpose of the first pass of qualitative coding for coder is to read every communication message of each team and determine whether utterances contain reflexivity related information. The results of the coders agreement for the first pass codes using Cohen's κ and Krippendorff's α can be found in Appendix D. No substantial difference in agreement scores between Cohen's κ and Krippendorff's α were found. The coding scheme is presented in Table 31.

Table 31. Coding Scheme of Reflexivity.

Reflexivity			
Annotation	Definition	Example	
Review Performance	Information about prior team performance and task activities	"I don't think we did well"	1
Strategy Development	Suggestions for improving team performance, developing potential strategies or plans	"Let's divide up sections" "Let's pair up one helicopter and one fire engine"	2
Strategy Implementing	Adaption and Implementing of developed strategies or plans	"I'm taking the bottom left" "I'm watching the village"	3

¹⁸Communication volume was estimated after annotates finished the qualitative coding process similar to the procedure done by Yoo & Kanawattanachai (2001).

5.4.4 Phase I: Reflexivity Coding Results

The coding results for reflexivity of the entire dataset are shown in Table 32. This table portrays the number of reflexivity utterances, Median and Standards Deviations and percentage of dataset of messages that contained reflexivity information. A chi – square goodness of fit test was conducted that revealed significant variation of reflexivity indicators in team communication ($\chi^2(2, N = 2185) = 63.1, p < .001$) varied by performance, with a small effect size ($\phi = .17$). Residual analysis revealed reflexivity indicator strategy development to account for this effect. Although, all reflexivity indicators were present in different volume in team communication thus answering the research questions (1.9 and 1.10), the majority of reflexivity behaviors are strategy development with 829 utterances and implementing strategy with 803 utterances. Review was present the least in team communication with 554 utterances.

Table 32. Number of Utterances, Means, Standard Deviations and Percent of Reflexivity.

Reflexivity Behavior Indicators			
Category	Number of Utterances	M(SD)	Percentage of Dataset
Reflexivity	2186	35.3(19.7)	29.2%
Review	554	8.94(7.3)	7.4%
Strategy Development	829	13.4(8.9)	11.1%
Implementing Strategy	803	13.0(9.2)	10.7%

5.4.5 Phase I: Reflexivity Cross-tabulated with Cognitive Behaviors

As reflexivity exhibits different behaviors (West, 2000), reflexivity indicators were mapped on to cognitive behaviors SA and TMS for examining their occurrence in team communication to answer research question 1.11. It is to note that none of the numerical data presented in the cross-tabulation section could undergo a statistical analysis. There was an inability to assign team members either randomly or by counter balancing to reflexivity observations, which resulted in the same sample pool participating in some of the observations but not all. This violates the independence of observation assumptions critical for statistical analysis (see, Parush et al., 2014). The cognitive behaviors of SAE were cross-tabulated with reflexivity, see Table 33. Descriptive results display reflexivity to exhibit high levels of cognitive behaviors. Examination of potential differences of SAE cognitive behavior by reflexivity indicators revealed that the occurrence of SAE cognitive behavior perception was to majority presented in reflexivity indicator review, indicating teams to review what they are perceived in the environment. Descriptive results for SAE comprehension shows that

the behavior was mainly displayed in both reflexivity indicator strategy development and implementation.

On the other hand, reflexivity indicator projection was to majority present in reflexivity strategy development. Descriptive results revealed SAE cognitive behavior action to majority to occur in reflexivity indicator strategy development and implementation. Similar to the descriptive results of SAE cognitive behaviors, SAT cognitive behavior perception was primarily identified in reflexivity indicator review. Descriptive results for the SAT cognitive behavior comprehension and SAT projection were to majority communicated during strategy implementation. Moreover, SAT cognitive behavior action was to majority identified in strategy implementation and strategy development. Table 33 presents cross-tabulated results of Mean and Standard Deviations.

Table 33. Means and Standard Deviations of Reflexivity by Cognitive Behaviors.

Reflexivity mapped on to Cognitive Behaviors			
Category	Review	Strategy	Strategy Implementation
	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>n</i>	<i>M(SD)</i> <i>N</i>
SAE			
Perception	0.3(0.6) 64	0.2(0.4) 41	0.1(0.3) 22
Comprehension	0.3(0.7) 68	0.5(0.9) 118	0.6(1.4) 149
Projection	0.0(0.3) 8	0.1(0.5) 21	0.0(0.1) 5
Action	0.1(0.4) 22	0.5(1.0) 124	0.1(1.2) 115
SAT			
Perception	0.5(0.9) 114	0.1(0.4) 28	0.1(0.3) 23
Comprehension	0.2(0.7) 56	0.7(1.2) 174	1.4(1.5) 344
Projection	0.0(0.3) 8	0.1(0.2) 12	0.3(0.7) 62
Action	0.0(0.6) 71	1.0(1.4) 259	1.4(1.4) 334
TMS			
Specialization	1.0(1.3) 243	0.5(0.9) 127	2.0(1.9) 481
Coordination	0.3(0.7) 76	2.0(2.2) 501	0.7(1.1) 162
Confusion	0.1(0.3) 12	0.1(0.2) 14	0.0(0.1) 5
Credibility	0.3(0.6) 63	0.1(0.9) 98	0.2(0.4) 40
Feedback	0.4(0.8) 104	0.1(0.3) 14	0.0(0.1) 5

Also TMS cognitive behaviors were cross-tabulated with reflexivity indicator, refer to Table 33. According to descriptive results, TMS cognitive behavior specialization were to majority communicated during strategy implementation while TMS cognitive behavior coordination was primarily present in strategy development. Although descriptive results indicate no major differences of TMS cognitive behavior confusion between reflexivity indicators, reflexivity indicator strategy development demonstrated the highest level of confusion. While the TMS cognitive behavior credibility was displayed to majority during strategy development, the TMS cognitive behavior feedback was primarily present both in the reflexivity indicator review as well as strategy development.

During the reflexivity transition phase review, team members were primarily reviewing their awareness (i.e., SA perception) of task related conditions in the environment (external) in addition to their own team events, conditions or actions (internal). Further, team members exhibited during review cognitive behaviors of feedback in form of providing feedback about task accomplishments. To some extent during the review, the cognitive behavior specialization reminds the team members' to review their own or other team members' expertise such as their status or condition. See examples:

<i>SAE</i>	<i>Perception</i>	<i>"yeah saved a few houses"</i>
<i>SAT</i>	<i>Perception</i>	<i>"my fire engine moved slower but refueled faster"</i>
<i>TMS</i>	<i>Specialization</i>	<i>"I don't think any of us has enough water to put out a big fire."</i>
	<i>Feedback</i>	<i>"I thought we did fine"</i>

During the reflexivity transition phase strategy development, results indicate that teams are more likely to exhibit behaviors of action to plan and coordinate activities related to the task environment (external). In addition, the cognitive behavior action reflects the team and team processes during strategy development. Cognitive behavior of understanding task and team related also occurrences. It exhibited and displaying cognitive behavior could project the task environment into the near future and seemed most crucial during strategy development.

During strategy development, team members' displayed to majority cognitive behaviors of coordination to plan, manage, and prioritize tasks. In addition, individuals displayed behaviors of confirming proposed strategies, or double checking information with other team members to evaluate possible strategies. See example:

Development of a Classification System

<i>SAE</i>	<i>Comprehension</i>	<i>“I say everything is important but the edges of the forests are first priority so they don’t even hit the towns”</i>
<i>SAE</i>	<i>Action</i>	<i>“also even when there’s a major fire that we’re helping out with we still need to be looking out for others if possible”</i>
<i>SAT</i>	<i>Comprehension</i>	<i>“2 can get the middle and 3 take bottom?”</i>
	<i>Action</i>	<i>“select the vehicle near to you.”</i>
<i>TMS</i>	<i>Coordination</i>	<i>“we should divide up section that each member can</i>
		<i>be in charge of”</i>
<i>it’s</i>	<i>Credibility</i>	<i>“sounds good but don't leave a fire just because</i>
		<i>not in your corner ok”</i>

During the action phase of implementing or adapting a strategy, cognitive behavior of awareness to understand task related occurrences in the environment (i.e., external) and team related task occurrences (i.e., internal) was displayed. The action phase was also displayed by teams projecting internal events into the near future. These cognitive behaviors seem essential for monitoring changes of external and internal events allowing the team to be highly adaptive to changes. Teams also exhibited cognitive behavior of action taking congruent to the task either regarding the task environment or regarding the team. Moreover, cognitive behaviors of specializing in team members’ status or condition of expertise was exhibited during the action phase contributing to monitoring and tracking changes. Further, coordination behaviors were exhibited to coordinate the planned activities for achieving strategy implementation and then the overall team goal. See example:

<i>SAE</i>	<i>Comprehension</i>	<i>“...patrol is from left to right across the forest”</i>
	<i>Action</i>	<i>”Need somebody patrolling the town”</i>
<i>SAT</i>	<i>Comprehension</i>	<i>“keeping my truck closer to the houses but my heli deeper in the woods”</i>
	<i>Action</i>	<i>“state your new position”</i>
<i>TMS</i>	<i>Specialization</i>	<i>“...My truck will be in the middle right where the houses are.”</i>
	<i>Coordination</i>	<i>“Are the top left and the right taken yet?”</i>

Mapping reflexivity indicators to cognitive behavior supports prior findings of displayed behavior during the reflexivity indicators of review, strategy development and strategy implementation (West, 2000). Further, these findings support Marks et al. (2001) suggestions that in the transition phase, team members frequently visit for planning and evaluation; while during the action phase, coordination and monitoring processes dominate the action phase of task accomplishment. In contrast to the author's postulation, these results show coordination behavior to be already displayed during the transition phase that may be attributed to TMS cognitive behavior of sharing information regarding coordinating tasks and/ or prioritizing tasks. This result contributes to research as it indicates which cognitive behaviors appear within each reflexivity indicator located in communication. Being able to identify behaviors related to each reflexivity indicator in communication might also leverage reflexivity indicators in relation to these cognitive behaviors.

5.4.6 Phase I: Reflexivity Cross-tabulated with Speech Act Behaviors

To understand which speech act behaviors are exhibit by reflexivity and answer research question 1.11, reflexivity indicators were cross-tabulated with speech act behaviors. Prior research, accepted that speech act behavior such as questioning as part of reflexivity (West, 2000). The following results expand the findings by West (2000) and indicate that the reflexivity construct displays several speech act behaviors depending on the reflexivity indicator. To identify differences in speech act behavior occurrences regarding reflexivity indicator, descriptive results were assessed, because none of the numerical data presented in the cross-tabulation section could undergo a statistical analysis.

Descriptive results indicated that the reflexivity indicator review occurred to majority in speech act behavior announcement. According to descriptive analysis, reflexivity indicator, strategy development, occurred mainly in speech act behaviors request, question and announcement. Further, results demonstrate reflexivity indicator strategy implementation to primarily being identified with speech act behavior announcement. Thus, review regards to proactive information sharing during the transition phase reflection (i.e., review) by announcing information to other team members. Table 34 presents cross-tabulated results. Strategy development on the other hand exhibits team communication to display an exchange of information between team members e.g., in form of questioning, proactively provide information to other team members in form of announcements and to manage the performance of actions by other team members (e.g., requesting something). During the action phase, communication is said to decrease as teams start working on their task (Yoo &

Kanawattachai, 2001), hence, strategy implementation concerns primarily proactive information sharing by providing information to other team members (Parush et al., 2014). Examples of SAE cognitive behavior indicators and speech act behavior:

<i>Review</i>	<i>Announcement</i>	<i>“I think we’ve done food so far”</i> <i>“Well I think we communicated enough it was just way harder than we expected”</i>
<i>Strategy</i>	<i>Request</i>	<i>“put the copters in the forest since that is where it looks like they start more...”</i>
	<i>Questions</i>	<i>“the fire trucks should deal with fires on the edge of the forest don’t you think?”</i>
	<i>Announcements</i>	<i>“...we can get there fast and provide some support.”</i>
<i>Implementing Strategy</i>	<i>Announcement</i>	<i>“I’m a helicopter and will cover the top half.”</i>

Table 34. Results of Reflexivity by Speech Act Behaviors.

<i>Category</i>	Reflexivity by Speech Act Behaviors					
	Request	Announcement	Question	Reply	Comment	Confirmation
	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>N</i>	<i>M(SD)</i> <i>n</i>	<i>M(SD)</i> <i>n</i>	<i>M(SD)</i> <i>n</i>
Review	0.8(1.4) 47	3.7(3.6) 229	1.5(1.6) 95	2.3(2.6) 141	0.2(0.4) 9	0.9(1.4) 56
Strategy	4.2(3.2) 257	2.6(2.7) 162	3.0(2.2) 184	1.7(1.6) 102	0.2(0.5) 9	1.3(1.7) 81
Implementing Strategy	1.8(2.2) 114	6.8(4.9) 422	0.9(1.3) 54	2.4(3.2) 151	0.1(0.3) 6	1.0(1.8) 60

5.4.7 Phase I: Key Findings: Case Analysis of Reflexivity, Cognitive Behaviors, Speech Act Behaviors and Performance

Case analysis was used to answer the original hypothesis 1.4 whether reflexivity volume in team communication varied in regard to team performance. For the detailed description of method, statistical procedure and key findings refer to Appendix E, Section 1.3. Three case analyses were conducted in which the first one examined the reflexivity communication volume in regards to team performances and the later ones investigated cognitive and speech act behaviors in reflexivity communication volume that exhibited cognitive and speech act behaviors in relation to team performances. Results supported the notion that high performance teams engage in more communication about reflexivity indicator review and strategy development compared to low performance teams. This may result in teams reaching a deeper level reflexivity in that teams spent time reviewing their

past performance to develop strategies and ultimately being able to implement these strategies according to task goal. Hence, a deeper level of review and strategy development is of importance for high performance teams. Both performance groups, however, spent a similar amount of communication on strategy implementation or adaption, thus supporting the hypothesis 1.4 partially.

Although high as well as low performance teams displayed fairly similar cognitive behaviors across reflexivity communication, some cognitive behaviors were more visible in high performance teams. Teams that engaged in reflexivity communication review and displayed cognitive behaviors of perceiving past event, factors or conditions related to the team ultimately performed better. These high performance teams also showed higher levels of the cognitive behavior action related to their own team during reflexivity indicator review. Hence, teams seem to review information regarding their own teams' conditions and actions they have been taken more vigorously compared to low performing teams (i.e., SAT perception and action). Teams that communicated during strategy development process of reflexivity more about their perception on information about objects, events or their states in the environment (i.e. SAE perception) also reached higher team performance. Further, these teams exchange more information regarding their expertise, status and mode of expertise (i.e., TMS specialization); as well as display higher amounts of cognitive behavior of accepting procedural suggestions and questioning assumption to validate or cross check information (i.e., TMS credibility).

No significant difference in reflexivity communication was found for cognitive behaviors during strategy implementation between low and high performance teams. Overall, these results suggest high performance teams to display more cognitive behaviors centered on the awareness of the teams' condition and action taken during review, while during strategy development the awareness transitions to center more on the environment. The displayed cognitive behaviors of TMS specialization and credibility from the high performance teams ensure the development of sound and feasible strategies. Teams therefore spent more time in specializing themselves for the future task (e.g., sharing information about their own capabilities or limitations thereof) and collaboratively validate the development of their strategy. A similar pattern of speech act behaviors was encountered across reflexivity communication. High performance teams questioned more during strategy development, which might relate to questioning the feasibility of the strategy, assumptions or information in regards to developing a strategy that later is adaptable to the real task. Although prior

research has identified awareness or questioning to be observed during reflexivity (West, 2000), these result expand previous findings in that cognitive and speech act behaviors are displayed at different times across reflexivity communication (e.g., questioning during strategy development). Further, certain cognitive and speech act behaviors across reflexivity communication seem to promote high performance, thus supporting the hypothesis 1.4 partially.

5.4.7 Phase II: Coding Results Verb for Reflexivity

The linguistic aspect of reflexivity that was focused on was to identify which verbs team members use to communicate the three reflexivity indicators. In addition to identify the verb construction, verb tense and other syntactical characteristics were mapped to the reflexivity indicators. The coding process and coding steps was the same as for mapping the cognitive behavior indicators. Tense-classification was used to mark present, past and future tense of verbs. Based on prior analysis, 5444 utterances, or 72.6% of the data set contained verbs, see Table 35. Of the total of 7498 utterances, 26.6% of the data contained verbs relevant to reflexivity. Major reflexivity verbs related to strategy 10.1% and strategy implementation 9.6%. Difference between the identified number of reflexivity utterances and verb can be attributed to no verbs or more verbs communicated in an utterance related to reflexivity. In the next coding process, identified tense of verbs that relate to reflexivity were analyzed. The results of verb tense are shown in Table 36.

Table 35. Number of Verbs identified to Represent Reflexivity.

Category	Number of Verb Utterances	Reflexivity Utterances	M (SD)	Percentage of Dataset
Verb	5444	-	87.8 (34.7)	72.6%
Reflexivity	1995	2186	32.2(20.0)	26.6%
Review	517	554	8.3(7.7)	6.9%
Strategy	758	829	12.2(8.5)	10.1%
Strategy implementation	720	803	11.6(8.9)	9.6%

Table 36 presents the Mean, Standard Deviation and Sum of utterances for each reflexivity indicator and verb tense. An additional in text analysis was conducted to gain distinct classifiers of the reflexivity indicators such as meaning-bearing verbs, copular verbs and characteristics that are essential for identifying reflexivity.

Table 36. Means and Standard Deviation of Verb tense by Reflexivity.

Category	Past Tense	Present Tense	Future Tense
	M(SD) N	M(SD) N	M(SD) N
Reflexivity	3.94(4.3) 244	21.29(12.7) 1320	6.95(6.8) 431
Review	2.9(3.5) 180	5.1(4.6) 316	0.3(1.0) 21
Strategy	0.6(1.1) 37	9.9(6.5) 613	1.74(3.4) 108
Implementing Strategy	0.4(0.9) 27	6.31(5.9) 391	4.9(3.9) 302

5.4.8 Phase II: Coding Results Verb Tense for Reflexivity

Reflexivity verbs of review were identified to majority as appearing as present and past tense in communication (example a). A detailed analysis indicated that the reflexivity indicator can also be characterized by copular verbs (*e.g., is, are, was, were*) to provide reflective information about the team, instruments and other factors. Also indicative of the reflexivity indicator are auxiliary verbs in appearance with the meaning-bearing verb (*e.g., is, was, are, were, have, had, do, did + meaning-bearing verb*) (example c).

Example¹⁹: a) *...we communicated enough it was just way harder than we expected.*
 b) *it was not that bad.*
 c) *we did a good job with task management so far.*

Verbs of reflexivity indicator strategy are mainly occurring as present tense and to a lesser extent as future tense in team communication (see example a/b.). Strategy can be identified through auxiliary verbs (*e.g., is, are, will, going to have, can, should, do, need + meaning-bearing verb*) and prepositions (*e.g., directional and connective*) for developing potential strategies or plans that include locations or relationships example b).

Example: a) *“ Do you think there is a better way to extinguish the fires?”*
“ we can improve I guess by staying in our section...then only if we have no fires then help someone that does”
 b) *“but keep an eye out for anyone who may need help”*
“ everyone will definitely need to help”

¹⁹ The following utterance examples of all cognitive behaviors are based on communication that took place between team members. In some instances the utterance was changed to fit the category.

Reflexivity indicator strategy implementation occurred in present and future tense. Besides the present tense forms of the auxiliary verb (e.g., is, are, do, can) the future tense form of will/shall/going to + meaning-bearing verb characterize the reflexivity indicator. Informal contractions of the form “going to” were considered in the content analysis as well (example b.). The reflexivity indicator will also be characterized by preposition of location to support the adaptation or implementation of the team strategy.

Example: a) *“I have northwest”*
 b) *“I will patrol the bottom”*

The results present information on how reflexivity indicators are constructed on the linguistic level. This information will aid in the development of text analytics to identify reflexivity within communications.

5.5 Creation of Linguistic Classifiers of Reflexivity

Similar to the coding process for mapping verbs to verb classes of cognitive behaviors, here the classifying process involved going to the VerbNet website and locating the verb classes associated with verbs related to reflexivity information. Both VerbNet classes and copular verbs that elicit information regarding reflexivity information are outlined in Appendix H. The verbs appearance, become, and seem are represented as both a verb and a verb class. Although, as a verb they function as a copular verb, the verb class does not. Instead the verb class contains verb members that show the same syntactic features. After verbs were matched to reflexivity, VerbNet allowed identifying preposition congruent with the verb that represents a cognitive behavior indicator. Prepositions were the same to the ones encountered for cognitive behavior indicators and therefore not separately listed. See Table 29 for the classified prepositions. Similar to developing the classifiers for the cognitive behaviors, the reflexivity indicators were mapped to generate linguistic classifiers that are functional for automated communication analytics. An exception poses in that cognitive behaviors are also classified to each reflexivity indicator. Classifiers were generated for each reflexivity indicator by combining the verb frame, semantic role, prepositions, verb class, verb tense, speech act behavior and identifiable copular, auxiliary verbs or other characteristics. For analytics to tag reflexivity indicators, the classifiers had to be distinct from one another. Results of the classifiers illustrate a distinct syntactic construct of the reflexivity indicators. See Table 37 for an example; Appendix H presents the classification system of reflexivity.

Table 37. Classification of Reflexivity Indicator Review.

Reflexivity – Review		
Syntactic Structure	Frames	Semantic Roles
	NP V NP V ADJ NP V ADV NP V for NP NP V NP NP V NP ADVP NP V NP 1[apart} NP V NP PP.Co-Patient NP V NP PP.Destination NP V NP PP.Instrument NP V NP PP.Location NP V NP PP.Material NP V NP PP.Source NP V NP PP.Theme NP V NP S_INF NP V NP S_INF Location NP V NP S_ING NP V NP to be ADJ . . .	Actor V Theme ({+Path} Location) Agent V Agent V ({with}) Co-Agent Agent V {about/with} Theme Agent V {Against before into on to onto } Destination Theme Agent V {at, in, on } Agent V {on Upon} Destination Agent V {with} Co-Agent {at, in, on } Theme Agent V Destination Agent V Location {for} Theme Agent V Patient Agent V Patient {into} Results Agent V Patient {off of from with} Co-Patient Agent V Patient {with} Instrument Agent V Patient Result {to_INF} Agent V PP.Location . . .
Verb Class	Amalgamate-22.2, appear- 48.1.1, become-109.1, bring-11.3, conjecture-29.5, contribute- 13.2, cooperate-73.3, correspond-26.1, create 26.4, disappearance-48.2, focus-87.1, force-59, get-13.5.1, help-72, leave – 51.2, light_emission-43.1, meet-36.3, obtain -13.5, occurrence-48.3, order-60, other_cos-45.4, put-9.1, reach – 51.8, rehearse-26.8, roll – 51.3.1, search-35.2, seem-109-1, split-23.2, want – 32.1, wish-62	
Verb Tense	Past, Present	
Speech Act Behavior	Announcement	
Cognitive Behavior	SAE(Perception, Comprehension), SAT(Perception, Action), TMS (Specialization, Feedback)	
Copular verbs	is, are, was, were, appear, become, get, run, look, seem	
Auxiliary verbs	is, are, was, were, have, had, do, did	
Others	Review descriptive words (awesome, bad, better, best, effectively, good, great, impossible, bad/good job, performance, productive, teamwork, together, successful, suck, unrealistic)	

The reflexivity indicator review centers on communication content about reviewing team performance and prior task activities. Review is characterized by a syntactic frame with variations of semantic roles (e.g., NP V NP PP Theme, NP V NP.Patient). As a verb review is occurring as past and present tense, features path, locative and connective prepositions in announcements. In addition, review descriptive words characterize the reflexivity indicator (e.g., effectively, good job, performance, teamwork). The reflexivity indicator strategy is

characterized by a syntactic frame and semantic roles that support the development of potential plans or strategies (e.g., NP V NP PP.Goal, NP V PP.Co-Agent). As a verb, strategy is occurring as present or future tense appearing in announcements, requests and questions and feature path, locative and connective prepositions. The reflexivity indicator strategy implementation is characterized by a syntactic frame and semantic role similar to the reflexivity indicator strategy, to supports also adaptation and implementation of the developed strategies or plans. As a verb strategy implementation is appearing as present and future tense and appears to majority in announcements. Path, locative and connective preposition also identify this classifier.

All three classifiers indicate a diverse syntactic frame and use of semantic frames, which can be attributed to the variety of context specific information. Yet, compared to the cognitive behaviors, these classifiers are not as distinct in their classification characteristics. Particular the reflexivity classifier strategy development and strategy implementation display similar syntactic structure and behaviors which might make it difficult for analytics to discriminate between one another. This might be caused by the limitation of the environment and task the virtual teams had to accomplish. Future research should therefore look at different task events and environments to expand and train classifiers further.

Overall, this part of the study presents a first approach to identify reflexivity indicators in team communication and further analyze which speech act and cognitive behaviors can be observed. Besides the classifiers limitation, the classifier model can be used and expanded for natural language processing to automatically identify reflexivity indicators. In the following, the overall proposed model is specified with the prior classified cognitive behavior and reflexivity indicators. This section also presents the experimental phase of this research by examining the nature of reflexivity transition and action phase in form of communication shifts, the effect of diversity on communication, and the overall effect of team reflexivity intervention on cognitive behaviors in communication.

5.6 Discussion and Conclusion

This summary provides the findings and contribution of Chapter Five (5). Discourse analysis was used to examine cognitive behaviors in communication. A three-pass qualitative coding process reveals which cognitive behavioral indicators contribute to team cognition. A low level analysis of behavioral speech act, syntax and identification of verb use was conducted to identify which communication is indicative of cognitive behaviors

communication. Major findings from the case studies in regards to hypothesis testing are summarized in Table 38.

5.6.1 Findings

This section summarizes the findings and contribution of the research described in this Chapter.

- i. *An outline and definitions of cognitive behaviors communicated.* A coding scheme based on research about cognition was developed and used to identify communication utterances that contributed to the identification of 13 specific indicators of cognitive behaviors. This process involved close attention to context, background knowledge, linguistic phenomena on which team members relied on when communicating.
- ii. *A resource for qualitative coding of team communication.* The identification of cognitive behavior indicators and the coding process created a basis for this and future research. The process of identifying communication utterances involved a five step manual coding process based on the coding schemes and inductive analysis of communication. Through the coding procedure, cognitive behavior and reflexivity indicators could be identified in the utterances and tagged according to classes. The result of each of these passes of coding served to categorize the utterances at different levels of granularity.
- iii. *A discourse analytic description of communication that displayed speech act behavior, verb use and syntactic construction.* The process of identifying speech act indicators, verb use and syntactic construction in team communication involved a fine granulated analysis of the language form relied on by team members. This involved the analysis of speech act behavior indicators employed by team members (e.g., request, announcement, question, reply, comment, confirmation, read-back), the indicators of verbs used, and a syntactic construction that represented the indicators. The result of each of these passes of coding and analysis served to construct a key for tagging cognitive behavior and reflexivity indicators in communication.
- iv. *A resource for the development of natural language processing techniques that classify cognitive behavior communication based on the content of the message.* With the identification of VerbNet classes through cognitive behavior and reflexivity indicators that show high representation in messages, a key for tagging those indicators was developed. The key serves as a foundation for natural language

processing application to identify cognitive behavior and reflexivity information in team communication.

Table 38. Summary of Hypotheses of Indicators in High vs. Low Performing Teams.

Number	Hypothesis	Results
Hypotheses to Indicators in High versus Low Performing Teams		
1.1	Different SA cognitive behaviors are displayed in teams in regards to high versus low team performance.	Supported.
1.2	Different TMS cognitive behaviors are displayed in teams in regards to high versus low team performance.	Partially supported. ¹
1.3	Different speech act behaviors are displayed in teams in regards to high versus low performance.	Rejected
1.4	Different reflexivity behaviors are displayed in teams in regards to high versus low performance.	Partially supported. ¹

¹No significant difference for some of the indicators in teams that were high versus low performing.

5.6.2 Significance of Findings

Chapter Five (5) demonstrate teams to communicate information that contributes to cognitive behavior. The detailed analysis of team communication content revealed in what ways team members rely on linguistics, context, and background to convey many types of cognitive behavior information that supports overall team communication and team performance. This study also provides an overview of the type of cognitive behaviors team members communicate in socio-technical situations. Additionally, an approach is provided for the development of natural language processing to aid in automatically identifying team communication that contain cognitive behaviors like SA and TMS.

6 Results of Cultural Awareness and Diversity Hypothesis Testing

The aim of the second part of research was to examine the effect of cultural awareness and diversity on communication contribution. This Chapter presents the study's findings as they relate to the hypotheses questions. To identify whether team members were accurately cultural aware of ethnic or language diversity and whether such diversity impacted communication contribution and performance, non-parametric statistics were conducted.

6.1 Method Procedure of Cultural Awareness and Diversity

Communication patterns across virtual teams of different cultural backgrounds, specifically, teams consisting of English speakers and nonnative English speakers were analyzed. An interaction analysis approach was chosen to quantitatively assess language structure such as frequency and types of verbal interaction. As defined by Aritz & Walker (2010) member contribution was measured by tracking the number of turns taken by team members, the number of words communicated, and the average turn length. The transcripts were coded for analysis in those three areas. Not included in the analysis were the number of overlaps, backchannels, latching and interruptions, because in a computer-mediated communication environment these aspects are essentially nonexistent. Turn-taking was defined as the ordering of moves that involves the interchanging of messages by team members (Aritz & Walker, 2010). Contribution was also tracked by counting the number of words written. The numbers of words written were chosen, because this has been found to be a better indicator of contribution, particularly, since some of the team members were not writing in their native language (Aritz & Walker, 2010). These team members might take longer to formulate sentences or some may be comparably faster in typing than others, even when using their native language. Turn length was another variable to measure team member contribution.

Previous studies noted cultural differences in turn length. For example Clyne (1994) demonstrated that a strong correlation between turn length and cultural groups exist. The average turn length in this research was measured by dividing the total number of words written by each team member by the number of turns they took (e.g., Aritz & Walker, 2010). In addition to the transcripts, participants were asked to complete a short questionnaire. Questions were intended to report participants' biographical data and to assess whether they were aware of fellow team members' whose native language was/was not English and ethnic diversity.

6.1.1 Results of Awareness by Team Members of their Team Composition

The distributional shape of cultural awareness scores was examined to determine the extent to which the assumption of normality was met. The Shapiro-Wilk's test ($p < .001$) (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of the histograms, normal Q-Q plots and box plots indicated cultural awareness scores to not be normally distributed. Therefore to assess cultural awareness across homogenous and heterogeneous teams, a chi-square analysis was conducted at the individual level. Hypothesis 2.1 predicted that team members were aware of their homogeneous or heterogeneous team composition (i.e., ethnically and language diverse). Before computing the analysis, it was assessed whether team members who indicated to be culturally aware of their team diversity, to also be correct in their assumption. Although team members' native language was to 90% English, team members' of which English was not their native language their native language included Arabic, Chinese, German, Georgian, Japanese, Spanish, Swahili and Vietnamese.

Generally, team members varied significantly in their cultural awareness of ethnic diversity $\chi^2(1, N = 248) = 8.53, p = .003$ with a small effect size $\phi = 0.19$. Of all team members, 40.7% possessed cultural awareness of their own teams' diversity, with 59.3% being incorrect. Particularly for heterogeneous teams that are ethnically diverse, team members differed significantly in their cultural awareness ($\chi^2(1, N = 204) = 34.59, p < .001$ with a medium effect size $\phi = 0.41$) with 29.4% being aware of their team members ethnicity. In comparison homogenous teams that were not ethnically diverse team members were to 93.2% aware of their ethnic uniformity ($\chi^2(1, N = 44) = 32.82, p < .001$ with a medium effect size $\phi = 0.86$). Therefore, the hypothesized awareness of team composition was only partially supported, see Figure 10.

Team members were to 74.6% correct in their cultural awareness of their team member's native or non-native language, $\chi^2(1, N = 248) = 60.02, p = .003, \phi = 0.49$. For teams that were composed of language diverse membership, team members were to 36.1 % aware of other team members language being native or non-native English, $\chi^2(1, N = 72) = 5.56, p < .05, \phi = 0.28$. On the other hand, team members of teams in which the primary language was native English their awareness was to 90.3% correct $\chi^2(1, N = 176) = 114.57, p < .001$ with a large effect size $\phi = 0.81$. Only 9.7% of team members were incorrect and thought of having non-native English speakers on their teams. Thus, the hypothesis 2.1 that awareness exist for both homogeneous and heterogeneous team composition was only partially supported for awareness, see Figure 10.

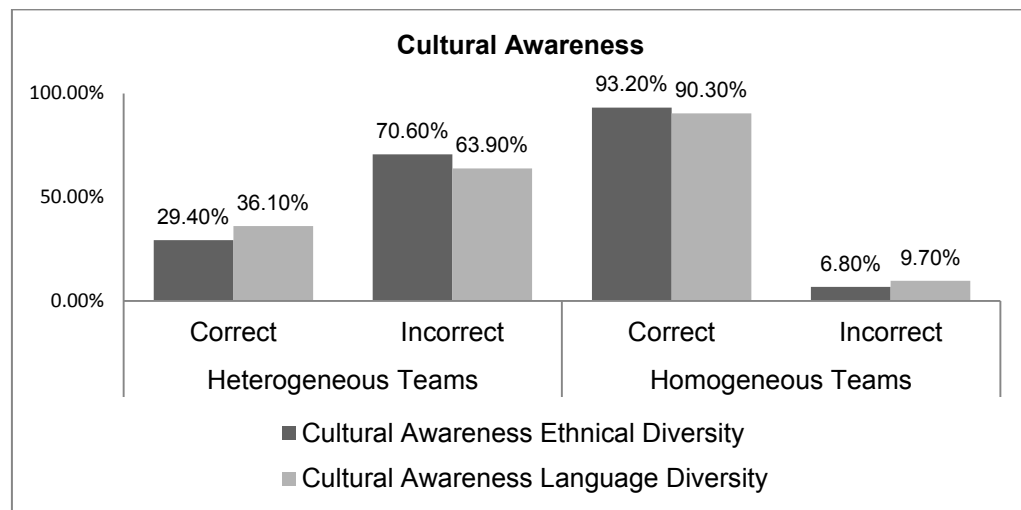


Figure 10. Cultural Awareness in Virtual Teams.

6.1.2 Results of Cultural Aware Teams on Team Performance

To answer the hypothesis 2.2 whether team members that are culturally aware show higher team performance, performance was median split at a performance score of 66.25% at task 2 at to generate categories of high and low performance teams. Although, some individuals underwent experiment interventions (i.e., team reflexivity intervention), this phase of research focuses solely on cultural awareness and overall performance. The effect of team reflexivity intervention in on cultural awareness is discussed in a forthcoming section. A chi-square analysis of team members cultural awareness and performance revealed cultural aware individuals of ethnical diversity to also show higher team performance $\chi^2(2, N = 248) = 10.44, p < .05$ with a small effect size $\phi = 0.21$. Hence, team members of high performance teams were to 50.5% correct aware of ethnical diversity in comparison to low performance teams of 30.6%. However, no cultural awareness difference of language diversity between low and high performance teams was found ($p = .24$), indicating language in computer-mediated communication not to be influenced by language diversity at a moderate to high proficiency. Hence, the hypothesis was only supported for cultural aware teams of ethnic diversity to show higher team performance.

6.1.3 Results of Differences in Contribution of English Native Speakers

To assess the effect of language diversity on virtual team communication, analyses were conducted to examine the differences in contribution of English native speakers and non-native speakers. According to the Shapiro-Wilk's test ($p < .001$) (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of the histograms the data was not normally

distributed, yet test of homogeneity of variance found equal variance between groups. Hence, computing Mann-Whitney U rank-based nonparametric test was justified (Mann & Whitney, 1949).

Hypothesis 2.3 predicted significant differences in contribution of English native speakers and non-native English speaker across tasks in form of turn taking, word count, and turn length in heterogeneous diverse teams. The count of turn taking, measured in number of messages sent across all tasks, were rank ordered and a Mann-Whitney-U-test was used to compare the ranks of the $n = 26$ non-native speakers and $n = 46$ native English speakers. Medians and Ranges are shown in Table 39. The results indicate no significant difference in turn taking was found between native English speakers ($Mdn = 33.5$) and non-native English speakers ($Mdn = 28.5$) across tasks, $U = 565.5, p > .05$. The word count, measured as the number of words communicated across all tasks, were rank ordered and computed. Also no significant difference was found between native English speakers ($Mdn = 186$) and non-native English speakers ($Mdn = 147$) in word count across tasks, $U = 511.5, p > .05$. The scores of turn length, measured in number of words divided by the number of messages sent, were also rank ordered and computed for comparison between native and non-native English speakers. No significance was attained across tasks, $U = 540, p > .05$, indicating native ($Mdn = 5.7$) and non-native English speaker ($Mdn = 5.3$) to exhibit similar turn lengths during computer-mediated communication.

The results demonstrate native and non-native English speaker to exhibit the same communication pattern in form of turn taking, word count or turn length indicate that, for native and non-native speakers, there was no significant difference in turn length during computer-mediated communication. Therefore, the postulated differences between native and non-native English speakers' contribution to virtual team communication was not supported. This result might be influenced by the English proficiency of language diverse team members in a way that other team members' could not recognize any deficiency in the English language used during the computer-mediated communication. This suggests that the language proficiency level of non-native English speakers needs to be accounted for in research that considers the effect on language diversity. Limitations to gained results exist, as the unequal sample size may diminish power of the tests conducted.

Language diversity in teams was proposed to have an effect on communication contribution across tasks. Language diversity scores were grouped into two categories (1 = language diverse, 0 = language not diverse) and aggregated to the team level for statistical

comparison that resulted in $n = 44$ homogeneous teams and $n = 18$ heterogeneous language diverse teams. Table 39 represents descriptive statistics of level of diversity for turn taking, word count and turn length. The Welch's t-test was computed as it adjusts for unequal sample size (Zimmer, 2004), however, in cases where assumption of normality was not met, the Mann-Whitney- U test was applied. Homogeneity of variance was met for all variables ($p > .05$). No significant differences in use of turn taking was found between language diverse and language uniform teams ($U = 335, p > .05$). Further no significant difference between language diverse and uniform teams was found for word count ($t = .903, p > .05$) or turn taking ($U = 383, p > .05$). Table 39 presents Medians and Ranges for turn taking, word count and turn length. Hence, the hypothesis 2.3 was rejected and results indicated language diversity to have no effect on overall communication contribution.

Table 39. Medians and Ranges of Native vs. Non- Native English Speakers.

	Turn Taking	Word Count	Turn Length
	Median (R)	Median (R) <i>Mean</i>	Median (R)
Native English Speakers in Diverse Teams	33.5 (84.0)	186 (524.0)	5.7 (8.9)
Non-Native English Speakers Diverse Teams	28.5 (77.0)	147.0 (341.0)	5.3 (8.22)
Language Diverse Teams	33.9 (67.0)	197.5 (302.5) <i>202.1</i>	5.6 (7.8)
Language Uniform Teams	32.9 (52.8)	176.1 (324.8) <i>181.6</i>	5.9 (5.5)

6.1.4 Results of Cognitive and Speech Act Behaviors in Language Diverse Teams

To assess the effect of language diversity on the communication of cognitive behaviors, analyses were conducted to examine the differences in contribution of teams that are composed of either native and non-native English speakers or solely native English speakers. According to the Shapiro-Wilk's test ($p < .001$) (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of the histograms the data of cognitive behaviors was not normally distributed, and test of homogeneity of variance found equal variance for most data variables. Hence, computing Mann-Whitney- U rank- based nonparametric test was justified for teams with equal variance, while teams not meeting equal variance Mood's Median test was conducted (Mann & Whitney, 1949). No significant differences between language diverse ($n = 18$) and language uniform teams ($n = 44$) were found for number of messages sent of the cognitive behavior SAE perception ($U = 362, p > .05$), comprehension ($U = 388, p$

> 0.5), projection ($U = 363, p > .05$), and action ($U = 271, p = .05$). Total number of SAE cognitive behavior words did also not differ between diverse and non-diverse teams ($U = 378, p > .05$). Although, no significant difference was found for cognitive behaviors SAT perception ($U = 371, p > .05$), comprehension ($U = 356.5, p > .05$) and action ($U = 338.5, p > .05$), language uniform teams indicated significant higher amount of number of messages regarding cognitive behavior projection ($Mdn = .00, M = 4.7, SD = .73; \chi^2(1, N = 62) = 4.55, p = .033, \phi = 0.27$) compared to diverse teams ($Mdn = .00, M = .03, SD = .08$). Total number of SAT cognitive behavior words did not differ between diverse and non-diverse teams ($U = 384, p > .05$).

Further no significant differences between diverse and non-diverse teams were found for the cognitive behavior TMS (specialization $U = 358.5, p > .05$; coordination $U = 313.5, p > .05$; confusion $U = 352, p > .05$, credibility $U = 377, p > .05$ and feedback $U = 343.5, p > .05$). Also teams did not differ in total numbers of TMS cognitive behavior words communicated, $U = 395, p > .05$. Hence, the hypothesis 2.4 was only supported for the cognitive behavior SAT projection indicating language uniform teams to project team future events more than language diverse teams. No further differences in cognitive behaviors between language diverse and language uniform teams were observed. Based on the gained results above, language diverse teams did not indicate a higher amount of TMS cognitive behavior confusion or misunderstanding compared to teams that are language uniform and thus the hypothesis 2.6 was rejected.

To assess the effect of language diversity on speech act behaviors, analyses were conducted to examine the differences in contribution of teams that language diverse or non-language diverse. According to the Shapiro-Wilk's test ($p < .001$) and the visual inspection of the histograms the data of cognitive behaviors was not normally distributed, however, test of homogeneity of variance found equal variance between groups. Hence, computing Mann-Whitney- U rank- based nonparametric test was justified (Mann & Whitney, 1949). Teams did not significantly differ in their speech act behavior in computer-mediated communication request ($U = 350.5, p > .05$), announcement ($U = 395.5, p > .05$), question ($U = 395.5, p > .05$), reply ($U = 361, p = .05$), comment ($U = 355, p = .05$) and confirmation ($U = 324, p = .05$). Overall, the hypothesis 2.5 was rejected for speech act behaviors as language diverse or uniform teams displayed a similar amount of speech act behaviors in computer-mediated communication.

6.1.5 Results of Diverse Teams' Engaging in the Team Reflexivity

Hypothesis 2.7 states team reflexivity intervention to predict higher reflexivity communication in diverse teams during the intervention compared no intervention. As the distribution of the outcome measures had a greater variability than expected under a Poisson distribution negative binomial regression models were specified to account for over – dispersion (Aiken et al., 2015; Hausman, Hall, & Griliches, 1984). The negative binomial regression model analysis with the treatment condition reflexivity (yes, no) as independent variable, and the message or word count of reflexivity (review, strategy development, strategy implementation) as the dependent variable was computed for diverse teams ($n = 18$). The likelihood ratio $\chi^2(1)$ was reported compared to the Wald $\chi^2(1)$, as the likelihood ratio may have higher power for sample sizes realized in group research (Aiken et al., 2015; Cohen, Cohen, & Aiken, 2003).

Team reflexivity intervention was not a predictor of messages sent ($p = .38$) or words written (.17) about review between language diverse teams that received reflexivity condition compared to teams that did not. However, in the negative binomial regression model, reflexivity intervention was a significant predictor of strategy development for messages sent ($\chi^2(1) = 8.47, p < .05$) and words written ($\chi^2(1) = 8.75, p < .05$). Diverse teams in the reflexivity intervention sent 4.59 (95% CI, 1.67 - 12.68) and wrote 4.31 (95% CI, 1.67 - 11.13) times more messages/ words about strategy development compared to diverse teams that did not engage in reflexivity. Team reflexivity was further a significant predictor of strategy implementation for messages sent ($\chi^2(1) = 11.91, p < .05$) and words written ($\chi^2(1) = 8.75, p < .05$). Hence, diverse teams in the reflexivity intervention sent 6.87 (95% CI, 2.4 - 20.46) and wrote 7.49 (95% CI, 2.86 - 19.59) times more messages/ words about strategy development compared to diverse teams that did not engage in reflexivity. See Table 40 for all findings.

Table 40. Diverse Teams Engaging in Team Reflexivity.

<i>Measuring Level</i>	<i>Reflexivity Intervention on Outcome Variable</i>	<i>B</i>	<i>B SE</i>	<i>OR</i>	<i>p</i>
Volume Message sent	<i>Review</i>	0.61	.69	1.83	.38
	<i>Strategy Development</i>	1.53	.51	4.59	.004
	<i>Strategy Implementation</i>	1.93	.55	6.87	.001
Volume Words written	<i>Review</i>	0.69	.51	2.00	.17
	<i>Strategy Development</i>	1.46	.48	4.31	.003
	<i>Strategy Implementation</i>	2.01	.48	7.49	.001

The results support the hypothesis 2.7 only partially, indicating that language diverse teams engaging in the team reflexivity intervention to send and write more messages regarding

strategy development and strategy development compared to language diverse teams not engaging in the intervention. On the other hand, teams reviewed task and team accomplishments similarly. Consequently, team reflexivity interventions are beneficial for improving communication contribution in teams that are language diverse for eliciting the exchange of information regarding strategy development and strategy implementation.

6.2 Discussion and Key Findings

Chapter Six (6) addresses the questions of whether language and ethnical diverse virtual teams differ in the contribution to team communication and whether virtual team members are aware of diversity in their own team composition. Analyses regarding communication contribution, the exhibition of cognitive and speech act behaviors, performance and reflexivity were conducted. Major findings from the hypothesis testing are summarized in Table 41.

6.2.1 Findings

The findings of the first part are described in this section.

- i. *Team composition of diverse team members influences cultural awareness.* Virtual team members' cultural awareness of their heterogeneous or homogeneous team composition was twofold. The majority of team members in homogeneous teams were found to be accurate in their awareness about their team members' cultural background whereas for heterogeneous teams, most team members were unaware of the existence of cultural diversity in their team. Only 29% of team members were aware of their ethnic diverse team composition, while team members were only to 36% aware of language diversity. In these heterogeneous teams, awareness of cultural diversity stayed unnoticed even with the presence of anonymity, suggesting only subtle recognition of cultural diversity in computer-mediated communication. This aligns with prior research done by Vignovic and Thompson (2010) who identified lower awareness of cultural backgrounds to exist in cue deprived computer-mediated environments. Although, cultural awareness existed for both ethnic diversity and language diversity, team members of heterogeneous teams displayed significantly less awareness of other team members being ethnic or culturally diverse. Teams that are culturally aware of ethnic diversity in their teams elicit better team performance compared to teams who stay unaware of their heterogeneous composition. However,

the 36% team members aware of language diversity in their team did not show higher team performance in comparison.

- ii. Native and non-native English speaker contribute similarly to overall communication.* The results demonstrate native and non-native English speaker to exhibit the same communication pattern in form of turn taking, word count or turn length indicate that, for native and non-native speakers, there was no significant difference in turn length during computer-mediated communication. Both native English speakers and non-native speakers contributed similarly to the overall team communication, suggesting language diversity to have minimal to no impact on communication in computer-mediated communication environments. Indeed, language diverse teams did not portray any differences in communication contribution compared to language uniform teams. This is somewhat contrary to findings of Aritz and Walker (2010) who showed that group composition affected communication patterns, but only when cultural diverse participants moved from being a majority to a minority in a group.
- iii. Contribution of cognitive and speech act behaviors.* Although, diverse teams did not demonstrate a higher amount of cognitive and speech act behaviors in communication compared to uniform teams, language uniform teams did exhibit a higher amount of projection regarding communication possible future actions of the team (i.e., SAT projection). Teams that were composed of language diverse teams did also not show higher amounts of confusion or misunderstanding compared to teams that were language uniform. This finding is contrary to prior research suggesting language diverse teams to exhibit confusion and misunderstandings (e.g., Chan et al., 2006). However, language diversity may influence communication contribution if language proficiency has not progressed to a mediocre or higher language level. Future research needs therefore to examine the levels of language proficiency on computer-mediated communication. Particularly, future research needs to determine the level of language proficiency to explore the potential influence of language diversity on cognitive and speech act behaviors within computer-mediated communication.
- iv. Team reflexivity intervention to expedite communication contribution in language diverse teams.* With the gained understanding of the impact of cultural diversity on team communication, team training may be used to help teams to increase information sharing. Indeed, team reflexivity intervention was found to be beneficial for the engagement and communication contribution of language diverse team members,

particularly contributing to the reflexivity phases' strategy development and strategy implementation.

6.2.2 Significance of Findings

The overall results suggest teams operating in computer-mediated communication environments to not be influenced by language diversity, if language proficiency of the native English language is moderate to very high proficiency. Although, teams that were aware of ethnic diversity showed better team performance, awareness of language diversity did not show to have an impact performance. The results still found team reflexivity intervention to be a promising approach to increase communication contribution, specifically regarding strategy development and strategy implementation, in teams that are language diverse.

Table 41. Summary of Hypotheses Cultural Awareness and Diversity.

Number	Hypothesis	Results
Hypotheses		
2.1	There will be a significant awareness by team members of their homogeneous or heterogeneous team composition.	Partially supported.
2.2	Team members that are culturally aware show higher team performance.	Partially supported.
2.3	Significant differences in contribution of English native speakers and non-native speakers in virtual teams exist across time.	Rejected.
2.4	Higher amount of cognitive behaviors are leveraged from team communication in virtual low diversity teams compared to when team diversity is high.	Partially supported.
2.5	Patterns of speech act behaviors in virtual high diversity teams differ from teams low in diversity.	Rejected.
2.6	Diverse teams show a significant higher amount of cognitive behavior of confusion and misunderstanding.	Rejected.
2.7	Diverse teams engaging in the team reflexivity intervention will show more reflexivity during the intervention.	Partially supported.

7 Results of the Underlying Theoretical Model and Hypothesis Testing

The third part of research presents the findings as they relate to research and hypotheses questions. With the identification of cognitive behavior and reflexivity indicators, findings in this Chapter are presented as followed: first, results regarding the underlying theoretical process model of team reflexivity and team cognition are provided; second, the effects of team reflexivity on the intervention phase are presented; third, the temporal nature of reflexivity are provided and discussed and last, findings regarding the effect of team reflexivity on cognitive behaviors across time are presented. While the first findings center on reflexivity's contribution to communication and performance; the latter examines the temporal nature of reflexivity and reflexivity effects on cognitive behaviors across time. Table 42 provides an overview of Means and Standard Deviations of team performance and all variables used.

7.1 Theoretical Model

The central focus of this part of the study was to assess the theoretical process model by which the team reflexivity intervention produced its effects on cognitive behaviors, reflexivity, communication, and performance. The proposed theoretical model is tested as a full model with all possible paths first, then the concentration is laid on mediation effects. This allowed for examining the influence of the exogenous variables including control variables on the endogenous variables for the entire theoretical model. The theoretical model considers the cognitive behavior indicators SA (i.e., SAE and SAT are combined to one construct in this model) and TMS as two separate constructs while reflexivity is considered as a single construct.

7.1.1 Measurement Method

The theorized model was analyzed by employing partial least squares (PLS) path analysis with the statistical software application SmartPLS 2.0 (Hair, Hult, Ringle and Sarstedt, 2014; Ringle, Wende and Will, 2005) and SPSS analyses. The PLS variance-based approach emerged as more suitable as a traditional multiple regression procedure as this part of research was exploratory in nature and the research objective was to predict structural relationships of the theoretical model that regarded a formative measurement model (see Hair, Ringle, and Sarstedt, 2011 for an overview of PLS application).

Results of the Underlying Theoretical Model and Hypothesis Testing

Table 42. Means, Standard Deviations and Aggregated Team Level Intercorrelations.

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
Performance T1 ^a	61.47	7.98													
Performance T2 ^b	66.37	8.78	.20												
Messages Total T1	34.32	20.54	-.09	-.09											
SAE T1	13.15	10.35	-.13	.13	.69**										
SAT T1	9.58	6.24	-.00	.13	.41**	.12									
TMS T1	14.84	8.27	-.15	.28*	.76**	.69**	.54**								
Reflexivity T1	0.97	1.72	.08	.10	.46**	.49**	.48**	.64**							
Messages Total T2	89.92	34.55	.02	-.03	.80**	.52**	.35**	.55**	.33**						
SAE T2	21.68	15.20	.02	.19	.57**	.64**	.12	.54**	.45**	.63**					
SAT T2	24.13	13.10	-.02	.20	.22	.20	.34	.15	.24	.46**	.38**				
TMS T2	41.55	19.82	-.03	.26*	.43**	.47**	.18	.37**	.34**	.61**	.71**	.69**			
Reflexivity T2	1.97	2.07	-.17	.23	.20	.4**	-.04	.22	.20	-.21	.68**	.45**	.66**		
Language Diversity	0.29	0.46	-.16	.05	.03	.02	.02	.11	-.13	-.13	-.01	-.09	-.04	.08	
Ethnical Diversity	0.82	0.38	-.14	.02	.06	.04	.30*	.21	.20	-.18	-.21	-.13	-2.0	-.25	.11

Note. N = 62 teams.

^a Correlations are based on z-score transformed percentages.

* $p < .05$.

** $p < .01$.

^aT1 = Task1.

^bT2 = Task2.

PLS has been applied in various fields of research such as in the area of spectral analysis in the chemical industry (Haaland & Thomas, 1988), feedback control (Piovoso & Kosanovich, 1994; Piovoso, Kosanovich & Pearson, 1992), discriminant analysis (Barker & Rayens, 2003), marketing and product quality research (Fornell and Bookstein, 1982; Mejdell & Skogestad, 1991), organizational and management research (e.g., Hulland, 1999, Konradt et al., 2015; Sosik, Kahai and Piovoso, 2009, Yoo & Kanawattanachai, 2001) and other applications. PLS allows for flexibility in modeling. For example, PLS allows to model conditions in experiments and use indicators or scales as measures of latent variables (Sosik et al., 2009). PLS has also been recommended as a robust tool for early stage research where the theoretical background is still developing (Falk & Miller, 1992), as is the case here.

From a measurement standpoint, PLS enables to conduct combined regression within the same statistical procedure in addition to applying reliability and validity statistics to test the underlying theoretical model (Wold, 1982). Further, PLS estimates relationships among latent variables by including measurement errors in the observable indicators (Fornell & Bookstein, 1982), deals with unreliability and heteroscedasticity issues efficiently (Martens & Naes, 1989), and ultimately does not make general assumptions about data distribution, observation independence or variable metric (e.g., Henseler, Ringle, & Sinkovics, 2009). PLS gets around the data normality assumption for estimating model parameters by using subspaces (Martens & Naes, 1989; Sosik et al., 2009). As such, the data are converted into pseudo-variables (i.e., scores) to capture the variability in the data related to the predictor by presenting a linear combination of variables (e.g., Sosik et al., 2009, Wold, 1985). The modeling statistic facilitates modeling of a relatively large number of indicator variables that are either formative or reflective. This research employs the formative measurement model, as the formative indicators cannot be substituted for each other but instead combine to give rise to the latent variables (Fornell & Bookstein, 1982). With the formative measurement model, a multiple regression model is estimated with the latent construct as the dependent variable and the assigned indicators as independent variables (Hair, Ringle & Sarstedt, 2011). Thus, the indicators are represented with regression weights leading to their latent variable (Hair, Hult, Ringle, and Sarstedt, 2014).

PLS is capable to estimate models with relatively small sample sizes (Chin and Newsted, 1999), which characterizes group research and this study ($n = 62$). For the PLS analyses, the minimum sample size should equal to either 1) 10 times the largest number of formative indicators used to measure one latent variable or 2) 10 times the largest number of

a structural path leading to a latent variable (Chin, 1997, 1998). Based on the rule of 10 (10 x 4 formative indicators and 10 x 6 structural paths leading to a latent variable) a sample size of 60 was required. This study exceeded the required sample size ($n = 62$) which was considered adequate for generating stable parameter estimates. One dummy variable was created to represent the experimental condition of reflexivity intervention (0 = no, 1 = yes), which allowed for assessing mean differences between both conditions. Similar to Konradt and colleagues (2015), while testing different hypotheses, these dummy variables were applied to control for additional effects of the experimental conditions (see also Preacher & Hayes, 2008). Prior to analysis, all indicator variables needed to be standardized as variables were measured on different scales. Given that the PLS draws on standardized latent variable scores, data is automatically standardized (i.e., z-standardized, where each individual indicators has a *Mean* of 0 and *Variance* of 1) through the PLS-SEM algorithm (Hair et al., 2014). As previously stated, 62 observations were used to build the formative measurement model.

The theoretical model of volume of messages of cognitive behavior indicators and reflexivity were assessed. Although, using communication volume for examining a theoretical model regarding reflexivity and cognitive behaviors in PLS is a rather new approach, evidence exists of including communication volume in path model analyses to explain cognitive states (e.g., Yoo and Kanawattanachai, 2001). Variable distributions were inspected and statistics calculated to test normality using the Shapiro-Wilk test. Statistics indicated that the normality assumptions were not met for all indicators and a positively skewed distribution was present, confirming PLS to be the best approach in testing the underlying theoretical model. PLS comprises testing of two models 1) a measurement model (i.e., outer model), specifying the relationships between latent variables and their associated manifest (i.e., observed variables), and 2) a structural model (i.e., inner model), relating latent variables to other latent variables (Chin, 1998). Hence, after assessing the measurement model, the structural model of the theoretical-based model is considered.

7.1.2 Formative Measurement Model

To evaluate the formative measurement model regarding internal reliability and validity, the formative measurement assessment procedure by Hair and colleagues (2014) was followed: 1) Assessing convergent validity through redundancy analysis for each construct 2) examining the issue of collinearity between indicators and 3) evaluating significance and relevance of the formative indicators. To assess convergent validity, a separate redundancy

analysis for each construct was conducted. The global measure of the two constructs cognitive behaviors and reflexivity were used as measures of the dependent construct in the redundancy analysis. The global assessment was used as a single-item construct representing the total volume of messages of indicator variables in task 2. The redundancy analysis of cognitive behavior SA yielded a path coefficient of .977, TMS of .986, and for reflexivity .892, which lied above the threshold of .80, hence providing support for the formative construct’s convergent validity (see, Hair et al., 2014).

In the subsequent step, the formative measurement model was tested for collinearity of indicators. According to the results exhibited in Table 43, credibility had the highest variance inflation factor (VIF; 2.058), indicating VIF values to be uniformly below the threshold of the value 5.0 (e.g., Hair et al., 2014). This concludes that collinearity is not an issue in the formative constructs nor for estimating the PLS path model.

Table 43. Variance Inflation Factor Results.

SA		TMS		Reflexivity		Diversity (covariance)	
Indicators	VIF	Indicators	VIF	Indicators	VIF	Indicators	VIF
Perception	1.572	Specialization	1.659	Review	1.742	Ethnical diversity	1.012
Comprehension	1.590	Coordination	1.221	Strategy Development	1.607	Language diversity	1.012
Projection	1.157	Confusion	1.495	Strategy Implementation	1.188		
Action	1.425	Credibility	2.058				
		Feedback	1.296				

In the following step, the outer weights of the indicators for the significance and relevance were analyzed by means of bootstrapping. Bootstrapping was first introduced by Efron (1979). It draws on repeated samples with replacement from individual data. The empirical distribution of the data replaces a theoretical distribution that underlies the variance in parametric tests. The bootstrapping algorithm was computed with the path weighting scheme, standardized data metric, and the procedure set to no sign changes option, a sample of 62 and recommended 5,000 bootstrap subsamples (Hair et al., 2014). The bootstrap analysis revealed significance for all indicators except projection, confusion, credibility, and language diversity as seen in Table 43. Because of the single-items of performance task 1 and performance task 2, the weights and loadings equal 1 as it was measured as an observed variable in the path model. The indicator language diversity (covariate) was deleted from further analysis, because the outer weight and outer loading were low (Outer loading = -.004, $t = .007$, $p = .994$) and not significant in the measurement model. The resulting single-item

measure of ethnic diversity seemed suitable to use, as this formative indicator was readily observable. Although, language diversity was of importance to this study, earlier results supported language diversity not to be an influential variable on other constructs. See Figure 11 for an illustration of the primary and resulting secondary formative measurement model.

A great number of indicators per construct can result in the likelihood that the formative indicator weights are low in magnitude and statistically nonsignificant, even though the possibility of multicollinearity can be excluded (Cenfentelli and Bassellier, 2009). Because, formative measurements have an inherent limit to the number of indicators that are able to retain a statistically significant weight as described by Cenfentelli and Bassellier (2009), a second order construct is formed for SA and TMS by the first order formative measurement construct.

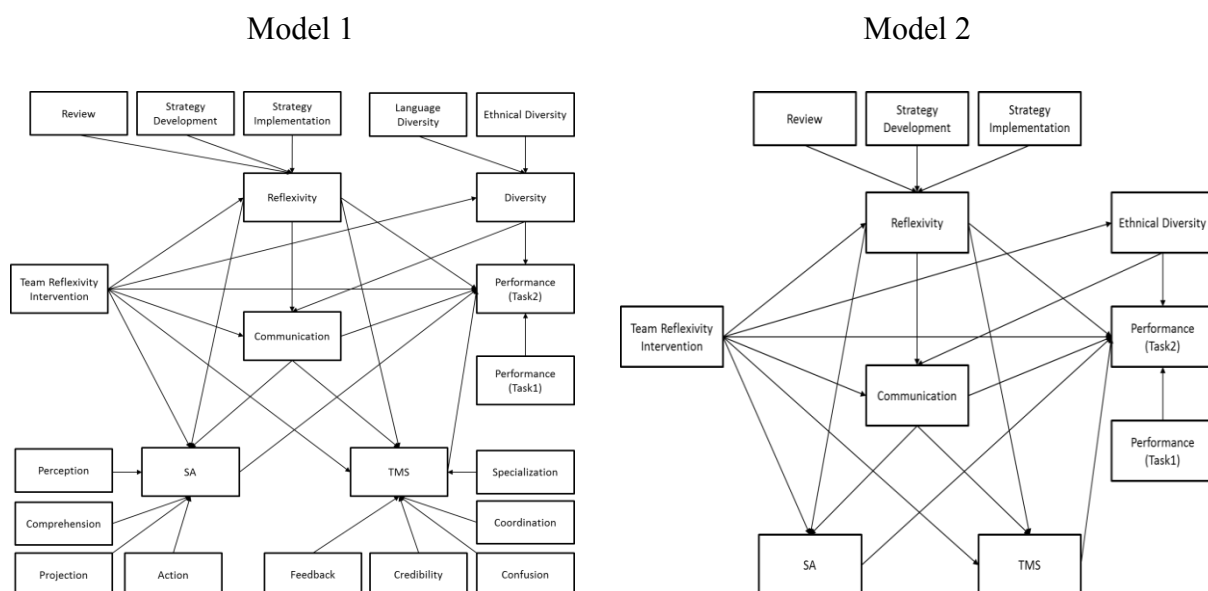


Figure 11. Illustration of Formative Measurement Models.

Here, the second order construct “SA” is formed by its indicators perception, comprehension, projection, and action. Second order constructs were created for both SA and TMS constructs by following a two-step approach (i.e., repeated indicator approach) after Lowry and Gaskin (2014) to analyze the data. In the first stage, the repeated indicator approach was used to obtain latent variable scores for the indicators, which then served as manifest variables in the second order construct. This allowed for other latent variables as predecessors to explain some of the second order constructs variance (Hair et al., 2014). The revised model as seen in Figure 11 and both Tables 44 and 45, clearly meets the requirements of formative measurement models. The established convergent validity, excluding

multicollinearity amongst indicators, and the established significance and relevance of formative indicators suggests a high level of reliability and validity. This can be attributed to the formative measurement model. The subsequent analyses investigated the structural model to depict the relationship between the indicators and their respective constructs.

Table 44. Outer Weights Significant Testing of Formative First Order Model 1.

Formative Constructs	Formative Indicators	Outer Weights	t Value	Significance Level	p Value	Confidence Value Bias Corrected ^a
SA	Perception	.452	3.194	***	.001	.093, .658
	Comprehension	.446	3.256	***	.001	.180, .719
	Projection	.034	.314	NS	.753	-.199, .213
	Action	.320	2.899	***	.004	.087, .529
TMS	Specialization	.298	2.181	**	.029	.045, .557
	Coordination	.596	6.212	***	.000	.343, .722
	Confusion	-.100	.906	NS	.365	-.292, .139
	Credibility	.211	1.624	NS	.104	-.104, .407
	Feedback	.300	2.457	**	.014	.080, .573
Reflexivity	Review	-.217	2.527	**	.012	.030, .540
	Strategy	.646	4.207	***	.000	.305, .813
	Development					
Diversity	Strategy	.744	3.076	***	.002	.106, .602
	Implementation					
	Ethnical	1.006	2.017	**	.044	-.872, .690
Communication	Diversity					
	Language	-.115	.220	NS	.826	-.591, 1.028
Condition	Diversity					
	Communication	1.0				
Performance	Volume					
	Team reflexivity	1.0				
Performance	intervention					
	Task1	1.0				
	Task2	1.0				

Note: NS = not significant.

a. Bootstrap confidence intervals for 5% probability of error ($\alpha = 0.05$).

* $p < .10$. ** $p < .05$. *** $p < .01$.

7.1.3 Structural Model

After generating the formative measurement and structural model, the structural model was assessed to identify the relationship between constructs. The proposed model conceptualized two formative second order constructs of SA and TMS and first order constructs of reflexivity. Before assessing the structural model and test hypotheses by examining path coefficients and their significance levels (Chin, 1998), the structural model was evaluated for collinearity. To assess collinearity, the same measures as in the evaluation of the formative measurement models were applied to examine each set of predictor constructs separately for their subpart of the structural model (Hair et al., 2014). Each predictor construct's revealed VIF values higher than .20 and lower than 5.0 indicating that

collinearity was also not an issue in the structural model (see Hair et al., 2014), see Table 46. To evaluate the structural model for examining hypothesized relationships among the constructs, the significance test for the path coefficients was computed using bootstrapping ($p < .05$, two-tailed test, 5000 subsamples). For evaluating the structural model, the significance levels of each path coefficient, the coefficient of determination (R^2) and the effect sizes of the R^2 values (Cohen's f^2) were calculated. Cohens f^2 was calculated to indicate whether the amount of variance explained is negligible, small (.02), medium (.15) or large (.35) (Chin, 1998; Cohen, 1988).

Table 45. Outer Weights Significant Testing of Formative First and Second Order Model 2.

Outer Weights Significant Testing: Formative first and second order model 2						
Formative Constructs	Formative Indicators	Outer Weights	t Value	Significance Level	p Value	Confidence Value Bias Corrected ^a
Reflexivity	Review	.396**	2.741	**	.006	.087, .649
	Strategy	.572***	3.910	***	.000	.219, .813
	Development Strategy Implementation	.263*	2.292	**	.022	.064, .510
SA	SA	1.0				
TMS	TMS	1.0				
Diversity	Ethnical diversity	1.0				
Communication	Communication Volume	1.0				
Condition	Team reflexivity intervention	1.0				
Performance	Task 1	1.0				
Performance	Task 2	1.0				

Note: NS = not significant.

a. Bootstrap confidence intervals for 5% probability of error ($\alpha = 0.05$).

* $p < .10$. ** $p < .05$. *** $p < .01$.

Table 46. Collinearity Assessment of Structural Model.

First Set "Performance"		Second Set "SA"		Third Set "TMS"		Fourth Set "Communication"	
Constructs	VIF	Constructs	VIF	Constructs	VIF	Constructs	VIF
SA	1.377	Reflexivity	3.392	Reflexivity	3.392	Reflexivity	3.202
TMS	1.799	Communication	1.123	Communication	1.123	TRI	3.050
Reflexivity	3.664	TRI	3.205	TRI	3.205	Diversity	1.103
Communication	1.466						
TRI	3.453						
Diversity	1.160						
Perf Task1	1.134						

7.1.3.1 Evaluation of Heterogeneous Data in the Model

Since this research is an experimental research study which randomly assigned participants to two conditions, it is of interest to first identify differences in the underlying model for teams engaging in the team reflexivity intervention compared to teams that did not. To evaluate the differences between groups, a multi-group analysis was conducted in which the samples of team reflexivity versus control condition are split into subsamples and exposed to separate bootstrap analyses. Based on results, groups did not specifically differ in path coefficients ($p > .10$) indicating no differences existed between conditions in conceptualizing the effects and/ or relations in the structural model (Andreev, Hear, Maoz, & Pliskin, 2009).

7.1.4 Results: Hypothesis Testing of Predictor Variables

To demonstrate meaningful predictive power of the PLS model, high R^2 s and substantial and significant structural paths need to be present (Chin, 1998a). The full model with all possible paths was tested for answering hypotheses questions. Figure 12 indicates that team reflexivity intervention explained 67% of the variance of reflexivity communicated about review, strategy development, and strategy implementation. Further, team reflexivity intervention explained 5% of variance in ethnic diversity and combined with reflexivity explained 11% in overall communication volume. On the other hand, communication and reflexivity explain 19% of variance in SA cognitive behaviors and 38% in TMS cognitive behaviors. Overall, the predecessors of performance task 2 explained together 31% of the variance. Although, some of the paths predictive power was low, the model presents

substantial paths close to .20 and .30 or higher which demonstrates that the model has meaningful predictive power (Chin, 1998).

Reviewing the relative importance of the exogenous, driver construct team, reflexivity intervention on endogenous constructs, team reflexivity intervention was found to be the primary driver for reflexivity. This is illustrated by the increased path coefficients compared with those to performance, communication and the cognitive behaviors. Moving on in the model, although, reflexivity seems not to exert a direct importance on to the endogenous constructs of cognitive behaviors and performance, it was found to be the primary driver for overall communication volume. Hence, an increase in communication regarding reflexivity also increases the overall communication volume. This driver construct communication is of importance for the exhibition of SA and TMS cognitive behaviors in team communication. When considering the relative importance of all exogenous drivers constructs on performance, the cognitive behavior TMS was found to be most important followed by the cognitive behavior SA. Reflexivity on the other side did not exert any direct influence on performance, while communication volume had a negative bearing on performance. Teams high in overall communication volume seem to display lower team performance, suggesting that the act of communication preoccupies the team's ability to perform. See Figure 12 for an illustrative summary of all variables involved.

While some of the hypothesized paths were not significant in the present research model (see Figure 12 and Table 50 for summary of hypothesis testing results) results of team reflexivity intervention indicated a marginal negative relationship with communication volume ($\beta = -.38, p < .10, f^2 = .05$). This result suggests teams engaging in reflexivity intervention to decrease in their overall communication, because these teams were guided during the intervention through which their communication processes became more structured. Thus, a decline in communication of topics irrelevant to team reflexivity intervention might be found. Note, that the variance explained was small. The hypothesis 3.1 that states team reflexivity intervention to increase overall communication volume was therefore rejected. In addition, a marginal negative relationship between team reflexivity intervention and diversity was revealed ($\beta = -0.21, p < .10, f^2 = .05$) indicating teams that receive reflexivity intervention to become more uniform, thus supporting the hypothesis 3.4.

Hypothesis 3.2 which proposed team reflexivity intervention to positively influence reflexivity in communication regarding review, strategy development and strategy implementation, received also support ($\beta = .82, p < .001$). The amount of variance was 67%,

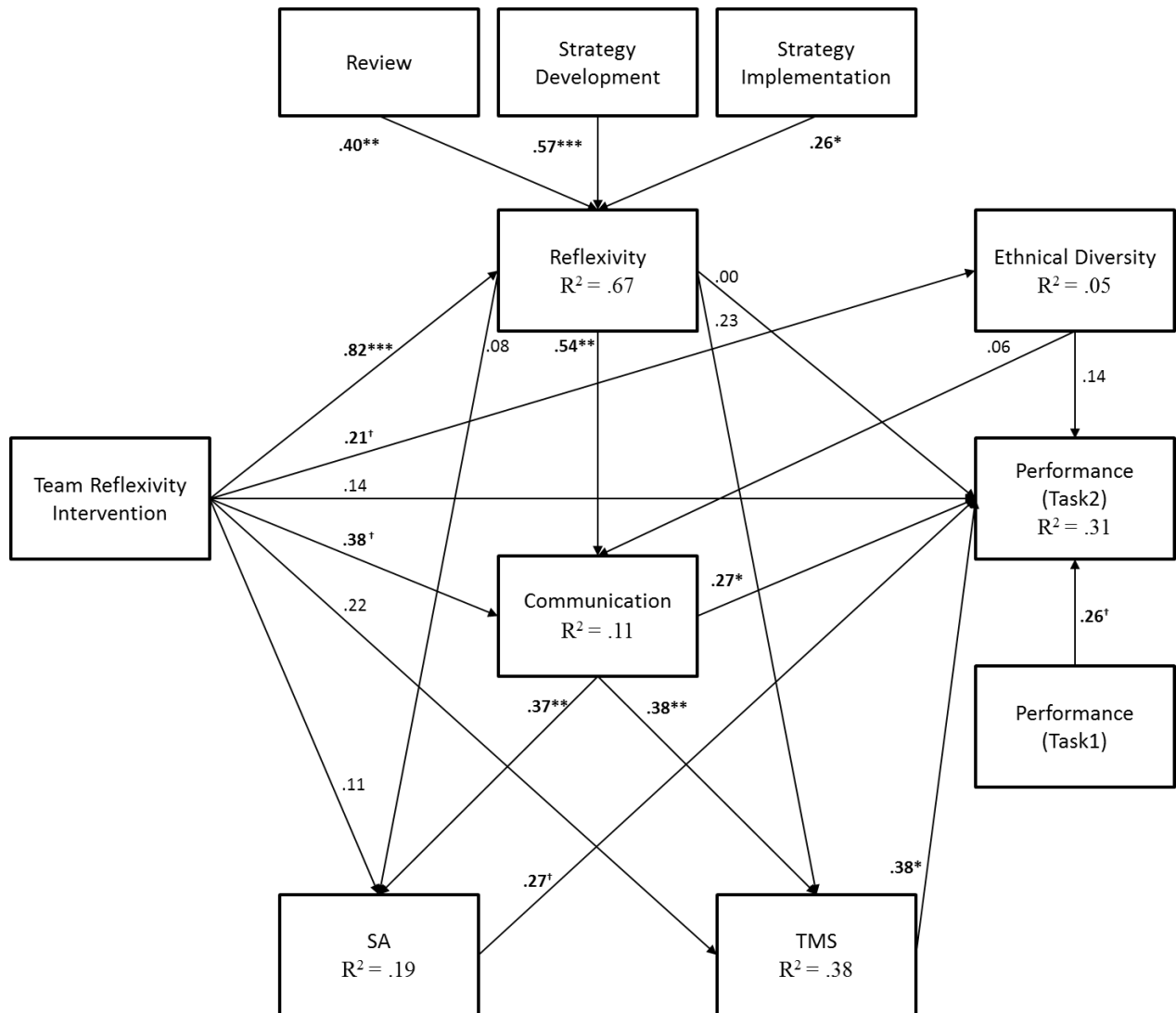
indicating a substantive explanatory power. Thus, teams engaging in team reflexivity increase reflexivity communication significantly. Although, reflexivity intervention was found to positive influence performance when assessing the relationships independent of other constructs (i.e., communication, reflexivity and cognitive behaviors; $\beta = .34, t = 2.805, p = .005, 95\% \text{ CI}, .111 - .569$). An evaluation of team reflexivity intervention in the structural model revealed no significant influence on performance ($\beta = .14, p = .531$), thus partially supporting the hypothesis 3.5. Also a positive influence of team reflexivity intervention on the cognitive behaviors of SA ($\beta = .20, t = 1.767, p = .10, 95\% \text{ CI}, -.036 - .413$) and TMS ($\beta = .43, t = 4.665, p = .000, 95\% \text{ CI}, .239 - .602$) was exerted when assessed independent, in the proposed structural model that comprises all constructs no significance was found ($\beta = .11, p = 0.67; \beta = .22, p = .21$ respectively). This may be attributed to possible mediator or suppressor effects of another construct that suppresses the significance of the direct relationship between team reflexivity intervention and team performance or cognitive behaviors (see next section for mediator effects; Maasen & Bakker, 2001; Urban and Mayerl, 2011). Thus, the hypothesis 3.3 was only partially supported.

Reflexivity communication regarding review, strategy development and strategy implementation exerts a positive relationship to overall communication volume ($\beta = .54, p < .05, f^2 = 0.10$). Hence, the hypothesis 3.6 stating that reflexivity communication positively influences overall communication was supported. However, no significant positive relationships between reflexivity and performance ($\beta = .14, p = .531$), and SA ($\beta = .14, p = .531$) or TMS ($\beta = .14, p = .531$) were revealed. Yet, a marginal significant influence of reflexivity on performance ($\beta = .38, t = 1.868, p = .062, 95\% \text{ CI}, .079 - .639$), cognitive behaviors SA ($\beta = .26, t = 2.761, p = .006, 95\% \text{ CI}, .247 - .614$) and TMS ($\beta = .53, t = 6437, p = .000, 95\% \text{ CI}, .458 - .748$) were exerted when evaluating the relationships independently of other constructs. This suggests possible multiple mediator effects to exist within the structural model (see next section on proposed mediation effects). Thus, hypotheses 3.7 and 3.8 were partially supported in that an influence was present, however, only when assessing the relationships independent of other constructs. See Table 47 for all significant path coefficients and Figure 12 for an illustrative summary of all variables involved.

Hypothesis (3.9) predicted SA and TMS to positively influence performance was marginal significant for cognitive behavior SA ($\beta = .27, p < .10, f^2 = .08$) and significant for cognitive behaviors TMS ($\beta = .38, p < .05, f^2 = .12$). Thus, both cognitive behaviors exhibited in computer-mediated communication resulted in an increase in team performance,

supporting the hypotheses 3.9. A small negative influence was exerted by communication on performance ($\beta = .27, p < .05, f^2 = .07$), suggesting teams high in communication volume to show lower team performance.

Figure 12. Illustrative Summary of PLS Results.



$N = 62$. † $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$. All coefficients are standardized estimates. Team reflexivity intervention: no = 1, yes = 1. Ethical diversity: no = 0, yes = 1.

This result supported hypothesis 3.11, which predicted communication volume to have a negative influence on performance as teams under these circumstances might often be preoccupied with the act of communication rather than action taking. Yet, it was predicted that with an increase in communication volume, an increase in the cognitive behaviors would

be evident, when reflexivity exerts a positive relationship with overall communication volume. Communication volume showed a positive influence on SA and TMS cognitive behaviors in that higher communication volume increases the likelihood for SA and TMS cognitive behaviors to be exhibited ($\beta = .37, p < .05, f^2 = .15; \beta = .38, p < .05, f^2 = .21$); hypothesis 3.12 was thus supported.

Table 47. Significant Path Coefficients of the Structural Model.

	Path Coefficients	T Values	P Values	Confidence Intervals Bias Corrected
TRI → Communication	-.380 [†]	1.881	.060	-.790, -.000
TRI → Diversity	-.211 [†]	1.780	.075	-.444, .019
TRI → Reflexivity	.819***	17.274	.000	.717, .897
Reflexivity → Communication	.539**	2.871	.004	.180, .905
SA → Performance Task2	.268 [†]	1.660	.097	-.042, .580
TMS → Performance Task2	.378*	2.270	.023	.039, .688
Communication → Performance Task 2	-.273*	2.023	.043	-.538, -.009
Communication → SA	.369**	2.951	.003	.039, .549
Communication → TMS	.381**	3.070	.002	.086, .576
Performance Task2 → Performance Task1	.262 [†]	1.886	.059	.014, .559

Note: N = 62; Estimates represent 5000 bootstrapping testing.

[†] $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

7.1.5 Results: Hypothesis Testing of Mediation Effects

Tests of mediation were conducted by assessing the significance of the indirect paths that emerged from the independent to the dependent variables, using the bootstrapping procedures incorporated in SmartPLS. SmartPLS is capable to analyze multiple mediator effects. When examining mediating effects, past work has suggested the bootstrapping approach to be superior to the alternative methods of testing indirect effects (e.g., the Sobel test) with respect to power and Type I and II error rates (MacKinnon, Lockwood, & Williams, 2004). The significance of the indirect effects was analyzed both in the absence of the intervening variable(s) (total effects, denoted C paths) and in their presence (direct effects, denoted C₁ paths). Baron and Kenny's (1986) formal steps for testing mediation were followed: (a) the independent variable indicates an effect on the dependent variable; (b) the independent variable has an effect on the intervening variable(s); and (c) intervening variable(s) affects the outcome, after controlling for the independent variable. To establish full mediation, the total effect of the independent variable on the outcome (C path) must become nonsignificant in the presence of the intervening variable(s) (C₁ path), while the indirect effect is significant. Partial mediation is established when the C₁ path remains

significant but is substantially reduced and the indirect effect is significant. Finally, the significance of the amount of the total effect that is explained by the indirect effects via the mediator(s) was assessed to assure that no suppression effects were present in the model (Shrout & Bolger, 2002) This is a preferable method for describing mediated effects to overcome the full/ partial mediation distinction.

Table 48 shows the total effects for all possible combinations in the structural model. Results of the mediation analysis and the roles of the mediators are displayed in form of indirect effects in Table 49. Key formative constructs were evaluated in form of total effect on how strongly they influence the target variable via a mediating construct. The driver construct reflexivity had a strong total effect on overall communication (0.539) indicating reflexivity to contribute to communication volume. Among the driver constructs, team reflexivity intervention together with reflexivity had the strongest effect on the cognitive behavior TMS (.434, .433 respectively), followed by communication (.381). Specifically, the reflexivity indicator strategy development with an outer weight of .572, seemed to be responsible for eliciting the effect on the cognitive behavior TMS. This indicated that teams who spent more time on developing strategies to form better and exhibit more TMS cognitive behaviors in their communications. In contrast, the driver construct communication showed the strongest effect on the cognitive behavior SA (.369), followed by team reflexivity intervention (.202). Among all the driver constructs, the cognitive behavior TMS presented the strongest effect on performance (.378) followed by the team reflexivity intervention (.318) and the cognitive behavior SA (.268). Therefore, it is of high importance for teams to focus on increasing the exhibition of cognitive behaviors in their communications and to implement team reflexivity interventions for reaching higher performance levels. Although, reflexivity presented a small effect on performance, reflexivity showed strong effects on the cognitive behaviors, which in turn presented strong effects on performance in task 2. The results in Table 48 display the total effects that are significant at a 10% level.

Several multiple mediators for the relationship of the independent variables on the dependent variables were proposed in the theoretical model. Hypothesis 3.13 proposed communications to serve as a mediator on the influence of reflexivity on cognitive behaviors. To test whether this mediation was statistically supported, the bootstrapping method suggested by Preacher and Hayes (2004, 2008) was followed. Communication was found to serve as a partial mediator for reflexivity on cognitive behavior TMS ($\beta = .21$, $t = 2.130$, $p < .036$, 95% CI, .024 -.392, variance accounted for 33%), but not for the cognitive behavior

SA. Hence, the hypothesis 3.13 was only partially supported in that communication acted as a partial mediator in the relationship between reflexivity and TMS cognitive behavior.

Table 48. Significant total Effects of structural Model.

	Path Coefficients	T Values	P Values	Confidence Intervals Bias Corrected
Communication → SA	.369**	2.951	.003	.039, .549
Communication → TMS	.381**	3.070	.002	.086, .576
TRI → Performance Task2	.318**	2.751	.006	.078, .532
TRI → Reflexivity	.819***	17.274	.000	.717, .897
TRI → SA	.202 [†]	1.739	.082	-.044, .416
TRI → TMS	.434***	4.698	.000	.227, .590
Reflexivity → Communication	.539**	2.871	.004	.180, .905
Reflexivity → TMS	.433*	2.311	.021	.193, .896
SA → Performance Task2	.268 [†]	1.660	.097	-.042, .580
TMS → Performance Task2	.378*	2.270	.023	.039, .688

Note: N = 62; Estimates represent 5000 bootstrapping testing.

[†] $p < 0.10$. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

To assess whether SA and TMS mediate the influence of team reflexivity intervention and reflexivity on team performance (Hypothesis 3.10), the mediators were treated independently and analyzed separately. TMS served as a partial mediator for reflexivity communication ($\beta = 0.18$, $t = 2.101$, $p < .036$, 95% CI, .027 - .362, accounted variance 32%) and partial mediator for team reflexivity intervention ($\beta = 0.16$, $t = 2.196$, $p < .028$, 95% CI, .017- .292, accounted variance 32%) on team performance. On the other hand, SA cognitive behavior was not found to mediate the relationship between reflexivity and performance. This supports the hypothesis 3.10 moderately in that the relationship between team reflexivity intervention/ reflexivity and performance was partially mediated through the cognitive behavior TMS.

Table 49. Results of Mediation Testing.

Relationship			Direct Effects	Total Effects	Indirect Effects	Effect
From	To	Via				
Reflexivity	SA	Communication	0.29	0.28	19*	No mediation
Reflexivity	TMS	Communication	0.43*	0.43*	0.21*	Partial mediation
Team Reflexivity Intervention	Performance Task2	TMS	0.34**	0.43***	0.16*	Partial mediation
Reflexivity	Performance Task2	TMS	0.38	0.36**	0.18*	Partially mediation

Note: N = 62; Estimates represent 5000 bootstrapping testing.

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

7.1.6 Results: Diversity and Control Variables

The control variables were comprised of ethnic diversity in computer mediating settings and performance at task 1 to control for training or carry-over effects. Team performance at task 2 was therefore controlled for by ethnic diversity and performance task 1. The control variable of ethnic diversity was dichotomous while the variable for performance at task 2 was continuous. Ethnic diversity exerted no significant impact on communication or performance at task 2 ($p > .10$), thus rejecting the hypothesis 3.14 and 3.15. However, a marginally significant influence of performance task 1 on performance task 2 was found ($\beta = .26, p < .10, f^2 = .09$) indicating possible training effects and/or carry over effects to influence performance at task 2 positively.

7.1.6 Key Findings: Theoretical Model

This section evaluates the proposed theoretical model for cognitive behaviors and reflexivity, rooted in the ITC Theory (Cooke et al., 2013) that builds upon a communication-based approach. The theoretical model aimed to depict relationships of cognitive behavior and reflexivity constructs with regulatory processes on overall team communication in a computer-mediated environment. Major findings from hypotheses testing are summarized in Table 50 and discussed hereafter.

Team reflexivity intervention was found to have no direct effect on performance in the structural model, but shows to significantly increase reflexivity and its indicators review, strategy development and strategy implementation. Team reflexivity intervention seems also to unify teams that show levels of ethnic diversity. While no significant influence of reflexivity on cognitive behaviors is exerted, reflexivity does increase overall communication volume. With the increase in volume of communications, the exhibition of cognitive behaviors increases as well. A partial mediator effect of communication volume was for example found for the relationship between reflexivity and the cognitive behavior TMS. Further, the cognitive behavior TMS was found to mediate the influence of the team reflexivity intervention and reflexivity on team performance.

While the cognitive behavior SA was not found to elicit a mediator effect, the exhibition of the cognitive behavior TMS seems to be the most predominant predictor of overall team performance. Yet, the exhibition of cognitive behavior SA and TMS in utterances leads to a positive influence on team performance. Ultimately, teams with high levels of SA and TMS cognitive behaviors in their team communication show higher performance levels.

Table 50. Summary of Hypotheses of Theoretical Model.

Number	Hypothesis	Results
Hypotheses to main Constructs		
3.1	Team reflexivity intervention positively increases overall communication volume.	Rejected.
3.2	Team reflexivity intervention positively influences reflexivity communication regarding review, strategy development, and strategy implementation.	Supported.
3.3	Team reflexivity intervention positively influences cognitive behaviors SA and TMS.	Partially supported. ²
3.4	Team reflexivity intervention decreases diversity in teams.	Supported.
3.5	Team reflexivity intervention positively increases performance.	Partially supported. ¹
3.6	Reflexivity exerts a positive influence on overall communication volume.	Supported.
3.7	Reflexivity positively influences the exhibition of cognitive behavior SA and TMS.	Partially supported. ⁴
3.8	Reflexivity positively influences performance	Partially supported. ³
3.9	SA and TMS cognitive behaviors positively influence performance.	Supported.
3.11	Higher communication volume will negatively impact performance.	Supported.
3.12	Communication increases the exhibition of SA and TMS cognitive behaviors.	Supported.
Hypotheses to Mediation		
3.10	SA cognitive behaviors mediate the influence of team reflexivity intervention on team performance.	Rejected, n.s.
3.10	TMS cognitive behaviors mediate the influence of reflexivity on team performance.	Supported.
3.13	Communication mediates the relationship between reflexivity and the cognitive behaviors SA and TMS.	Partially supported for TMS.
Hypotheses to Diversity		
3.14	Diversity negatively influences communication volume.	Rejected, n.s. ⁴
3.15	Diversity negatively influences performance.	Rejected, n.s.
Covariate Performance Task 1		
	Performance of Task 1 has no influence on Task 2.	Significant

¹Team reflexivity intervention positively influenced performance when assessed independent.²Team reflexivity intervention positively influenced cognitive behaviors when assessed independent.³Reflexivity positively influenced performance when assessed independent.⁴Reflexivity positively influenced cognitive behaviors SA and TMS when assessed independent.⁵ n.s. = not significant.

However, teams should not be preoccupied with the act of communicating for the reason that high volumes of communication negatively affect performance as the structural model shows. Previous research supports this finding and states communications to negatively affect a team's ability to perform their task during team effort in time pressured environments (van Dijk & Broekens, 2010). Although diversity had no influence on the regulatory processes or overall performance, performance scores attained in the previous task seemed to influence later performance which might be attributed to trainings or carry-over effects to some degree that need to be taken into consideration when evaluating the results of the proposed theoretical model.

Overall, reflexivity has been found to positively impact the level of cognitive behaviors within team communication with a positive outcome on team performance. The exchange of information containing the SA and TMS cognitive behavior indicators expressed during review, strategy development, and/or strategy implementation aid in aligning team interaction processes and improving performance.

7.2 Effect of Team Reflexivity Intervention on Team Performance

In the following section, results on the effect of team reflexivity intervention on overall team performance are presented.

7.2.1 Results: Team Reflexivity Improvement of Team Performance

This section examines hypothesis 4.1 on whether team reflexivity intervention will improve team performance for teams engaging in the intervention. The distributional shape of performance scores was examined to determine the extent to which the assumption of normality was met. The Shapiro-Wilk's test ($p > 0.05$) (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of the histograms, normal Q-Q plots and box plots indicated performance scores to be approximately normally distributed across scenarios and condition. Performance scores were examined at the team level.

Hypothesis 4.1 stated that the team reflexivity intervention would enhance performance for teams in the team reflexivity condition. The hypothesis was tested with an independent z-test for proportions. Z-scores were computed for raw scores of the performance data set. Teams in the reflexivity intervention condition displayed higher team performance in task 2 with an average of 68.5% ($SD = 9.27$), compared to an average performance of 64.2% ($SD = 7.81$), $z = -1.98$, $p < .05$, in the control condition. Further a significant difference between task 1 and task 2 was found for teams engaging in reflexivity

intervention $z = -4.21, p < .05$, but not in the control condition $z = 0.31, p = 0.8$. Teams in the reflexivity group had an average performance improvement of 9.2% while teams in the control had a smaller performance improvement of 0.6%. See Table 42 for the Means, Standard Deviations, and Inter-Correlations of variables. The hypothesis 4.1 of whether team reflexivity intervention effectively increases team performance was hence supported.

7.2.1.1 Excuse 1: Effect of Reflexivity on Low versus High Performance Teams

A median split of the performance scores of task 1 into low and high performance teams was performed to assess whether the team reflexivity intervention is more effective for teams that show initial low performance compared to teams that already perform high. A Welch t-test demonstrated that the team reflexivity intervention was more effective for teams that had initial low performance in demonstrating expedited performance improvements ($M = 13.92, SD = 10.87$) compared to teams that already were high performing ($M = 2.69, SD = 6.54; t(28) = 12.78, p = .001, d = 1.25$). This finding supports the hypothesis 4.1 and indicates that teams engaging in reflexivity interventions have significantly higher and improved performance compared to teams that do not. Yet teams that showed initial poor performance benefited from team reflexivity intervention to the greatest degree.

7.2.1.2 Excuse 2: Reflexivity Predictor of Team Performance

As the theoretical model examined reflexivity as one construct, to understand whether reflexivity phases (review, strategy development and strategy implementation observed during the experimental phase), are good predictors of high performance, a multiple regression analysis was conducted. In the multiple regression analysis, standardized performance score at task 2 was entered as the dependent variable; and standardized performance score at task 1 was entered as a control variable. Reflexivity indicators review, strategy development, and strategy implementation in form of volume of messages sent were then entered as predictor variables. Overall, the multiple regression was marginally significant $F(4, 57) = 2.25, p < .10, R^2 = .14$. Of the predictors investigated, strategy development ($\beta = .39, t(57) = 2.45, p = .017$) was significant. Both review ($\beta = -.05, t(57) = -.31, p = .76$) and strategy implementation ($\beta = -.08, t(57) = -.56, p = .59$) were not significant predictors of performance. These results suggest that of the reflexivity phases, the indicator strategy development is the most effective in predicting team performance.

7.2.2 Key Findings: Effect of Team Reflexivity Intervention on Performance.

Teams that engaged in team reflexivity interventions improved performance by 9.2%, indicating team reflexivity, which is structured to provide guidance, to have a significant impact on team performance. On the other hand, teams that received no team reflexivity intervention did not show any form of performance improvement. The beneficial effect of reflexivity on team performance agrees with prior research on teams and planned reflexivity interventions (Gurtner et al., 2007; Konradt et al., 2015). Teams with initial high performance did benefit from team reflexivity interventions, but teams that initially performed poorly, had a higher benefit with team reflexivity intervention, possibly, due to simply having more room for improvement (Schippers et al., 2013). Specifically, for the positive effect of reflexivity, the reflexivity indicator strategy development was the most promising predictor of high performance outcomes. Major findings from the hypothesis testing are summarized in Table 51.

7.3 Effects of Team Reflexivity on Communication during Intervention

The effect of team reflexivity intervention on reflexivity indicators and cognitive behaviors during the experimental period was examined. Results for indicators exhibited in utterances during intervention are presented for reflexivity indicators (i.e., review, strategy development and strategy implementation) and or cognitive behaviors.

7.3.1 Data Analysis

The analysis in the following section focused on the experimental period, during which teams received either the team reflexivity intervention or the control discussion task. Several considerations informed the analysis of the communication data. The analysis involves aggregated team data. The data rests on a clustered structure in which individuals within each team are more similar to another than one would expect from the scores of randomly composed groups of individuals (Aiken et al., 2015). Thus, a generalized linear model was employed for analyzing the count outcomes of reflexivity and cognitive behaviors during reflexivity phases in computer-mediated team communication with inherent clustering. The count data (i.e., volume number of messages and or words regarding reflexivity or cognitive behaviors in team communication) were positively skewed and hence, violated normal distribution (Aiken, Mistler, Coxe, & West, 2015). As the distribution of the outcome measures had a greater variability than expected under a Poisson distribution (e.g. review message sent $Mean = 6.5$, $Variance = 37.4$), negative binomial regression models

were specified to account for over- dispersion (Aiken et al., 2015; Hausman, Hall & Griliches, 1984). To determine the best model fit statistics, indices and information criteria statistics (e.g., Chi- squared difference test, Akaike’s information criterion (AIC), Bayesian Information Criterion (BIC)) were used for model comparison (i.e., Poisson and negative binomial regression). The model with the smallest BIC was chosen as the best generalizing model. The likelihood ratio $\chi^2 (1) = (D_{p-1} - D_p)$ for individual predictors was reported as compared to the Wald $\chi^2 (1)$. Previous studies suggest the likelihood ratio to have higher power for sample sizes realized in group research (Aiken et al., 2015; Cohen, Cohen, & Aiken, 2003).

7.3.2 Results of the Effect of Team Reflexivity on Reflexivity in Communication

Hypothesis 4.2 stated team reflexivity intervention to predict higher reflexivity communication during the intervention compared to no intervention. The negative binomial regression model analysis with the treatment condition reflexivity (yes, no) as independent variable, and the message or word count of reflexivity (review, strategy development, strategy implementation) as the dependent variable was computed. In the negative binomial regression model, reflexivity intervention was indeed a significant predictor of review ($\chi^2 (1) = 39.1, p < .001$). Teams in the reflexivity intervention sent significant more reflexivity messages about review of 6.5 (95% CI 3.66 - 11.59) times that of teams that were not instructed to reflect. Table 51 presents a summary of negative binomial regression of the predictor reflexivity intervention on reflexivity communication. Reflexivity was further a significant predictor of strategy development ($\chi^2 (1) = 20.47, p < .001$) and strategy implementation ($\chi^2 (1) = 19.98, p < .001$). Hence, teams in the reflexivity intervention sent significantly more reflexivity messages about strategy development of 3.5 (95% CI, 2.06 - 6.07) and strategy implementation of 3.7 (95% CI, 2.08 - 6.41) times that of teams in the control condition.

Table 51. Significant Effects of Team Reflexivity on Reflexivity Communication.

<i>Measuring Level</i>	<i>Reflexivity Intervention on Outcome Variable</i>	<i>B</i>	<i>B SE</i>	<i>EXP(B)₂₀</i>	<i>p</i>
Volume Message sent	Review	1.87	0.29	6.50	0.001
	Strategy Development	1.26	0.27	3.54	0.001
	Strategy Implementation	1.29	0.29	3.65	0.001
Volume Words written	Review	1.55	0.26	4.7	0.001
	Strategy Development	1.24	0.26	3.46	0.001
	Strategy Implementation	1.27	0.26	3.56	0.001

²⁰ The exponential indicates the factor change in odds for every unit increase in the respective independent variable (Long & Freese, 2006).

Similar results were also found on the measurement level words written. Teams in the team reflexivity intervention wrote significantly more words about review ($\chi^2(1) = 33.25, p < .001$), strategy development ($\chi^2(1) = 22.17, p < 0.001$) and strategy implementation ($\chi^2(1) = 22.79, p < .001$). Teams engaging in the reflexivity intervention wrote significantly more words that regarded review of 4.7 (95% CI, 2.84 - 7.82), strategy development of 3.5 (95% CI 2.09 - 5.73), and strategy implementation of 3.6 (95% CI, 2.06 - 6.07) times that of teams not receiving a team reflexivity intervention. See Table 51 for all significant effects of team reflexivity on reflexivity communication. The hypothesis 4.2 was supported indicating teams in the reflexivity intervention to send more messages and use more words indicating deeper level processes of reflexivity. Similar results have been found by Konradt and colleagues (2015), who suggested that teams in the reflexivity condition should use more words regarding reflexivity.

7.3.3 Results of the Effect of Team Reflexivity on Cognitive Behaviors during Intervention

Hypothesis 4.3 predicted a higher amount of cognitive behaviors SA and TMS during reflexivity phases in communication compared to teams that did not engage in the reflexivity intervention. The negative binomial regression analysis model with the treatment condition reflexivity (yes, no) as independent variable, and the message of cognitive behaviors SA and TMS during reflexivity phases (review, strategy development, strategy implementation) as the dependent variable was computed. The generalized regression analysis converged for all variables except SAE projection and TMS feedback model. No observations of the variables in the control condition accounted for this by creating zero counts. As the proposition of the analysis was to compare teams that received and did not receive team reflexivity interventions, merging was not an option and therefore analysis for these outcome variables was terminated. Table 52 presents a summary of the analysis for volume of messages sent

7.3.3.1 Results: Volume of Messages sent

In the negative binomial regression model, reflexivity intervention was a significant predictor of messages sent regarding cognitive behaviors of SEA, $\chi^2(1) = 18.94, p < .001$, indicating teams in the reflexivity condition to exhibit significantly more SAE cognitive behaviors of 3.4 (95% CI, 1.97 - 5.86) times that of teams not receiving the team reflexivity intervention. Specifically, reflexivity intervention was a significant predictor of SAE perception ($\chi^2(1) = 11.79, p = .001$) and comprehension ($\chi^2(1) = 11.93, p = .001$) during the reflexivity phase review. Teams in the reflexivity intervention displayed significantly more

Table 52. Significant Effects of Team Reflexivity on Cognitive Behaviors.

Measuring Level	During Reflexivity Phase	Reflexivity Intervention on Outcome Variable	B	B SE	OR	p
Volume Message sent	Reflexivity	SAE	1.22	.28	3.40	.001
	Review	SAE perception	1.50	.47	4.50	.001
	Review	SAE comprehension	1.47	.45	4.33	.001
	Strategy Development	SAE comprehension	1.40	.38	4.07	.001
	Strategy Development	SAE action	1.33	.39	3.79	.001
	Strategy Implementation	SAE perception	2.20	1.08	9.00	.011
	Strategy Implementation	SAE comprehension	1.65	.43	5.20	.001
	Strategy Implementation	SAE action	2.04	.50	7.67	.001
	Reflexivity	SAT	0.75	.26	2.12	.005
	Review	SAT perception	1.67	.40	5.33	.001
	Review	SAT comprehension	1.31	.50	3.71	.005
	Review	SAT action	1.21	.43	3.36	.003
	Strategy Development	SAT comprehension	1.39	.35	4.00	.001
	Strategy Development	SAT action	0.80	.30	2.23	.008
	Strategy Implementation	SAT perception	2.30	1.08	10.00	.006
	Strategy Implementation	SAT comprehension	0.83	.31	2.29	.008
	Strategy Implementation	SAT projection	2.04	.66	7.67	.001
	Strategy Implementation	SAT action	0.61	.31	1.84	.047
	Reflexivity	TMS	1.24	.26	3.45	.001
	Review	TMS specialization	1.82	.34	6.17	.001
	Review	TMS coordination	1.17	.40	3.21	.003
	Review	TMS credibility	3.22	.76	25.00	.001
	Review	TMS feedback	2.00	.42	7.40	.001
	Strategy Development	TMS specialization	1.31	.36	3.70	.001
	Strategy Development	TMS coordination	1.21	.29	3.34	.001
	Strategy Development	TMS comprehension	0.83	.31	2.29	.008
	Strategy Development	TMS credibility	2.40	.50	11.00	.001
	Strategy Implementation	TMS specialization	1.45	.31	4.28	.001
	Strategy Implementation	TMS coordination	.95	.34	2.58	.005
	Strategy Implementation	TMS credibility	3.00	1.06	20.00	.001

perception of 4.5 (95% CI, 1.87 – 11.83) and comprehension of 4.3 (95% CI, 1.86 – 10.92) times that of teams in the control condition during review. Cognitive behavior projection had to be excluded for the low level analysis, due to convergence criteria not being satisfied. The reflexivity intervention was not found to significantly increase action ($p = .10$) during review as was expected according to the results from the transition and action phase model of reflexivity (Marks et al., 2001; West, 2000). See Table 54 for all significant results of the analysis.

Teams that received reflexivity intervention did not show significantly higher cognitive behaviors SAE perception ($p = .19$) and projection ($p = .13$) during strategy development compared to teams that did not participated in the team reflexivity intervention. Yet, reflexivity intervention was a significant predictor of messages sent regarding SAE

cognitive behavior comprehension ($\chi^2(1) = 14.22, p < .001$) and action ($\chi^2(1) = 12.22, p < .001$) during strategy development, demonstrating teams in the reflexivity condition to display significantly more comprehension of 4.1 (95% CI, 1.94 - 8.82) and action of 3.8 (95% CI, 1.78 - 8.38) times that of teams not receiving team reflexivity intervention. In addition, reflexivity was a significant predictor of SAE cognitive behavior perception ($\chi^2(1) = 6.47, p < .05$), comprehension ($\chi^2(1) = 16.66, p < .001$) and action ($\chi^2(1) = 20.56, p < .001$) during strategy implementation. These teams displayed 9.0 (95% CI, 1.55 - 171.02) times the SAE cognitive behavior perception, 2.3 (95% CI, 2.31 - 12.54) times comprehension 7.7 (95% CI, 3.03 - 22.36) times action compared to teams that did not engage in reflexivity. Cognitive behavior projection had to be excluded for the low level analysis.

In the negative binomial regression model, reflexivity intervention was a significant predictor of messages sent regarding cognitive behaviors of SAT, $\chi^2(1) = 7.94, p < .05$, suggesting teams in the reflexivity condition to exhibit significantly more SAT cognitive behaviors of 2.1 (95% CI, 1.26 - 3.56) times that of teams not receiving the team reflexivity intervention. Indeed, reflexivity intervention was a significant predictor of SAT perception ($\chi^2(1) = 18.98, p < .001$), comprehension ($\chi^2(1) = 7.82, p < .001$) and action ($\chi^2(1) = 8.66, p < .05$) during review. Teams in the reflexivity intervention displayed significantly more perception of 5.33 (95% CI, 2.47 - 12.15), comprehension of 3.71 (95% CI, 1.46 - 10.44) and action of 3.4 (95% CI, 1.49 - 8.02) times that of teams in the control condition during review. However, teams displayed the same amount of the SAT cognitive behavior projection ($p = 1.0$) during the phase of reflexivity. Teams that received reflexivity intervention did not show significantly higher cognitive behaviors SAT perception ($p = .07$) and projection ($p = .35$) during strategy development compared to teams that did not participated in the team reflexivity intervention. Yet, reflexivity intervention was a significant predictor of messages sent regarding SAT cognitive behavior comprehension ($\chi^2(1) = 16.42, p < .001$) and action ($\chi^2(1) = 7.12, p < .001$) during strategy development, demonstrating teams in the reflexivity condition to display significantly more comprehension of 4.0 (95% CI, 2.04 - 8.02) and action of 2.2 (95% CI, 1.24 - 4.04) times that of teams not receiving team reflexivity intervention.

Team reflexivity intervention was a significant predictor of SAT perception ($\chi^2(1) = 7.4, p < .05$), comprehension ($\chi^2(1) = 6.94, p < .05$), projection ($\chi^2(1) = 12.86, p < .05$) during strategy implementation. Teams in the reflexivity intervention displayed significantly more perception of 10.0 (95% CI, 1.76 - 189.09), comprehension of 2.29 (95% CI, 1.24 - 4.25),

projection of 7.67 (95% CI, 2.36 - 34.69) times that of teams in the control condition during strategy implementation. The reflexivity intervention was also found to be a marginal significant predictor for SAT cognitive behavior action during strategy implementation, $\chi^2(1) = 3.95, p < .05$, of 1.84 (95% CI, 1.01 - 3.38) times that of teams that did not receive the reflexivity intervention.

For the cognitive behavior TMS, the team reflexivity intervention was found to be a significant predictor of message sent, $\chi^2(1) = 21.26, p < .001$, indicating teams in the reflexivity condition to display significantly more TMS cognitive behaviors of 3.45 (95% CI, 2.06 - 5.79) times that of teams not receiving the reflexivity intervention. For instance, reflexivity intervention was a significant predictor of TMS specialization ($\chi^2(1) = 30.23, p < .001$), coordination ($\chi^2(1) = 9.10, p < .05$), credibility ($\chi^2(1) = 34.28, p < .05$) and feedback ($\chi^2(1) = 26.09, p < .05$) during the reflexivity phase review. Teams in the reflexivity intervention displayed significantly more specialization of 6.17 (95% CI, 3.22 - 12.06), comprehension of 3.21 (95% CI, 1.50 - 7.17), credibility of 25.0 (95% CI, 6.90 - 161.22) and feedback of 7.4 (95% CI, 3.34 - 17.64) times that of teams in the control condition in review. TMS cognitive behavior confusion had to be excluded for the low level analysis, due to convergence criteria not being satisfied.

Reflexivity intervention was a significant predictor of TMS specialization ($\chi^2(1) = 13.92, p < .001$), coordination ($\chi^2(1) = 17.45, p < .001$), credibility ($\chi^2(1) = 30.67, p < .001$) and feedback ($\chi^2(1) = 26.09, p < .05$) during the reflexivity phase strategy development. Teams in the reflexivity intervention displayed significantly more specialization of 3.7 (95% CI, 1.85 - 7.57), coordination of 3.3 (95% CI, 1.91 - 5.87), and credibility of 11.0 (95% CI, 4.41 - 31.75) times that of teams in the control condition during strategy development. Teams that received reflexivity intervention did not show significantly higher cognitive behaviors TMS confusion ($p = .11$) during strategy development compared to teams that did not participated in the team reflexivity intervention. TMS cognitive behavior feedback had to be excluded for the low level analysis, due to convergence criteria not being satisfied.

Reflexivity intervention was a significant predictor of TMS specialization ($\chi^2(1) = 21.96, p < .001$), coordination ($\chi^2(1) = 7.74, p < .05$), credibility ($\chi^2(1) = 16.68, p < .001$) and feedback ($\chi^2(1) = 26.09, p < .05$) during strategy implementation. Teams in the reflexivity intervention displayed significantly more specialization of 4.28 (95% CI, 2.34 - 7.91), coordination of 2.6 (95% CI, 1.32 - 5.10), and credibility of 20.0 (95% CI, 3.80 - 369.80) times that of teams in the control condition during strategy implementation. Teams that

received reflexivity intervention did not show significantly higher cognitive behaviors TMS confusion ($p = 1.0$) during strategy implementation compared to teams that did not participated in the team reflexivity intervention. TMS cognitive behavior feedback had to be excluded for the low level analysis, due to convergence criteria not being satisfied.

The hypothesis 4.3 was supported for teams engaging in team reflexivity intervention that displayed during a) review cognitive behavior SAE perception and comprehension; SAT perception, comprehension and action; TMS specialization, coordination, credibility and feedback; b) strategy development cognitive behavior indicators SAE comprehension and action; SAT comprehension and action, TMS specialization, coordination, credibility and feedback; c) strategy implementation cognitive behavior indicators SAE perception, comprehension and action; SAT perception, comprehension, projection and action; and TMS specialization, coordination, credibility and feedback.

7.3.3.2 Results: Volume of Words written

Generally, teams in the team reflexivity intervention wrote significantly more words about SAE during reflexivity communication ($\chi^2(1) = 7.623, p = .006$), but not significant more words about SAT ($\chi^2(1) = 2.43, p = .12$) and TMS ($\chi^2(1) = 3.34, p = .07$). Teams engaging in the reflexivity intervention wrote significantly more words that regarded SAE cognitive behaviors of 2.04 (95% CI, 1.23 - 3.37) times that of teams not receiving a team reflexivity intervention. Hence, assessing number of words written across reflexivity phases did only reveal a significant finding for SAE cognitive behaviors, thus partially supporting hypothesis 4.3. Although, significance was found for the effect of team reflexivity on cognitive behaviors, no understanding was provided on how deep teams engaged in reflexivity. In future research, the analysis of cognitive behaviors should also be tailored to evaluate each of the reflexivity phases as the overall effect of team reflexivity on cognitive behaviors exhibited during reflexivity communication may be assessed more accurately and readily.

7.3.4 Key Findings: Effects of Team Reflexivity on Communication

This section provides key findings on the effects of team reflexivity intervention on communication during the time the intervention takes place. Teams participating in team reflexivity intervention exhibited more reflexivity indicator's (i.e. review, strategy development, and strategy implementation) which was characterized by both a higher volume of messages sent and words written. Teams exchanged information regarding reviewing team performance and team tasks, as well as actively participated in the development of strategies,

and communicated about the implementation of those strategies. While these results support findings by Konradt and colleagues (2015) suggesting teams in the reflexivity condition to use more words regarding reflexivity, the current findings postulate teams to also engage in reflexivity at a deeper level to tackle challenging assumptions about shared and underlying objectives in the joint team task (Schippers et al., 2014).

Teams that participated in team reflexivity intervention showed greater amount of cognitive behaviors in reflexivity phases during the intervention. The cognitive behaviors displayed in each reflexivity phase may elicit a deeper level of reflexivity and contribution to overall team cognition for developing and implementing strategies (i.e., action taking). Table 53 displays a summary of the results of exhibited cognitive behaviors during the reflexivity phases. The Table shows that to majority the same cognitive behaviors across the reflexivity phases are displayed in teams that participate in team reflexivity. Yet, indicators for strategy implementation differed especially for the cognitive behaviors SAE and SAT.

Table 53. Results of Exhibited Cognitive Behaviors during Reflexivity Phases.

Cognitive Behaviors	Review	Strategy Development	Strategy Implementation
SAE	Perception, Comprehension	Comprehension, Action	Perception, Comprehension, Action
SAT	Perception, Comprehension, Action	Comprehension, Action	Perception, Comprehension, Projection, Action
TMS	Specialization, Coordination, Credibility, Feedback	Specialization, Coordination, Credibility, Feedback	Specialization, Coordination, Credibility, Feedback

Overall, teams receiving the reflexivity intervention showed high volumes of SA cognitive behavior during the reflexivity phase review. The SA cognitive behaviors concerned information regarding conditions or actions of environmental (e.g., SAE) and team factors (e.g., SAT) as well as information about external and internal related occurrences for understanding their location or relationships (i.e., perception and comprehension). Further, teams displayed higher volume of SAT cognitive behavior concerning information regarding action taken by the team (i.e., action) during review. Table 53 displays under column strategy development the exhibition of higher levels SA cognitive behaviors comprehension and action for teams engaging in team reflexivity. On the other hand, as presented in the Table 53 under strategy implementation (i.e., action phase), teams engaging in team reflexivity

demonstrated higher volumes of all SA indicators (i.e., perception, comprehension, projection, and action). Particularly then when focusing on activity within the own team.

Further, the Table 53 presents the three reflexivity phases with the information regarding cognitive behavior TMS exchanged by teams that engaged in team reflexivity. To majority, teams exchanged cognitive behaviors regarding team members' expertise and status, task coordination and prioritization, accepting or confirming procedural suggestions or cross checking information, and providing feedback regarding task accomplishments (TMS specialization, coordination, credibility and feedback). Hence, teams that pass through each reflexivity phase not only exhibit higher amounts of cognitive behaviors, but also seem to engage in a deeper level of reflexivity. For instance, a deeper level of engagement may have translated into action or change in action taking. Hence, exhibiting these cognitive behaviors in all of the reflexivity phases may be of great importance for the overall team outcome. Especially since these cognitive behaviors have been found to positively affect performance (see section 6.1 for results of the theoretical model). Major findings from the hypothesis testing are summarized in Table 54.

Table 54. Summary of Hypotheses to the Effect of Team Reflexivity.

Number	Hypothesis	Results
Hypotheses		
4.1	Team reflexivity intervention will improve team performance	Supported.
4.2	Teams engaging in the team reflexivity intervention will show more reflexivity in communication during the intervention.	Supported.
4.3	Teams engaging in the team reflexivity intervention will show more cognitive behaviors in reflexivity phases during the intervention.	Partially supported. ¹

¹ For some indicators, no difference was found for teams engaging in the team reflexivity intervention compared to those that did not.

7.4 Temporal Nature of Reflexivity - Reflexivity Transition and Action Shifts

In the following section, results on communication shifts of reflexivity phases (i.e., transition and action) in computer-mediated team communication are presented and discussed. In addition, a detailed overview of the methods used to analyze reflexivity shifts is provided.

7.4.1 Method of Measuring Reflexivity Communication Shifts

To understand the temporal nature of shifts regarding reflexivity during the transition and action phase better, the focus was set on communication flow among topics regarding reflexivity. Moreover, it was of interest to examine how communication shifts in teams subjected to a reflexivity intervention compared to shifts in teams not subjected to an intervention. Particularly as reflexivity intervention may direct discussions for initiating transition processes of reflection and planning. According to the procedure for process shifts by Kennedy and McComb (2014), a shift of the transition phase of reflexivity was present, when teams completed the transition process. For this research, the transition phase was present, when teams either reviewed their performance or developed a strategy and shifted between or to the action phase of reflexivity. An action phase was present when team members were engaged in the action process of monitoring, tracking or performing a task (Kennedy & McComb, 2014).

For understanding the flow of communication shifts among the reflexivity phases, it was necessary to examine the transition patterns and when the transitions occurred. Hence, each message shift was measured by indicating whether teams stayed on the same topic or digressed to another topic. Both for the transition and action phase, the start was measured as the message at which the team first communicated about implementing the strategy or their actions. The message was determined as staying the same if the shift occurred within the phase topic or was determined as digressed if the shift occurred to a different phase or topic. Similar to Kennedy and McComb (2014), the phase shift measure was scaled to accommodate for variations of the communication length. Here, the message was divided by the total number of messages of team communication to represent the proportion of transitions from topic to topic. As team discussions vary across time during team interaction, communication over time was captured and the data parsed into quartiles (e.g., Ballard, Tschan, & Waller, 2008; Hewes & Poole, 2012; Kennedy & McComb, 2014; Yoo & Kannawattachai, 2001). The first 25% of messages were denoted to quartile 1, the second 25% of messages to quartile 2, the third 25% of messages to quartile 3, and the fourth 25% of messages to quartile 4.

7.4.2 Results of Communication Shifts of Reflexivity Phases across Time

The hypothesis 5.1 of whether teams are shifting between reflexivity phases differs across time was analyzed. In Table 55, the proportions of communication shifts for each quartile are presented for teams that engaged in the reflexivity intervention. The highest

proportion of communication shifts centered on the same topic review and strategy development in the reflexivity transition phase across time (i.e. quartiles). The highest proportion of communication shifts in the reflexivity action phase was also centered on the same topics, here on strategy implementation and action. Proportion on the digression of teams from one topic to another between reflexivity phases varied across quartiles. Hence, as the Table of proportions indicates, different reflexivity phases are important at different times during team collaboration. In the following, results between the shifts are presented.

Table 55. Proportions of Reflexivity Phases of Quartiles.

From	To	All Qs	Q1	Q2	Q3	Q4
Review	Review	.019	.009	.034	.028	.003
Review	Strategy		.003	.013	.008	.001
	Development	.006				
Review	Strategy		.001	.004	.002	.001
	Implementation	.002				
Review	Action	.004	.005	.001	.006	.003
Strategy	Review		.001	.010	.008	.002
Development	Strategy	.005				
Strategy	Strategy		.008	.053	.026	.003
Development	Development	.023				
Strategy	Strategy		.005	.006	.009	.001
Development	Implementation	.005				
Strategy	Action		.008	.010	.009	.004
Development	Review	.008				
Strategy	Strategy		.003	.004	.003	.001
Implementation	Development	.003				
Strategy	Strategy		.002	.006	.007	.002
Implementation	Development	.004				
Strategy	Strategy		.024	.021	.027	.010
Implementation	Implementation	.021				
Strategy	Action		.021	.004	.009	.007
Implementation	Review	.010				
Action	Strategy	.005	.005	.008	.005	.001
	Development		.007	.008	.009	.003
Action	Strategy	.007				
	Implementation		.009	.004	.006	.005
Action	Action	.006				
		.118	.125	.049	.086	.211

To examine the proportion on communication shifts of reflexivity phases, the data central to the team that engaged in the reflexivity was computed. Quartiles of communication for teams that participated in reflexivity intervention included task 1, reflexivity intervention and task two accordingly. Communication shifts of reflexivity phases were examined by computing independent t-tests. For cases in which equality of variance was not met, the un-pooled estimate for the error term was used and adjustments to the degrees of freedom were made to correct the violation (i.e. Welch's t-test; Ruxton, 2006; Welch, 1947).

Results indicate communication shifts of reflexivity phases to differ across time. Team communication during the reflexivity transition phase on to the same topic review ($t(51) = -4.29, p < .001, d = -1.09$) and strategy development ($t(34) = -4.35, p < .001, d = -1.10$) increased significantly from Q1 (review $M = .009, SD = .017$; strategy development $M = .008, SD = .015$) to Q2 (review $M = .034, SD = .027$; strategy development $M = .053, SD = .056$). Also a significant increase during the reflexivity transition phase was found from Q1 for review to strategy development ($M = .003, SD = .007; t(51) = -3.81, p < .001, d = -0.97$) and strategy development to review ($M = .001, SD = .003; t(37) = -4.65, p < .001, d = -1.18$) to Q2 (review to strategy development $M = .013, SD = .011$; strategy development to review $M = .010, SD = .010$). On the other hand a significant decrease during the action phase on to the same topic action from Q1 ($M = .124, SD = .053; t(60) = 5.84, p < .001, d = 1.48$) and the shift on strategy implementation to action ($M = .021, SD = .032; t(60) = 2.78, p < .05, d = 0.71$) to Q2 (action $M = .049, SD = .049$; strategy implementation to action $M = .004, SD = .010$) was found. Refer to Table 56 to review a summary of all significant findings across quartiles according to reflexivity phases.

No significant differences for the shifts from the reflexivity transition to the action phase or vice versa from Q1 to Q2 were found. No significant differences emerged for shifts from reflexivity transition or action phases to reflexivity action or transition phases across Q2 to Q3. Yet significant increases were found in the action phase from Q2 for the shift on strategy implementation to action ($M = .004, SD = .010; t(60) = -2.05, p < .05, d = -0.52$) and on to the same topic action ($M = .049, SD = .049; t(52) = -2.33, p < .05, d = -0.59$) to Q3 (strategy implementation to action $M = .009, SD = .009$; action $M = .087, SD = .073$). Lastly, a decrease was found during the reflexivity transition phase on to the same topic strategy development from Q2 ($M = .053, SD = .056, t(47) = 2.30, p < .05, d = 0.58$) to Q3 ($M = .026, SD = .031$).

For reflexivity, transition and action phase shifts from Q3 to Q4 communication changed significantly. For shifts from reflexivity transaction to the action phase, a significant decrease was found from Q3 for the shift review to action ($M = .006, SD = .008; t(56) = 2.11, p < .05, d = 0.54$), strategy development to strategy implementation ($M = .009, SD = .0013; t(33) = 3.41, p < .05, d = 0.87$), strategy development to action ($M = .009, SD = .012; t(60) = 2.09, p < .05, d = .53$) to Q4 (review to action $M = .003, SD = .006$, strategy development to strategy implementation $M = .001, SD = .003$, strategy development to action $M = .004, SD = .008$).

Table 56. Significant Differences across Quartiles.

From	To	Analysis of Difference across Quartiles		
		Q1 vs Q2	Q2 vs. Q3	Q3 vs. Q4
Review	Review	-4.288***	0.740	3.611***
Review	Strategy	-3.813***	1.655	3.086**
	Development			
Review	Strategy	-1.435	0.691	1.264
	Implementation			
Review	Action	-1.458	0.823	2.113**
Strategy	Review	-4.654***	0.834	2.750**
Development				
Strategy	Strategy	-4.349***	2.301**	4.041***
Development	Development			
Strategy	Strategy	-0.610	-0.966	3.408**
Development	Implementation			
Strategy	Action	-0.836	0.380	2.092**
Development				
Strategy	Review	-1.020	0.770	1.672
Implementation				
Strategy	Strategy	-1.599	-0.591	2.591**
Implementation	Development			
Strategy	Strategy	0.496	-0.761	3.125**
Implementation	Implementation			
Strategy	Action	2.778**	-2.047**	0.897
Implementation				
Action	Review	-1.496	1.524	2.763**
	Strategy	-0.455	-0.188	2.512**
Action	Development			
	Strategy	1.783	-0.819	0.337
Action	Implementation			
Action	Action	5.840***	-2.332**	-8.258***

Note: *** $p < .001$, ** $p < .05$

Also significant decreases for shifts from reflexivity action to transition phases such as the shift from strategy implementation to strategy development ($M = .007$, $SD = .010$; $t(45) = 2.59$, $p < .05$, $d = 0.66$), action to review ($M = .005$, $SD = .007$; $t(43) = 2.76$, $p < .05$, $d = 0.70$), and action to strategy development ($M = .009$, $SD = .011$; $t(46) = 2.51$, $p < .05$, $d = 0.64$) to Q4 were found (strategy implementation to strategy development $M = .002$, $SD = .005$, action to review $M = .001$, $SD = .003$, action to strategy development $M = .003$, $SD = .006$). Further, a significant decrease was found from Q3 for on to the same topic review ($M = .028$, $SD = .038$; $t(33) = 3.61$, $p = .001$, $d = 0.92$) and strategy development ($M = .026$, $SD = .031$; $t(35) = 4.04$, $p < .001$, $d = 1.03$) to Q4 (review $M = .003$, $SD = .009$ and strategy development $M = .003$, $SD = .009$) during the reflexivity transition phase. A significant decrease in shifts from Q3 between topics during the transition phase was found for review to strategy development ($M = .008$, $SD = .012$; $t(35) = 3.09$, $p < .05$, $d = 0.78$) and strategy development to review ($M = .008$, $SD = .012$; $t(37) = 2.75$, $p < .05$, $d = 0.70$) to Q4 (review to strategy development $M = .001$, $SD = .0003$ and strategy development to review $M = .002$,

$SD = .004$). Also during the action phase, a significant decrease from Q3 for a shift on to the same topic strategy implementation was found ($M = .027$, $SD = .037$), $t(37) = 3.13$, $p < .05$, $d = 0.80$ to Q4 ($M = .006$, $SD = .013$). Also a significant increase from Q3 for a shift on to the same topic action ($M = .086$, $SD = .073$; $t(47) = -8.26$, $p < .001$, $d = -2.10$) to Q4 ($M = .211$, $SD = .041$) was examined.

7.4.3 Key Findings: Communication Shifts of Reflexivity Phases

The hypothesis 5.1 whether teams are shifting between reflexivity phases differs across times was supported with the attained results. The findings indicate different shifts between reflexivity phases to be vital at different points in time. With a decrease in shifts between action phase topics, action taking has ended and the reflexivity transition phase is turned to from the first to the second quartile of team communication. The decrease in shifts between action phase topics was characterized by shifts between strategy implementation to action or by staying longer on the same action topics that were related to the first team task. Teams entered the reflexivity transition process by an increased shift on to reflexivity transition topics such as by staying on topics regarding review (e.g., reviewing past events, team or task performances), shifting between reflexivity transition topics from review to strategy development or staying on the same topic strategy development.

Across time (i.e., here second to third quartile of team communication), teams decreased their communication shifts between topics on strategy development in the transition phase. Instead they shifted from the reflexivity transition phase to the action phase indicating the transition phase was ending and developed strategies were adapted. Findings show that teams shifted more intensively between the action phases with topics related to strategy implementation to action topics. In addition, more communication about the same topic action was observed in teams. The third to the fourth quartile of team communication centered solely on the action phase, suggesting that strategies have been implemented or tried to be implemented. Communication shifts between topics in the reflexivity transition phase such as communication shifts to the same topic review, strategy development or shifts between review to strategy development, and strategy development to review significantly reduced. Further, shifts from the reflexivity transition phase to action phase or action phase to the transition phase (e.g., from review to action, strategy development to strategy implementation or action, strategy implementation to strategy development, action to review or action to strategy development) significantly reduced. Then, shifts mainly focused on the same topic action.

7.4.4 Results of Communication Shifts of Reflexivity for Teams Receiving Team Reflexivity

The hypothesis 5.2 of whether communication shifts between topics across collaboration over quartiles differs for teams who received the reflexivity intervention compared to those who did not was examined. Quartiles of communication for teams that participated in reflexivity intervention included task 1, reflexivity intervention and task two accordingly. On the other hand, the quartiles of communication for teams that did not engage in the reflexivity intervention included task 1, a discussion task and task two respectively. Communication shifts of reflexivity phases were examined between teams by computing independent t-tests. For cases in which equality of variance was not met, the un-pooled estimate for the error term was used and adjustments to the degrees of freedom were made to correct the violation (i.e. Welch's t-test; Ruxton, 2006; Welch, 1947).

There were differences of reflexivity transition and action phases of teams who went through the reflexivity intervention compared to teams who did not. Specifically, during Q1, teams of the reflexivity intervention ($M = .003$, $SD = .007$) indicated an increase in transition phase topics review to strategy development, $t(32) = 2.33$, $p < .05$, $d = 0.59$ compared to teams who did not ($M = .0002$, $SD = .001$). Refer to Table 57 for results on the differences in the reflexivity shifts when teams are receiving interventions. Further teams of the reflexivity intervention showed more shifts during the reflexivity transaction phase in Q2 for on to the same topic review ($M = .034$, $SD = .027$, $t(34) = 6.47$, $p < .001$, $d = 1.64$), strategy development ($M = .053$, $SD = .056$; $t(31) = 4.80$, $p < .001$, $d = 1.22$) and shifts from review to strategy development ($M = .013$, $SD = .011$; $t(41) = 4.84$, $p < .001$, $d = 1.23$) or from strategy development to review ($M = .010$, $SD = .010$, $t(38) = 4.54$, $p < .001$, $d = 1.15$) compared to teams who did not participate in the reflexivity intervention (review $M = .002$, $SD = .007$; strategy development $M = .004$, $SD = .007$; review to strategy development $M = .002$, $SD = .005$ and strategy development to review $M = .001$, $SD = .004$). Also shifts from the reflexivity transition phase to the action phase were found to be higher in teams that received the reflexivity intervention, such as from review to strategy implementation ($M = .004$, $SD = .009$; $t(30) = 2.28$, $p < .05$, $d = 0.58$) and strategy development to strategy implementation ($M = .006$, $SD = .011$, $t(32) = 3.02$, $p < .05$, $d = 0.77$) compared to teams who did not receive a reflexivity intervention (review to strategy implementation $M = .000$, $SD = .000$; strategy development to strategy implementation $M = .004$, $SD = .002$).

Table 57. Difference in Reflexivity Shifts for Teams Receiving Team Reflexivity.

From	To	Analysis of Difference across Interventions			
		Q1	Q2	Q3	Q4
Review	Review	1.171	6.466***	3.626***	0.855
Review	Strategy	2.327**	4.839***	2.674**	1.000
Review	Development				
Review	Strategy	1.112	2.281**	2.562**	1.161
Review	Implementation				
Review	Action	0.448	1.305	-0.131	-0.566
Strategy	Review	1.204	4.535***	3.172**	1.310
Development					
Strategy	Strategy	0.229	4.799***	1.768	1.408
Development	Development				
Strategy	Strategy	0.048	3.021**	1.109	-1.047
Development	Implementation				
Strategy	Action	-0.144	0.289	-0.206	-0.527
Development					
Strategy	Review	1.334	3.122**	2.422**	1.427
Implementation					
Strategy	Strategy	0.047	2.688**	2.034**	0.043
Implementation	Development				
Strategy	Strategy	1.326	3.393**	1.828	-0.783
Implementation	Implementation				
Strategy	Action	0.991	0.821	0.712	-1.284
Implementation					
Action	Review	0.157	0.874	-0.599	-2.131**
Action	Strategy	-1.088	0.039	-1.263	-1.364
Action	Development				
Action	Strategy	0.092	1.275	-0.020	0.630
Action	Implementation				
Action	Action	-1.464	-12.298***	-4.132***	0.246

Note: *** $p < .001$, ** $p < .05$

As teams collaborate in a dialogue with each other, a shift from the reflexivity action to the transition phase from strategy implementation to review ($M = .004$, $SD = .008$, $t(30) = 3.12$, $p < .05$, $d = .79$) or to strategy development ($M = .006$, $SD = .011$, $t(31) = 2.69$, $p < .05$, $d = .68$) was also much higher in teams of the reflexivity intervention compared to teams that did not engage in the reflexivity intervention (strategy implementation to review $M = .000$, $SD = .000$; strategy implementation to strategy development $M = .0003$, $SD = .002$). In addition during the reflexivity action phase in Q2, teams of the reflexivity intervention demonstrated higher shifts ($M = .021$, $SD = .030$) among the same topic strategy implementation, $t(33) = 3.39$, $p = .001$, $d = 0.86$ in comparison to teams not participating in the reflexivity intervention ($M = .002$, $SD = .007$). Teams that did not undergo the reflexivity intervention demonstrated shifts to the same topic action to be significant higher ($M = .159$, $SD = .065$, $t(60) = -12.30$, $p < .001$, $d = -3.12$ in comparison ($M = .086$, $SD = .073$), which was expected as teams were solving a discussion task whereas teams in the reflexivity intervention were given time to reflect.

In the Q3 of task completion, significant difference of reflexivity shifts to the same topic and the digression to another topic was evident for teams that underwent the reflexivity intervention compared to teams that did not. Teams of the reflexivity intervention showed a higher shift in the reflexivity transition phase for on to the same topic review ($M = .028$, $SD = .038$, $t(32) = 3.63$, $p = .001$, $d = .92$) and a shift to another topic from review to strategy development ($M = .008$, $SD = .012$, $t(36) = 2.67$, $p < .05$, $d = .68$) and strategy development to review ($M = .008$, $SD = .012$, $t(34) = 3.17$, $p < .05$, $d = .81$) in comparison to teams not receiving reflexivity intervention (review $M = .003$, $SD = .007$, review to strategy $M = .001$, $SD = .004$, strategy development to review $M = .001$, $SD = .003$).

Further a shift from reflexivity transition to action phase was significantly more present in teams of the reflexivity phase for review to strategy implementation ($M = .002$, $SD = .005$, $t(30) = 2.56$, $p < .05$, $d = .65$) and from the action phase to the transition phase for strategy implementation to review ($M = .007$, $SD = .010$, $t(31) = 2.42$, $p < .05$, $d = 0.61$) and to strategy development ($M = .002$, $SD = .005$, $t(58) = 2.04$, $p < .05$, $d = .52$) compared to teams not engaging in reflexivity (review to strategy implementation $M = .000$, $SD = .000$, strategy implementation to review $M = .0002$, $SD = .009$, strategy implementation to strategy development $M = .002$, $SD = .009$). During the action phase in Q3 the teams that did not receive the reflexivity intervention demonstrated more sifts on to the same topic of action ($M = .159$, $SD = .065$, $t(60) = -4.13$, $p < .001$, $d = -1.05$) compared to teams that underwent the reflexivity intervention ($M = .086$, $SD = .073$).

While teams that did not participate in the reflexivity intervention showed a significant higher shift in Q4 between the action phase and transition phase from action to review ($M = .004$, $SD = .008$, $t(41) = -2.13$, $p < .001$, $d = -0.54$) compared to teams of the reflexivity intervention ($M = .001$, $SD = .004$), indicating that teams who did not receive a reflexivity intervention are more likely to shift from the action to the reflexivity transition phase for reviewing their activities.

7.4.5 Key Findings: Communication Shifts of Reflexivity Phases for Teams Receiving Team Reflexivity

Teams differed in shifting between reflexivity phases across collaboration depending on whether a team engaged in a reflexivity intervention or not, thus supporting hypothesis 5.2. Teams of the reflexivity intervention shifted more between review and strategy development in the reflexivity transaction phase during the first quartile of team communication. These teams stayed also longer on the same reflexivity topics review and strategy development in the transition phase during the second quartile. Moreover, these teams shifted more significantly between reflexivity transition phase topics between review or strategy development to strategy during the quartile. Further, more increased communication shifts from the reflexivity transition phase to the action phase such as from topics strategy development to strategy implementation and for shifts on to the same topic strategy implementation were observed in teams engaging in the reflexivity intervention.

Communication shifts from the action phase to the transition phase for topics strategy implementation to review or strategy development were also evident for teams that participated in the reflexivity intervention. The communication shifts from the reflexivity action phase to the transition phase suggest that during strategy implementation or adaption teams monitor the implementation by referring back to previous task performances or procedures (i.e. review) or to developing or changing their strategy (i.e. strategy development). Teams of the reflexivity intervention showed similar patterns of the second quartile in the third quartile compared to teams that did not engage in reflexivity. Yet, teams did not differ significantly for staying on the same topic strategy development and strategy implementation during the third quartile. Also communication shifts in the transition phase from topic strategy development to action phase strategy implementation were not significant different between teams during the third quartile indicating that teams not engaging in the reflexivity intervention are also voluntarily participating in reflexivity processes. However, these teams stayed longer on action related topics during the second and third quartile. Still, teams not engaging in reflexivity intervention demonstrated some lower level of reflexivity processes during the fourth quartile by shifting from topics on action (i.e., action phase) to review (i.e., transition phase) for reflecting on their current action which suggests that teams do reflect but do not engage in reflexivity at a deeper level. This might be regarded to the factor time, as no time is allocated to these teams for getting involved in reflexivity at each level (i.e., review, strategy development and strategy implementation).

7.4.6 Results of Differences in Communication Shifts of Reflexivity Phases for High vs. Low Performance Teams

To answer the hypothesis 5.3 on whether communication progression of topics regarding reflexivity differs between high and low performing teams over time, the 62 teams were median split at a performance score of 66.25% at task 2 to generate categories of high and low performance teams. This resulted in the low performance category to contain 31 teams and the high performance category to also contain 31 teams. The subsequent analysis was conducted using a Mann-Whitney-U test due to the assumption of normality not being met (Mann & Whitney, 1947). In cases of data not being justified for the assumption of homogeneity, which was tested with a non-parametric Levene's test, the Mood's Median test was conducted using Chi-Square as the test statistic (Brown & Mood, 1951).

Although differences between teams that engaged in the reflexivity intervention and teams that did not were significant in regard to the shifts between the reflexivity transition and action phases, no major differences of communication flow between high and low performance teams were found. Comparing low performance teams to high performance teams' across interventions, high performing teams stayed longer on the same topic strategy development in the transition phase ($Mdn = 13$; $\chi^2(1) = 5.01, p = .025, \phi = .28$ and digressed more often from the action phase to the transition phase of strategy implementation to strategy development ($Mdn = 9$; $\chi^2(1) = 7.63, p = .006, \phi = .36$) compared to low performance teams (on the same topic strategy development ($Mdn = 5$; strategy implementation to strategy development $Mdn = 1$) during the first quartile. Particularly, low performing teams who did not receive reflexivity intervention demonstrated a lesser amount of shifts ($Mdn = 0$; $\chi^2(1) = 9.44, p = .002, \phi = .29$) from strategy implementation (i.e. action phase) to strategy development (i.e., transition phase) compared to high performance teams that did not receive reflexivity intervention ($Mdn = 5$), see Table 58.

Differences were found between high and low performance teams across interventions during the second quartile of team communication. High performance teams shifted more often from review to strategy development ($\chi^2(1) = 5.31, p = .021, \phi = .29$) and stayed significantly longer on the same topic strategy development in the reflexivity transition phase ($\chi^2(1) = 7.81, p = .005, \phi = .35$) compared to low performance teams. On the other hand, low performance teams showed significant more communication shifts on the same topic action ($\chi^2(1) = 5.23, p = .022, \phi = .40$) during the action phase compared to high performance teams ($Mdn = .11$). Low performance teams that did not engage in the reflexivity intervention showed a significant lower shift between reflexivity transition topics review and strategy

development ($\chi^2(1) = 7.27, p = .007, \phi = .48$) and stay on the same topic strategy development ($\chi^2(1) = 4.18, p = .041, \phi = .36$) compared to high performance teams that did not engage in reflexivity intervention. Further these teams displayed lower amounts of shifts from action to the transition phase review during the second communication quartile compared to high performance teams not receiving the reflexivity intervention ($\chi^2(1) = 6.09, p = .014, \phi = .44$). No significant differences between performance teams and communication shifts of reflexivity phases was found in the third and fourth quartile ($p > .05$). Refer to Table 58 to view Mean, Standard Deviation and Median on reflexivity shifts for high versus low performance teams.

Table 58. Reflexivity Shifts for High vs. Low Performance Teams.

From	To	Low Performance Teams		High Performance Teams	
		Q1 M (SD) Median	Q2 M (SD) Median	Q1 M (SD) Median	Q2 M (SD) Median
<i>Low (n = 31) vs. High (n = 31)</i>					
Review	Strategy		.0053(.0102)		.0092(.0103)
	Development		.0000		.0093
Strategy	Strategy	.0047(.0155)	.0192(.0440)	.0094(.0151)	.0379(.0484)
	Development	.0000	.0000	.0000	.0196
Development	Strategy	.0047(.0155)	.0192(.0440)	.0094(.0151)	.0379(.0484)
	Development	.0000	.0000	.0000	.0196
Strategy	Strategy	.0004(.0021)		.0038(.0064)	
	Implementation	.0000		.0000	
Action	Action		.1538(.0919)		.0988(.0800)
			.1786		.0839
<i>Low (n = 19) vs. High (n = 12) not receiving reflexivity intervention</i>					
Review	Strategy		.0000(.0000)		.0047(.0072)
	Development		.0000		.0000
Strategy	Strategy		.0012(.0031)		.0085(.0101)
	Development		.000		.0049
Development	Strategy	.0000(.0000)		.0053(.0070)	
	Implementation	.0000		.0000	
Action	Review		.0037(.0090)		.0095(.0122)
			.0000		.0070

7.4.7 Key Findings: Differences in Communication Shifts of Reflexivity Phases for High vs. Low Performance Teams

This section presents key findings of differences in communication shifts of reflexivity phases between high versus low performance teams, partially supporting 5.3. Major findings from the hypothesis testing are summarized in Table 59. Differences in communication shifts of reflexivity phases between high and low performing teams vary in regards to shifts of topics in the reflexivity transition phase. Differences in the action phase or the digressions from action to the transition phase sets teams apart on whether they are low or

high performance teams. Results indicate strategy development to be from great importance for overall team effectiveness. Further, feedback- looping between strategy development and strategy implementation seems to be vital for overall adaption of team processes.

While teams of the reflexivity intervention show a higher performance level as compared to teams in the control condition, teams in the control condition set themselves apart by showing different communication shift patterns of reflexivity phases. For instance, teams that did not participate in reflexivity intervention and performed poorly demonstrated less shifts between reflexivity transition phase topics or digressed less from transition phase to action phases. Hence, overall results suggest communication shifts between reflexivity transition phase topics and or to action phases to contribute to overall performance.

Table 59. Summary of Hypotheses to Reflexivity and Cognitive Behaviors Across Time.

Number	Hypothesis	Results
Hypotheses		
5.1	Proportion of communication shifts between reflexivity phases differed across times.	Supported.
5.2	Communication shifts between topics across collaboration over quartiles differs for teams who received the reflexivity intervention compared to those who did not	Supported.
5.3	Communication progression of topics regarding reflexivity differs between high and low performing teams over time.	Partially supported. ¹

¹No significant difference for some of the indicators in teams that were high versus low performing.

7.5 Temporal Effects of Team Reflexivity on Communication

After having examined the temporal nature of reflexivity transition and action phases, the results of this section concern the evaluation of the effect of team reflexivity intervention across time on reflexivity and cognitive behavior indicators.

7.5.1 Data Analyses

The subsequent analysis focuses on communication across time and the effect of team reflexivity intervention on communication volume of reflexivity and cognitive behavior communication. Differences between four different time points: training, task 1, experimental phase, task 2 by condition was analyzed at the team level. Team reflexivity intervention effects over time were assessed in the context of computer-mediated team communication: Team members' volume of messages sent and numbers of words written ($n = 62$).

The team-by-time effects were assessed using generalized estimation equation (Zeger & Liang, 1986). This analysis method was chosen as the present data was clustered within groups and over time, and contained non-normally distributed outcome variables. The failure to incorporate correlation responses may lead to incorrect estimates of the regression model parameters. According to research, large correlations and assumed normality in counted outcomes may result in incorrect conclusion regarding the research questions (Diggle, Heagerty, Liang, & Zeger, 2002; Gardner, Mulvey, & Shaw, 1995). Hence, the generalized estimating equations (GEE) accounts for limitations such as correlation of responses within subjects for response variables (e.g., Liang & Zeger, 2002). It further demonstrates flexibility regarding response variables not normally distributed for use of repeated measures research designs (Harrison & Hulin, 1989; Liang & Zeger, 1986).

The statistical analysis provides the ability to assess the hypotheses regarding parameter estimates in a method analogous to those used in testing coefficients from normal-errors regression methods, such as repeated-measures ANOVA (Ballinger, 2004; Rotnitzky & Jewell, 1990). Based on the distribution of the count outcome variable (limited range, excess zero, large skew), a negative binomial regression model was specified, given the restrictive assumptions of Poisson model (Gardner et al., 1995). GEE's fit a naive standard regression model to the data and use the residual from the regression to estimate parameters for quantifying correlations between observations in the same subject (Burton, Gurrin, & Sly, 1998). Then according to the authors, it refits the regression model using a series of iterations until the estimates become stable. Although, the model is proposed to being robust to errors in the specification of correlation matrix, an appropriate correlation structure needs to be chosen for the model (e.g., Ballinger, 2004; Zeger & Liang, 1986). For instance, Ballinger (2004) suggested the autoregressive correlation (AR(1)) structure to be appropriate for repeated measures design.

A GEE with a negative binomial regression model was employed for the count outcomes of reflexivity and cognitive behaviors during reflexivity phases in computer-mediated team communication with the treatment condition reflexivity (yes, no) as independent variable. The message or word count of reflexivity as well as cognitive and speech act behaviors was entered as the dependent variable and condition- by-time as the repeated measure variable. All models fitted the AR(1) correlation structures according to the Pan's (2001) quasi-likelihood under the independence model information criterion' (QIC) well. The correlation structure with the lowest QIC score - closest to zero - was judged to be

the best, and was used for analysis (Ballinger, 2004). According to the author, the AR(1) is a more theoretically appropriate structure for the model. All estimates mentioned hereafter were assessed with AR(1).

7.5.2 Results of Volume of Reflexivity Indicators in Form of Messages Sent Across Time

The hypothesis 5.4 of whether volume of reflexivity differs across time for teams engaging in team reflexivity was assessed using a GEE analysis for messages sent. In Table 60, the Means and Standard Deviations are presented for reflexivity indicators for volume of messages sent. Teams in the reflexivity condition demonstrate higher volumes of review, strategy development and strategy implementation during the team reflexivity intervention phase and a decrease during task 2 in form of messages sent. As the Table 60 presents, the control condition did engage in some level of team reflexivity as evidenced by the volume of messages sent across tasks.

The GEE analysis revealed significant condition-by-time effects of reflexivity transition phase review (Wald $\chi^2(3) = 32.51, p < .001$) with a significant higher volume of review during training (OR = 12.28, $p = .004$, 95% CI, 2.25 - 67.01) and the experimental phase (OR = 13.96, $p < .001$, 95% CI, 5.16 - 37.77) compared to task 2 for teams engaging in team reflexivity. Time revealed to also be a significant predictor of the volume of review across tasks (Wald $\chi^2(3) = 116.92, p < .001$) with an increase of review in the experimental phase (OR = 3.87, $p < .001$, 95% CI, 1.81 - 8.26) compared to task 2. Post hoc analysis with Bonferroni correction specified at $p = .006$ revealed that for teams in the team reflexivity intervention an increase in the volume of review from task 1 to experimental phase ($M - D = 18.16, p = .002$) and a significant decrease to task 2 ($M - D = -18.81, p < .001$) was present. On the other hand, the control condition demonstrated a significant increase of review from training to task 1 ($M - D = .68, p < .001$). The results indicate teams engaging in team reflexivity to show different volumes of review across time compared to the control condition in form of messages sent. Teams in the team reflexivity condition demonstrated higher volume of review during the intervention phase with a significant decrease during task 2. On the other hand, the control condition revealed higher levels of review after the trainings phase. The volume of messages sent stayed similar for both conditions across time thereafter. Refer to Table 60 for all significant condition-by-time effects in regards to volume of messages sent of the reflexivity indicators.

Table 60. Means and Standard Deviations of Reflexivity on Messages Sent.

Messages	Training	Task 1	Experimental Phase	Task 2
	M(SD)	M(SD)	M(SD)	M(SD)
Review				
TRI	1.5(2.22)	1.0(1.79)	19.16(7.40)	.35(.66)
Control	.26(1.09)	.94(1.67)	2.87(5.00)	.74(1.00)
Strategy Development				
TRI	2.13(2.28)	1.87(2.03)	13.81(6.92)	0.65(1.02)
Control	1.39(1.86)	2.06(2.14)	3.90(3.87)	0.94(1.75)
Strategy Implementation				
TRI	2.78(2.45)	4.32(2.65)	8.71(8.37)	1.26(1.69)
Control	1.90(2.40)	3.32(2.65)	2.39(2.39)	1.32(2.27)

Results of GEE analysis revealed significant condition-by-time effects of reflexivity transition phase strategy development (Wald $\chi^2(3) = 25.21, p < .001$) with a significant higher volume of strategy development in the experimental phase (OR = 13.96, $p < .001$, 95% CI, 5.16 - 37.77) compared to task 2 for teams engaging in team reflexivity. Time was also found to be a significant predictor of strategy development (Wald $\chi^2(3) = 122.13, p < .001$) and indicated an increased volume of strategy development in the experimental phase (OR = 5.13, $p < .001$, 95% CI, 1.94 - 13.55) compared to task 2. Specifically, strategy development increased in volume from task 1 to experimental phase ($M - D = 11.94, p < .001$) and significantly decreased in task 2 ($M - D = -13.16, p < .001$) for teams in the team reflexivity intervention according to post hoc analysis with Bonferroni correction. No significant increase of strategy development was found for the control condition under Bonferroni correction ($p = .012$), however, a significant decrease of strategy development from experimental phase to task 2 ($M - D = -2.97, p < .001$) was found. Findings indicate teams engaging in team reflexivity to significantly differ in volume of messages sent regarding strategy development across time, particularly during the team reflexivity intervention. Although, no significant increase in volume of strategy development was found for the control condition, both condition decreased in volume during task 2 implying no further strategies to be developed during this phase.

The GEE analysis revealed significant condition-by-time effects of reflexivity action phase strategy implementation (Wald $\chi^2(3) = 17.41, p = .001$) with a significant higher volume of strategy implementation during the experimental phase (OR = 3.84, $p = .006$, 95% CI, 1.48 - 9.95) compared to task 2 for teams engaging in team reflexivity. Time revealed to also be a significant predictor of the volume of review across tasks (Wald $\chi^2(3) = 38.60, p < .001$) with an increase of review in task 1 (OR = 2.51, $p < .001$, 95% CI, 1.26 - 5.02)

compared to task 2. Post hoc analysis with Bonferroni correction specified at $p = .006$ indicated an increase in the volume of strategy implementation from task 1 to experimental phase ($M - D = 4.39, p = .001$) and a significant decrease to task 2 ($M - D = -7.45, p < .001$) in teams engaging in team reflexivity intervention. On the other hand, the control condition demonstrated a significant increase of strategy implementation from training to task 1 ($M - D = 1.42, p = .002$). Teams engaging in team reflexivity intervention demonstrated significant changes in volumes of strategy implementation across time compared to the control condition in form of messages sent. Teams in the control condition showed an increase in strategy implementation after the training phase without further significant fluctuations in volume of messages sent. In contrast, teams in the team reflexivity condition demonstrated high levels during the experimental phase with a decrease during the second task, implying that the strategy has been implemented. The hypothesis 5.4 on whether reflexivity communication in form of volume of messages sent differed for teams engaging in team reflexivity intervention across time was supported.

7.5.3 Results of Volume of Reflexivity Indicators in Form of Words Written Across Time

The hypothesis 5.4 of whether volume of reflexivity differs across time for teams engaging in team reflexivity was assessed using a GEE analysis also for words written. Table 61 displays Means and Standard Deviations of the reflexivity indicators for volume of words written across the team tasks. Teams in the reflexivity condition demonstrate higher volumes of words written regarding review, strategy development and strategy implementation during the team reflexivity intervention phase and a decrease during task 2 in volume. Yet, as the Table 61 presents, the control condition did engage in some level of team reflexivity as evidenced by the volume of words written regarding reflexivity.

The GEE analysis indicated significant condition-by-time effects of reflexivity in form of words written (Wald $\chi^2(3) = 10.79, p < .001$) with a significant higher volume of reflexivity indicators during training (OR = 3.15, $p = .001$, 95% CI, 1.59 - 6.24) and the experimental phase (OR = 5.85, $p < .001$, 95% CI, 2.84 - 12.07) compared to task 2 for teams engaging in team reflexivity intervention. See Table 62 for all significant condition-by-time effects in regards to volume of words written of the reflexivity indicators. Time revealed to also be a significant predictor of the amount of words written of reflexivity across tasks (Wald $\chi^2(3) = 63.36, p < .001$), with an increased volume of reflexivity in task 1 (OR = 1.77, $p = .006$, 95% CI, 1.18 - 2.67) and the experimental phase (OR = 2.81, $p < .001$, 95% CI,

1.50 - 5.26) compared to task 2. Post hoc analysis with Bonferroni correction specified at $p = .006$ revealed that teams in the team reflexivity intervention display an increase in the volume of reflexivity from task 1 to experimental phase ($M - D = 248.61, p < .001$) and a significant decrease to task 2 ($M - D = -286.45, p < .001$). The control condition demonstrated a significant increase of strategy implementation from training to task 1 ($M - D = 24.52, p < .001$), and a significant decrease from experimental phase to task 2 ($M - D = -31.12, p < .001$). The findings imply that teams in the reflexivity condition show more volume of words written of reflexivity indicators during the team reflexivity intervention with both conditions decreasing in reflexivity communication. This result also suggests teams to voluntarily engage in team reflexivity and reflexivity indicators to expedite in communication through a team reflexivity intervention.

Table 61. Means and Standard Deviations of Reflexivity on Words written.

Words	Training	Task 1	Experimental Phase	Task 2
	M(SD)	M(SD)	M(SD)	M(SD)
Reflexivity				
TRI	53.55(40.04)	56.42(37.01)	305.03(102.25)	18.58(20.87)
Control	26.13(24.33)	50.65(33.71)	80.10(76.16)	28.55(41.05)
Review				
TRI	9.39(12.14)	7.39(12.85)	98.87(58.25)	4.84(12.59)
Control	2.13(7.47)	7.35(13.84)	21.00(33.64)	10.97(16.22)
Strategy Development				
TRI	23.45(28.87)	19.87(21.90)	139.74(67.85)	6.03(10.14)
Control	9.71(13.04)	20.16(21.46)	40.42(40.40)	9.0(20.53)
Strategy Implementation				
TRI	20.71(18.85)	29.16(21.48)	66.42(54.16)	7.71(10.38)
Control	14.29(17.58)	23.13(17.17)	18.68(19.16)	8.58(16.16)

To evaluate whether differences between reflexivity indicators in form of words written exists between conditions, a GEE analysis was computed. Significant condition-by-time effects of reflexivity transition phase review in form of words written were found (Wald $\chi^2(3) = 18.92, p < .001$), with a significant higher volume of review during training (OR = 9.99, $p = .006$, 95% CI, 1.96 - 50.95) and the experimental phase (OR = 10.67, $p < .001$, 95% CI, 3.41 - 33.36) compared to task 2 for teams engaging in team reflexivity. Time revealed to also be a significant predictor of the amount of words written of review across tasks (Wald $\chi^2(3) = 63.36, p < .001$) with a decreased volume of review in training (OR = .194, $p < .001$, 95% CI, .06 - .69) compared to task 2. Post hoc analysis with Bonferroni correction specified

at $p = .006$ revealed that for teams in the team reflexivity intervention an increase in the volume of review from task 1 to experimental phase ($M - D = 91.48, p < .001$) and a significant decrease to task 2 ($M - D = 94.03, p < .001$) existed. No significant change across tasks was found for the control condition with a Bonferroni correction at $p = .006$.

This result suggests teams in the reflexivity condition to show different patterns regarding the volume of words written regarding review across time in comparison to the control condition. For instance, significantly increase in words written regarding review was observed together with a significant decrease in review after the experimental phase took place for teams of the team reflexivity condition. The control condition did not show significant changes in volume across time for the reflexivity indicator review, implying that words are exchanged regarding review during transition and action phases.

Results of GEE analysis revealed significant condition-by-time effects of reflexivity transition phase strategy development in form of words written (Wald $\chi^2(3) = 21.94, p < .001$) with a significant higher volume of strategy development in the training phase (OR = 3.6, $p = .011$, 95% CI, 1.34 - 9.73) and in the experimental phase (OR = 5.16, $p < .001$, 95% CI, 1.79 - 14.86) compared to task 2 for teams engaging in team reflexivity. Time was also found to be a significant predictor of strategy development (Wald $\chi^2(3) = 120.07, p < .001$) and indicated an increased volume of strategy development in task 1 (OR = 2.24, $p = .014$, 95% CI, 1.85 - 10.92) and in the experimental phase (OR = 4.49, $p = .001$, 95% CI, 1.85 - 10.92) compared to task 2. According to post hoc analysis with Bonferroni correction $p = .006$, strategy development increased in volume from task 1 to experimental phase ($M - D = 119.87, p < .001$) and significantly decreased in task 2 ($M - D = -133.71, p < .001$) for teams in the team reflexivity intervention. No significant increase of strategy development was found for the control condition under Bonferroni correction ($p = .012$).

However, a significant increase of strategy development from training to task 1 ($M - D = 10.45, p < .001$) and decrease of strategy development from experimental phase to task 2 ($M - D = -31.12, p < .001$) was revealed for the control condition. The findings indicate teams in the reflexivity condition to significantly differ in volume of strategy development across time, specifically showing an increase in volume during the intervention with a significant decrease during task 2. Although the control condition did exhibit a significant decrease towards task 2, volume of words written stayed comparable after the training phase across time.

Lastly, the GEE analysis revealed significant condition-by-time effects of reflexivity action phase strategy implementation in form of words written (Wald $\chi^2(3) = 16.64, p = .001$) with a significant higher volume of strategy implementation during the experimental phase (OR = 3.96, $p = .006$, 95% CI, 1.48 - 10.58) compared to task 2 for teams engaging in team reflexivity. Time revealed to also be a significant predictor of the volume of review across tasks (Wald $\chi^2(3) = 46.07, p < .001$) with an increase of review in task 1 (OR = 2.70, $p < .001$, 95% CI, 1.30 - 5.59) compared to task 2. Post hoc analysis with Bonferroni correction specified at $p = .006$ indicated an increase in the volume of strategy implementation from task 1 to experimental phase ($M - D = 37.26, p < .001$) and a significant decrease to task 2 ($M - D = -58.71, p < .001$) in teams engaging in team reflexivity intervention. On the other hand, the control condition demonstrated only a significant increase of strategy implementation from training to task 1 ($M - D = 8.84, p = .003$). Results demonstrate that teams engaging in team reflexivity to exhibit different volume of words written regarding strategy implementation.

Table 62. Significant Condition by Time Effects of Reflexivity.

	Outcome Variable	Effects	B	B SE	OR	p ≤	
Message sent	Review	Condition x Time: Training (TRI)	2.51	.87	12.28	.004	
		Condition x Time: Experimental Phase (TRI)	2.64	.51	13.96	.001	
		Time: Experimental Phase	1.35	.39	3.87	.001	
	Strategy Development	Condition x Time: Experimental Phase (TRI)	1.64	.50	5.13	.001	
		Time: Task1	.79	.34	2.21	.019	
		Time: Experimental Phase	1.43	.40	4.17	.001	
	Strategy Implementation	Condition x Time: Experimental Phase (TRI)	1.34	.49	3.84	.006	
		Time: Task	.92	.35	2.51	.009	
	Words written	Reflexivity	Condition x Time: Training (TRI)	1.15	.35	3.15	.001
			Condition x Time: Experimental Phase (TRI)	1.77	.37	5.85	.001
Time: Task1			.57	.21	1.77	.006	
Time: Experimental Phase			1.03	.32	2.81	.001	
Time: Training			-1.64	.64	.19	.011	
Review		Condition x Time: Training (TRI)	2.3	.83	9.99	.006	
		Condition x Time: Experimental Phase (TRI)	2.37	.58	10.67	.001	
		Time: Training	-1.64	.64	.19	.011	
		Time: Task1	.81	.33	2.24	.014	
		Time: Experimental Phase	1.50	.45	4.49	.001	
Strategy Development		Condition x Time: Training (TRI)	1.28	.51	3.60	.011	
		Condition x Time: Experimental Phase (TRI)	1.64	.54	5.16	.002	
		Time: Task1	.81	.33	2.24	.014	
		Time: Experimental Phase	1.50	.45	4.49	.001	
		Time: Training	-1.64	.64	.19	.011	
Strategy Implementation	Condition x Time: Experimental Phase (TRI)	1.38	.50	3.96	.006		
	Time: Task1	.99	.37	2.70	.008		

For instance, strategy implementation was observed in high volumes during the team reflexivity intervention with a substantial decrease in volume during the action phase, here task 2. Although, the control condition increased in exhibiting a higher volume of words written of strategy implementation after the training phase, no significant changes were observed thereafter, implying that some form and level of reflexivity did take place during the action phase. The hypothesis 5.4 on whether reflexivity communication in form of volume of words written differed for teams engaging in team reflexivity intervention across time was supported.

7.5.4 Key Findings: Volume of Reflexivity in Communication Across Time

The hypothesis 5.4 whether volume of reflexivity communication differed for teams engaging in team reflexivity intervention across time was supported. For both words written and messages sent, teams in the team reflexivity condition significantly differed in volume of reflexivity, review, strategy development, and strategy implementation across time. Indeed, these teams demonstrated high volumes of all reflexivity indicators during the intervention that decreased in the second task. This implies teams to engage in the team reflexivity intervention effectively for reviewing team task and performance, developing strategies and to implement those strategies such that no additional engagement in reflexivity is required during the action phase. Although, volume of messages sent and words written were exhibited similarly across time for the control condition, a significant decrease for reflexivity, specifically strategy development was observed during the second task. This suggests that teams in the control condition to voluntarily engage in some level of reflexivity that permits them on the surface to review their performance, develop strategies, and implement strategies. Conclusively, the application of team reflexivity intervention has shown to enhance the volume of reflexivity indicators in team communication during the intervention as compared to the action phases and teams not engaging in team reflexivity.

7.5.5 Results of Volume of SA and TMS Cognitive Behaviors in Form of Messages Sent Across Time

The hypothesis 5.5 of whether volume of SA and TMS cognitive behaviors differ across time for teams engaging in team reflexivity were assessed using a GEE analysis for messages sent. Table 63 presents Means and Standard Deviations of cognitive behaviors for volume of messages sent across the team tasks.

GEE indicated significant condition-by-time effects and/ or main effects of time on the volume of cognitive behaviors in form of messages sent by team members across tasks.

The GEE analysis revealed no significant condition-by-time effects of cognitive behavior SAE perception (Wald $\chi^2(3) = .74, p = .86$), however time was a predictor for volume of cognitive behavior across tasks (Wald $\chi^2(3) = 152.64, p < .001$). Analysis showed a significant lower volume of the cognitive behavior in training (OR = .566, $p < .001$, 95% CI, .43 - .75) and higher volume in the experimental phase (OR = 1.45, $p < .001$, 95% CI, 1.27 - 1.65) compared to task 2. For the post hoc test using Bonferroni correction, a p -value of less than .006 ($.05/8 = .006$) was required for significance using the Bonferroni correction to control for Type I errors across the eight pairwise comparisons (Dunn, 1961). Post hoc analysis with Bonferroni correction revealed that for teams in the team reflexivity intervention a significant decrease from experimental phase to task 2 ($M - D = -3.45, p < .001$) was present. The control condition indicated also a significant decrease in the volume of the cognitive behavior from the experimental phase to task 2 ($M - D = -1.97, p = .001$). Results indicate that teams in both conditions decreased the volume of the indicator perception in form of messages sent after the experimental phase took place, therefore rejecting the hypothesis 5.5. Refer to Table 64 for a summary of all significant findings.

Significant condition-by-time effects of cognitive behavior SAE comprehension (Wald $\chi^2(3) = .12.34, p = .006$) was found. Results indicated a significant higher volume of the cognitive behavior comprehension during the experimental phase (OR = 1.47, $p = .001$, 95% CI, 1.16 - 1.87) compared to task 2 for teams in team reflexivity intervention. Time was also a predictor for volume of the cognitive behavior across tasks (Wald $\chi^2(3) = 166.11, p < .001$) with a lower volume of comprehension in training (OR = .15, $p < .001$, 95% CI, .66 - .33) and a higher volume in the experimental phase (OR = 1.30, $p < .001$, 95% CI, 1.15 - 1.46) compared to task 2. Post hoc analysis with Bonferroni correction revealed that for teams in the team reflexivity intervention an increase in the volume of the cognitive behavior comprehension from training to task 1 ($M - D = 4.48, p < .001$), task 1 to experimental phase ($M - D = 5.06, p = .002$) and a significant decrease to task 2 ($M - D = -5.58, p < .001$) was present. Whereas, the control condition demonstrated a significant increase from training to task 1 ($M - D = 3.32, p < .001$) and decrease of the cognitive behavior comprehension from the experimental phase to task 2 ($M - D = -1.32, p = .001$). A significant higher volume of the SAE cognitive behavior comprehension during intervention was therefore only found for teams in the reflexivity condition, and thus supporting the hypothesis 5.5. However, both conditions did show a decrease in the indicator during task 2.

No significant condition-by-time effects of cognitive behavior SAE projection (Wald $\chi^2(3) = 1.50, p = .68$), but time was a predictor of volume of the cognitive behavior (Wald $\chi^2(3) = 17.34, p = .001$) for the experimental phase (OR = 3.17, $p = .002$, 95% CI, 1.54 - 6.50). However, no significance across tasks was found in the post hoc analysis using the Bonferroni correction $p = 006$.

Table 63. Means and Standard Deviations of Cognitive Behaviors on Messages sent.

Messages Sent	Training	Task 1	Experimental Phase	Task 2
	M(SD)	M(SD)	M(SD)	M(SD)
SAE Perception				
TRI	3.61(3.24)	6.19(5.26)	9.58(5.73)	6.13(4.92)
Control	2.48(1.89)	4.42(3.82)	6.35(5.32)	4.39(3.60)
SAE Comprehension				
TRI	2.13(2.86)	6.61(6.56)	11.68(8.78)	6.10(5.69)
Control	0.65(1.31)	3.97(3.41)	5.74(5.18)	4.42(4.39)
SAE Projection				
TRI	0.19(0.40)	0.26(0.58)	0.61(1.31)	0.35(0.71)
Control	0.13(0.06)	0.13(0.43)	0.61(1.23)	0.19(0.48)
SAE Action				
TRI	1.52(2.17)	3.19(3.59)	6.45(5.88)	2.39(2.56)
Control	0.32(0.60)	1.52(1.48)	2.32(2.12)	1.42(1.34)
SAT Perception				
TRI	1.19(1.96)	1.55(1.69)	6.77(5.13)	3.42(3.94)
Control	1.26(1.75)	1.81(2.01)	5.00(3.30)	2.61(2.68)
SAT Comprehension				
TRI	2.39(3.08)	2.77(2.33)	8.87(6.80)	1.94(2.71)
Control	2.26(2.42)	3.74(2.77)	4.26(3.81)	1.61(2.58)
SAT Projection				
TRI	0.45(1.12)	0.55(1.12)	1.10(1.74)	0.16(0.37)
Control	0.23(0.67)	0.16(0.73)	0.26(0.93)	0.10(0.30)
SAT Action				
TRI	2.35(2.65)	3.87(3.08)	11.13(7.44)	2.29(2.45)
Control	2.39(2.33)	4.71(3.65)	10.87(6.83)	2.32(2.01)
TMS Specialization				
TRI	5.29(4.13)	8.45(5.08)	21.68(9.84)	7.97(5.55)
Control	4.68(3.84)	7.35(4.99)	17.19(9.73)	7.42(5.04)
TMS Coordination				
TRI	2.65(2.46)	3.55(3.40)	14.94(7.51)	3.00(4.41)
Control	2.06(2.50)	3.23(2.93)	7.10(5.05)	2.45(2.67)
TMS Confusion				
TRI	0.16(0.58)	0.42(1.03)	0.90(1.58)	0.42(1.09)
Control	0.32(0.79)	0.87(1.77)	1.13(1.7)	0.61(1.36)
TMS Credibility				
TRI	1.61(2.03)	1.61(1.98)	7.81(5.11)	1.58(2.08)
Control	1.06(1.31)	1.26(1.37)	4.90(5.52)	1.35(1.74)
Confusion				
TMS Feedback				
TRI	0.48(0.85)	1.90(1.70)	5.23(2.73)	2.58(2.63)
Control	0.35(0.61)	1.03(1.65)	2.23(1.65)	1.48(1.43)

Results indicate that both conditions exhibit similar volume in form of messages sent of the indicator projection such as higher levels during intervention in contrast to task 2. The hypothesis 5.5 was rejected.

For the SAE cognitive behavior action, the GEE analysis demonstrated significant condition-by-time effects (Wald $\chi^2(3) = 10.84, p = .013$), with a significant higher volume of the cognitive behavior action in the training (OR = 2.80, $p = .014$, 95% CI, 1.23 - 6.36) and experimental phase (OR = 1.65, $p = .016$, CI, 1.08 - 2.49) for teams engaging in team reflexivity compared to task 2. Time was also a significant predictor of the cognitive behavior action (Wald $\chi^2(3) = 113.63, p = .001$), when comparing the lower volume of the cognitive behavior in training (OR = .23, $p < .001$, 95% CI, .12 - .43) and higher volume in the experimental phase (OR = 1.64, $p < .001$, 95% CI, 1.25 - 2.14) to task 2. Post hoc analysis with Bonferroni correction indicated an increase in the volume of the cognitive behavior action from task 1 to the experimental phase ($M - D = 3.26, p < .001$) and a decrease from experimental phase to task 2 ($M - D = -4.06, p < .001$) for teams in the team reflexivity intervention. A significant increase of the volume of action was only displayed for teams in the control condition from training to task 1 ($M - D = 1.19, p < .001$). Results support the hypothesis 5.5 in that the cognitive behavior SAE action was higher only for teams engaging in the reflexivity condition during the intervention and significantly decreased in volume during task 2.

The GEE analysis indicated similar results of SAT cognitive behavior in team communication across time for teams that engaged in the reflexivity condition and for teams that did not. Yet, differences of the cognitive behaviors were found across tasks in form of volume of messages sent. No significant condition-by-time effects of cognitive behavior SAT perception (Wald $\chi^2(3) = 3.00, p = .39$) was found, still time was a predictor for volume of cognitive behavior across tasks (Wald $\chi^2(3) = 222.46, p = .022$). Analysis showed a significant higher rate of the indicator perception in training (OR = .48, $p < .001$, 95% CI, .26 - .90) and higher volume in the experimental phase (OR = 1.91, $p < .001$, 95% CI, 1.50 - 2.45) compared to task 2. Post hoc analysis with Bonferroni correction specified at $p = .006$ revealed that for teams in the team reflexivity intervention an increase in the volume of the cognitive behavior SAT perception from task 1 to experimental phase ($M - D = 5.23, p < .001$) and a significant decrease from experimental phase to task 2 ($M - D = -3.35, p < .001$) existed. Results of the control condition presented also a significant increase from task 1 to experimental phase ($M - D = 3.19, p < .001$) and a decrease in the volume of perception from

the experimental phase to task 2 ($M - D = -2.39, p < .001$). This result rejects the hypothesis 5.5, which implies that teams in both conditions are showing a similar fluctuation of volume of messages sent across time, particularly from the experimental phase with a decrease in volume during task 2.

The assessment of the SAT cognitive behavior comprehension indicated significant condition-by-time effects across tasks (Wald $\chi^2(3) = 20.10, p < .001$), with a significant lower volume of the cognitive behavior comprehension for teams in the control condition in the experimental phase (OR = .51, $p = .042$, 95% CI, .26 - .98) compared to training and teams engaging in team reflexivity intervention. Time was also found to be a predictor for the volume of the cognitive behavior across tasks Wald ($\chi^2(3) = 96.44, p < .001$) with a significant higher volume of the cognitive behavior in task 1 (OR = 2.32, $p = .006$, 95% CI, 1.28 - 4.21) and experimental phase (OR = 2.64, $p < .001$, 95% CI, 1.74 - 4.01) compared to task 2. The Bonferroni correction revealed that for teams in the team reflexivity intervention an increase in the volume of the SAT cognitive behavior comprehension from task 1 to experimental phase ($M - D = 6.10, p < .001$) and a significant decrease to task 2 ($M - D = 6.94, p < .001$) existed. The control condition indicated also a significant decrease in volume of the cognitive behavior comprehension from the experimental phase to task 2 ($M - D = -2.65, p < .001$). Teams in the reflexivity intervention did show significant higher volume of the indicator SAT comprehension in form of messages sent during the intervention, supporting the hypothesis 5.5. Both conditions also decreased in volume during task 2.

Although, time was a significant predictor of the SAT cognitive behavior projection ($\chi^2(3) = 14.03, p = .003$) with a significant higher volume of the cognitive behavior projection in task 2 (OR = .36, $p = .030$, 95% CI, .14 - .90) and higher volume in the experimental phase (OR = 2.43, $p = .039$, 95% CI, 1.05 - 5.63) compared to training, no significant condition-by-time effects were found. Further, no significance across tasks for conditions was found in the post hoc analysis using the Bonferroni correction $p = .006$. This result indicates both conditions to demonstrate similar volume of the cognitive behavior across time, therefore rejecting the hypothesis 5.5.

Time was also a significant predictor of the SAT cognitive behavior action ($\chi^2(3) = 366.01, p < .001$) with a significant higher volume of the cognitive behavior in task 1 (OR = 2.03, $p < .001$, 95% CI, 1.51 - 2.72) and higher volume in the experimental phase (OR = 4.68, $p < .001$, 95% CI, 3.46 - 6.33) compared to task 2, no significant condition-by-time effects were found. A post hoc analysis using the Bonferroni correction specified at $p = .006$

revealed that for teams in the team reflexivity intervention an increase in the volume of the SAT cognitive behavior action from task 1 to experimental phase ($M - D = 7.26, p < .001$) and a significant decrease to task 2 ($M - D = -8.84, p < .001$) was present. The control condition indicated a significant increase from training to task 1 ($M - D = 2.32, p = .003$), from task 1 to experimental phase ($M - D = 6.16, p < .001$) with a decrease in volume of the cognitive behavior comprehension from the experimental phase to task 2 ($M - D = -8.54, p < .001$). Hence, similar volume of the cognitive behavior SAT action was found across time for teams in both conditions, thus rejecting the hypothesis 5.5.

The GEE analysis revealed no significant condition-by-time effects of cognitive behavior TMS specialization (Wald $\chi^2(3) = 2.21, p = .53$), however time was a predictor for volume of specialization across tasks (Wald $\chi^2(3) = 471.14, p < .001$). Analysis showed a significant lower volume of the cognitive behavior in training (OR = .63, $p < .05$, 95% CI, .45 - .89) and higher volume during the experimental phase (OR = 2.32, $p < .001$, 95% CI, 1.95 - 2.76) compared to task 2. The Bonferroni correction specified at $p = .006$ revealed that for teams in the team reflexivity intervention an increase in the volume of the cognitive behavior specialization from task 1 to the experimental phase ($M - D = 13.23, p < .001$) and a significant decrease to task 2 ($M - D = -13.71, p < .001$) was present. The control condition indicated also a significant increase from task 1 to experimental phase ($M - D = 9.84, p < .001$) and a decreasing volume of the TMS cognitive behavior specialization from the experimental phase to task 2 ($M - D = -9.77, p = .001$). Hence, results indicate that across time teams in both conditions demonstrated similar changes in volume of the indicator specialization in form of messages sent, rejecting the hypothesis 5.5.

Results indicated significant condition-by-time effects of cognitive behavior TMS coordination (Wald $\chi^2(3) = 8.57, p = .036$), with a higher volume of the cognitive behavior during the experimental phase (OR = 1.72, $p = .049$, 95% CI, 1.00 - 2.95) compared to task 2 for teams in team reflexivity intervention. In addition, the cognitive behavior coordination displayed a significant higher volume in the experimental phase (OR = 2.90, $p < .001$, 95% CI, 2.06 - 4.08) compared to task 2 with time being the significant predictor, Wald $\chi^2(3) = 166.03, p < .001$. The Bonferroni correction revealed that for teams in the team reflexivity intervention an increase in the volume of the cognitive behavior from task 1 to the experimental phase ($M - D = 11.71, p < .001$) and a significant decrease to task 2 ($M - D = -11.94, p < .001$) was present. The control condition indicated also a significant increase from task 1 to experimental phase ($M - D = 3.87, p < .001$) and a decreasing volume of the TMS

cognitive behavior specialization from the experimental phase to task 2 ($M - D = -4.65, p < .001$). Although, both conditions increased the level of the indicator coordination during the experimental phase, teams in the reflexivity condition demonstrated a significantly higher volume than teams in the control condition, thus supporting the hypothesis 5.5. Teams in both conditions lower volume of the cognitive behavior TMS was found in task 2.

While no significant condition-by-time was found for the TMS cognitive behavior confusion, time was a significant predictor (Wald $\chi^2(3) = 28.04, p < .001$) demonstrating a higher confusion volume during the experimental phase (OR = 1.84, $p = .016$, 95% CI, 1.12 - 3.02) compared to task 2. No significance across tasks for conditions was found in the post hoc analysis using the Bonferroni correction $p = .006$. Hence, the hypothesis 5.5 was rejected indicating teams in both conditions to show similar volume of cognitive behavior confusion across time.

In addition, no significant condition-by-time effects were revealed for TMS cognitive behavior credibility (Wald $\chi^2(3) = 2.11, p = .55$). Time, however, was an effective predictor of the cognitive behavior (Wald $\chi^2(3) = 224.46, p < .001$), which showed a significant higher volume in the experimental phase (OR = 3.62, $p < .001$, 95% CI, 2.89 - 4.53) compared to task 2. Also a significant increase in the volume of the cognitive behavior credibility from task 1 to experimental phase ($M - D = 6.19, p < .001$) and a significant decrease to task 2 ($M - D = -6.32, p < .001$) was present according to post hoc analysis using a Bonferroni correction specified at $p = 0.006$. The control condition indicated also a significant increase from task 1 to experimental phase ($M - D = 9.84, p = .003$) and a decreased volume of the cognitive behavior credibility from the experimental phase to task 2 ($M - D = -3.55, p = .001$). The results indicate teams in both conditions to show similar volume of the cognitive indicator credibility across time, therefore rejecting the hypothesis 5.5. Although, no significant condition-by-time effects were found for TMS cognitive behavior feedback (Wald $\chi^2(3) = 6.62, p = .09$), both time (Wald $\chi^2(3) = 183.56, p < .001$) and condition (Wald $\chi^2(3) = 10.70, p = .001$) were effective predictors of feedback.

The TMS cognitive behavior demonstrated a significant higher volume in teams receiving the team reflexivity condition (OR = 1.74, $p = .026$, 95% CI, 1.07 - 2.83), displayed a lower volume in training (OR = .24, $p < .001$, 95% CI, .12 - .49) and higher volume in the experimental phase (OR = 1.5, $p < .001$, 95% CI, 1.25 - 1.80) compared to task 2. Post hoc analysis with Bonferroni correction specified at $p = .006$ revealed that for teams in the team reflexivity intervention an increase in the volume of the cognitive behavior feedback from

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training to task 1 ($M - D = 1.42, p < .001$), from task 1 to experimental phase ($M - D = 3.32, p < .001$) and a significant decrease to task 2 ($M - D = 2.64, p < .001$) was present. The control condition indicated a significant decrease in the volume of feedback from the experimental phase to task 2 ($M - D = .74, p = .001$). No significant interaction in form of messages sent was found and the hypothesis 5.5 was rejected. Teams engaging in the team reflexivity intervention demonstrated significant higher volumes of the cognitive behavior feedback compared to the control condition. Teams engaging in the team reflexivity intervention also significantly increased in feedback during the intervention with a significant lower volume of messages sent during task 2.

Table 64. Significant Condition by Time Effects of Cognitive Behaviors.

Outcome Variable	Effects	B	B SE	OR	$p \leq$
SAE perception	Time: Training	-.57	.14	0.57	.001
	Time: Experimental	.37	.12	1.45	.001
SAE comprehension	Condition x Time: Experimental (TRI)	.39	.12	1.47	.001
	Time: Training	-1.92	.41	.15	.001
	Time: Experimental	.26	.06	1.30	.001
	Condition: Control	-1.19	.43	.30	.005
SAE projection	Time: Experimental	1.15	0.37	3.17	.002
SAE action	Condition x Time: Training (TRI)	1.03	.42	2.80	.014
	Condition x Time: Experimental (TRI)	.50	.21	1.65	.016
	Time: Training	-.48	.32	.23	.001
	Time: Experimental	.49	.14	1.64	.001
	Condition: TRI	.52	.25	1.68	.039
SAT perception	Time: Training	-.73	.32	.48	.022
	Time: Experimental	.65	.13	1.91	.001
SAT comprehension	Condition x Time: Experimental (Control)	-.68	.33	.51	.042
	Time: Task1	.84	.30	2.32	.006
	Time: Experimental	.97	.21	2.64	.001
SAT projection	Time: Task2	-1.03	.47	.36	.030
	Time: Experimental	.89	.43	1.24	.039
SAT action	Time: Task1	.71	.15	2.03	.001
	Time: Experimental	1.54	.15	4.68	.001
	Time: Task2	.50	.18	1.64	.005
	Time: Experimental	1.55	.19	4.73	.001
TMS specialization	Time: Training	-.46	.18	.63	.009
	Time: Experimental	.84	.09	2.32	.001
TMS coordination	Condition x Time: Experimental Phase (TRI)	.54	.28	1.72	.049
	Time: Experimental	1.06	.17	2.90	.001
TMS confusion	Time: Experimental	.61	.25	1.84	.016
TMS credibility	Time: Experimental	1.29	.11	3.62	.001
TMS feedback	Time: Training	-1.43	.37	.24	.001
	Time: Experimental	.41	.09	1.50	.001
	Condition: TRI	.55	.25	1.74	.026

7.5.6 Results of Volume of SA and TMS Cognitive Behaviors in Form of Words Written Across Time

The hypothesis 5.5 of whether volume of SA and TMS cognitive behaviors differ across time for teams engaging in team reflexivity were assessed using a GEE analysis for words written. Table 65 presents Means and Standard Deviations of cognitive behaviors for volume of words written across team tasks.

Table 65. Means and Standard Deviations of Cognitive Behaviors on Words written.

Words	Training	Task 1	Experimental Phase	Task 2
	M(SD)	M(SD)	M(SD)	M(SD)
SAE				
TRI	44.71(45.75)	71.87(51.85)	163.71(103.43)	63.39(40.11)
Control	19.77(16.59)	52.81(39.14)	80.35(63.09)	46.84(33.30)
SAT				
TRI	42.65(40.65)	50.26(32.97)	206.97(125.13)	45.35(38.59)
Control	34.19(32.55)	58.26(40.58)	138.97(70.18)	41.10(36.01)
TMS				
TRI	76.71(51.61)	102.87(57.33)	389.81(146.48)	85.45(55.81)
Control	56.61(43.46)	97.03(60.95)	244.39(177.54)	82.68(48.47)

GEE indicated significant condition-by-time effects and/ or main effects of time on the volume of cognitive behaviors in form of words written by team members across tasks. Significant condition-by-time effects for SAE cognitive behaviors across tasks (Wald $\chi^2(3) = 12.83, p = .005$). Results indicated significant higher volume of SAE cognitive behaviors in form of words written in the experimental phase (OR = 1.51, $p = .003$, 95% CI, 1.15 - 1.97) compared to task 2 for teams engaging in the team reflexivity intervention. Time was also a predictor for volume of words written of the SAE cognitive behaviors across tasks (Wald $\chi^2(3) = 207.08, p < .001$) with a decreased volume in training (OR = .42, $p < .001$, 95% CI, .30 - .60) and increased volume in the experimental phase (OR = 1.72, $p < .001$, 95% CI, 1.42 - 2.07) compared to task 2. Post hoc tests using the Bonferroni correction specified at $p = .006$ revealed that for teams in the team reflexivity intervention an increase in the volume of the cognitive behavior from task 1 to experimental phase ($M - D = 91.84, p < .001$) and a significant decrease to task 2 ($M - D = -100.32, p < .001$) was present. The control condition indicated a significant decrease of the volume of SAE cognitive behaviors only from the experimental phase to task 2 ($M - D = -33.52, p = .001$). The results support the hypothesis 5.5 indicating cognitive behavior SAE in form of words written to be significantly different between conditions across time. For instance, teams in the team reflexivity condition exhibited higher volume of words written of SAE during the intervention, but significantly

decreased in volume in task 2 similar to the control condition. Refer to Table 66 for a summary of all significant findings.

The GEE analysis revealed significant condition-by-time effects for SAT cognitive behaviors across tasks (Wald $\chi^2(3) = 9.42, p = .024$) with time being a significant predictor (Wald $\chi^2(3) = 336.73, p < .001$). A significant higher volume of the SAT cognitive behaviors were found in task 1 (OR = 1.42, $p = .018$, 95% CI, 1.06 - 1.89) and in the experimental phase (OR = 3.38, $p < .001$, 95% CI, 2.49 - 4.59) compared to task 2. The Bonferroni correction specified at $p = .006$ revealed that for teams in the team reflexivity intervention an increase in the volume of the cognitive behavior from task 1 to experimental phase ($M - D = 156.71, p < .001$) and a significant decrease to task 2 ($M - D = 161.61, p < .001$) was present. The control condition indicated also a significant increase from task 1 to experimental phase ($M - D = 80.71, p < .001$) and a decreased volume of SAT cognitive behaviors from the experimental phase to task 2 ($M - D = -97.87, p = .001$). These results support the hypothesis 5.5 in that teams in the reflexivity condition did significantly increased volume of words written during the intervention compared to the control condition. However, a significant decrease was during task 2 was found for both conditions.

Further, a significant condition-by-time was found for TMS cognitive behaviors (Wald $\chi^2(3) = 15.94, p = .001$), with teams in the reflexivity condition demonstrating a higher volume of TMS cognitive behaviors in the experimental phase (OR = 2.96, $p < .001$, 95% CI, 2.45 - 3.57) compared to the control condition. In addition, time revealed to be a significant predictor of the TMS cognitive behaviors (Wald $\chi^2(3) = 694.60, p < .001$). A lower volume of the cognitive behaviors were displayed in words written in training (OR = .69, $p = .001$, 95% CI, .55 - .86) and a higher volume in the experimental phase (OR = 2.96, $p < .001$, 95% CI, 2.45 - 3.57). A significant increase for teams in the team reflexivity intervention from task 1 to the experimental phase ($M - D = 286.94, p < .001$) and decrease from the experimental phase to task 2 ($M - D = -304.35, p < .001$) for the TMS cognitive behaviors according to the post hoc with Bonferroni correction specified at $p = .006$ were revealed. The control condition revealed similar results with an increase in volume of the TMS cognitive behavior from training to task 1 ($M - D = 40.42, p < .001$), task 1 to experimental phase ($M - D = 147.35, p < .001$), and a decrease from the experimental phase to task 2 ($M - D = -161.71, p < .001$). The hypothesis 5.5 is therefore supported and results demonstrate teams in the reflexivity condition to increase significantly the volume of TMS

words written during intervention. Both conditions significantly decreased the volume during task 2.

Table 66. Significant Condition by Time Effects of Cognitive Behaviors of Words written.

	Outcome Variable	Effects	B	B SE	OR	$p \leq$
Words written	SAE	Condition x Time: Experimental Phase (TRI)	.41	.14	1.51	.003
		Time: Training	-.86	.18	.42	.001
		Time: Experimental Phase	.54	.10	1.72	.001
	SAT	Time: Task1	.35	.15	1.42	.018
		Time: Experimental Phase	1.22	.16	3.38	.001
	TMS	Condition x Time: Experimental Phase (TRI)	.43	.12	1.54	.001
		Time: Training	-.38	.11	.69	.001
		Time: Experimental Phase	1.08	.10	2.96	.001

7.5.7 Key Findings: Volume of SA and TMS Cognitive Behaviors Across Time

The hypothesis 5.5 of whether volume of SA and TMS cognitive behaviors in computer- mediated team communication differs across time for teams engaging in team reflexivity compared to the control condition was partially supported. Volume of words written for cognitive behavior SAE were different across time between teams engaging in team reflexivity intervention compared to the control condition. Although, both conditions significantly decreased in volume of the cognitive behavior during the second task, the reflexivity condition did demonstrate higher volume of the SAE cognitive behavior during the intervention. However, results for the volume of messages sent indicated SAE comprehension and action demonstrated significant differences across time for teams receiving the team reflexivity condition. All other SAE cognitive behaviors revealed to be similar across time for both conditions with a decreased volume of these indicators during the second task.

Similar results were found for the SAT cognitive behavior suggesting both conditions to show significant differences in volume of words written regarding the cognitive behavior during the intervention. A significant decrease in volume of words written was demonstrated after the experimental phase took place in both conditions. Nevertheless, similar volume of messages sent regarding SAT cognitive behaviors across time was found for both conditions with a significant decrease in volume of messages sent during the second task. Cognitive behavior SAT comprehension was the exception and demonstrated significant differences between both conditions across time. For instance, SAT comprehension was for instance

significantly higher for teams participating in the team reflexivity condition during the intervention, supporting prior findings.

Results of TMS cognitive behavior demonstrate significant differences in volume of words written for teams receiving the team reflexivity intervention across time. Even though both condition significantly decreased in their volume of the TMS cognitive behavior during task 2, higher levels were present during the intervention for teams engaging in the reflexivity condition. In comparison, the volume of messages sent only resulted in significant differences between conditions for the TMS cognitive behavior coordination across time. All other TMS cognitive behaviors displayed the same pattern across time with a significant decrease during task 2 for both conditions. Major findings from the hypothesis testing are summarized in Table 67.

Table 67. Summary of Hypotheses to Reflexivity and Cognitive Behaviors Across Time.

Number	Hypothesis	Results
Hypotheses		
5.4	Volume of reflexivity in communication will differ across time for teams engaging in team reflexivity.	Supported.
5.5	Volume of SA and TMS cognitive behaviors in communication will differ across time for teams engaging in team reflexivity.	Partially supported. ¹

¹ For some indicators, no difference was found in form of volume across time for teams engaging in the team reflexivity intervention compared to those that did not.

7.6 Discussion and Conclusion

This summary provides findings and contribution to the research questions of Chapter Seven (7). PLS analysis was used to evaluate the theoretical model which depicts all constructs under investigation (i.e., cognitive behaviors, reflexivity and communication processes). The structural model examined in the investigation revealed the driver constructs with its influence on cognitive behaviors and team performance in computer-mediated environments. Lastly, analyses regarding individual constructs were conducted to examine the effect of a team reflexivity intervention on reflexivity and cognitive behaviors indicators during the intervention and across time. To explore the temporal nature of the reflexivity transition and action phase, reflexivity shifts were assessed by measuring whether teams stayed on the same reflexivity phase topic or digressed to another.

7.6.1 Findings

The findings of the first part are described in this section.

- i. *A theoretical model of cognitive behavior, reflexivity and communication process on performance.* The theoretical model was tested as a full model with all possible paths. First, the formative measurement model of the outer model with the relationship between the latent variables and their associated manifests were specified. The formative measurement model indicated good convergent validity, no issues of collinearity between indicators and significance of formative indicators. The resulting structural model conceptualized two formative second order constructs of SA and TMS and one first order construct of reflexivity. The structural model was evaluated for the significance of path coefficients, coefficient of determination, and effect size which revealed cognitive behaviors SA and TMS to have positive influence on team performance. Reflexivity did not show a direct effect on performance. A mediator analysis did reveal the TMS cognitive behavior to mediate the relationship between team reflexivity intervention/ reflexivity and performance. Communication was found to mediate the relationship between reflexivity and cognitive behavior TMS and to have a negative impact on overall performance in teams in which communication volume was high.
- ii. *Positive effect of team reflexivity intervention on team performance.* Teams received the team reflexivity intervention in form of a guided intervention, which included a structural outline on how to reflect. Teams were guided to reflect on information sharing and how the team was organized, to consider improvements, planning of new strategies (Gurtner et al., 2006) and how to implement strategies. Team reflexivity intervention was found to be effective in increasing performance in teams. Specifically, of the reflexivity indicators, strategy development was found to be the best predictor of high performance. Yet, teams that performed initially low benefitted considerably more from team reflexivity intervention than teams that already performed high initially.
- iii. *Team reflexivity intervention is a catalyst of reflexivity and cognitive behavior indicators in communication.* The experimental period during which teams either received the team reflexivity intervention or the control condition was examined for the exhibition of reflexivity and cognitive behavior indicators. Generalized linear models were employed for the count data during the intervention in computer-

mediated team communication with inherent clustering. Teams receiving the team reflexivity intervention displayed significantly higher volumes of the reflexivity indicators' review, strategy development and strategy implementation, compared to teams of the control condition. Although, cognitive behaviors displayed in each reflexivity phase for teams engaging in team reflexivity condition was similar, differences in exhibition certain cognitive behavior indicators for each reflexivity phase was present which aids in reviewing team structure and past task performances, developing and implementing strategies and ultimately translating to action.

- iv. *Reflexivity demonstrates different patterns between reflexivity transition and action shifts in communication.* Teams seemed to enter the process with an increase shift on reflexivity transition topics. Across time, teams digressed from the transition phase on to the action phase and then shifted more between action phase topics suggesting strategies are getting implemented until the completion of the action phase. Teams engaging in team reflexivity were observed to stay longer and to shift more between transition phase topics; and to shift more actively towards the action phase during the first communication quartiles compared to the control condition. Particularly high performance teams stayed longer in the transition phase on the topic strategy development and shifted back from the action phase regarding the topics strategy implementation to strategy development. Adapting developed strategies seemed to contribute to overall performance.
- v. *Team reflexivity intervention expedites reflexivity and certain cognitive behaviors across time.* The condition-by time effects were examined using generalized estimation equation. Different volume of reflexivity phase's review, strategy development, and strategy implementation across time were found for teams engaging in team reflexivity intervention while teams in the control condition showed similar volumes across time. Also teams engaging in team reflexivity were observed to show different volumes across times for certain cognitive behaviors (i.e., SAE comprehension and action, SAT comprehension, and TMS coordination) compared to the control condition. Both condition decreased significantly in volume of reflexivity and cognitive behaviors during the second task.

7.6.2 Significance of Findings

The results of this part demonstrate team reflexivity to expedite cognitive behaviors SA and TMS and show their positive effect on team performance. This research also provides

a theoretical model in computer-mediated communication environments to explain relationships and effects of all constructs under investigation on team performance. Further, the detailed analyses conducted reveal how team reflexivity intervention effects communication regarding reflexivity phases and cognitive behaviors during the intervention and across time which support communication processes and team performance. Additionally, an analysis of reflexivity shifts in communication, specifically of reflexivity transition and action phases provides further insight of the temporal nature on how reflexivity phases occur in team communication.

8 Discussion

This research contributes new insight to the literature on virtual teams and team cognition in four important ways. First, it examines the exhibition of cognitive behaviors and reflexivity in computer-mediated team communication and defines a classification system of indicators for employing automated information extraction measures. Secondly, it looks at cultural awareness of team members and the effect of diversity on team processes. Third, it investigates the effect of team reflexivity intervention on virtual team regulatory processes, particularly those of communication, emergent states, and improvement in team performance. Lastly, it assesses the temporal nature of reflexivity and team reflexivity intervention. This Chapter presents a general discussion of findings and their implication to theory and praxis. Further the studies limitations are presented which uncover opportunities for future research.

8.1 General Discussion

First, throughout this research, an examination of computer-mediated team communication data with respect to cognitive behaviors and reflexivity are provided. Attention is drawn to the fact that computer-mediated messages in the events under study are exchanging similar types of information but to varying degrees for teams that are high performance. Furthermore, characteristics of messages that may serve to enhance SA, TMS and reflexivity are considered. This research points to these analyses as a method to identify content features regarding cognitive and speech act behaviors in computer-mediated communications that can be applied toward the development of automatized measurement techniques of team communications. With the development of coding schemes of cognitive behaviors and reflexivity indicators, these data are perhaps the easiest to identify and automatically extract. This research characterized computer-mediated communication to describe the features of cognitive behaviors and reflexivity indicators. A classification system was generated based on linguistic features and speech act behaviors of indicators. The classification system represents a construct that has evolved from the analyses of the coding schemes and refines into indicator categories used in team communication. As an example for the cognitive behavior SA indicator, speech act behaviors related to requesting information in regard to action in the environment or directing to perform the action are exhibited. The cognitive behavior TMS was characterized by speech act behaviors that provide information to the team in form of announcements. With the exchange of information between team

members through questioning or requesting information, team members seemed to provide information proactively and directed others to perform actions (e.g., Parush et al., 2014).

Findings from the speech act behavior and linguistic analysis served as fundamental basis for creating the classification system with its distinct syntactic constructs for cognitive behaviors and reflexivity indicators. The classification system is not proposed as a definitive conceptualization of team cognition and team reflexivity occurring in team communication; rather, it represents an accounting of how computer-mediated team communication exchange information categories used in team tasks. Hence, it identifies features to inform systems that enhance cognitive behavior and reflexivity. The classification system evolves when other kinds of team events and tasks are considered. The methodological application of measuring features of team cognition and team reflexivity by fitting automated classifiers to objective communication data sets allows for a sped up process in analyzing ‘what’ and ‘how’ teams exchange information. This permits for the correct identification through communication-based text analyses of automated extraction techniques. Further, automated communication-based text analysis that tests for cognitive behaviors and reflexivity may significantly extend the ability to detect shortfalls in cognitive processes during early virtual team development phases, or prior to significant problems occurring in the field. The classification system presents a first approach to identify cognitive behaviors and reflexivity in team communications. The classification system provided further understanding of how cognitive behaviors and reflexivity occur in communication over time and how they relate and impact team performance.

Second, analyses of all constructs in this study are communication-based methods for measuring and analyzing the dynamics of cognitive behaviors and reflexivity in communication. These methods have potential in enhancing our understanding of the dynamics of team cognitive processes. Hence, this study gains important findings for the examination of individual constructs such as cognitive behaviors and reflexivity in relation to the overall model, in addition to assessing the proposed theoretical-based model. These analyses specifically investigate the effect of team reflexivity intervention on team regulatory processes such as of communication, emergent cognitive states, and improvement in virtual team performance. Virtual Teams were assigned to receiving either the team reflexivity intervention, which included structural guidance on how to reflect on information sharing and how their teams were organized, consideration of improvements, planning new strategies and their implementation (Gurtner et al., 2007), or the control condition.

A theoretical model was developed to consider all constructs under investigation, specifically those of cognitive behavior and reflexivity indicators of the prior defined classification system. The theoretical model was assessed using PLS which allowed for analyzing a structural model comprising all constructs with the overall findings hinging on the results of individual constructs in the model. Relational findings in the structural model suggested team reflexivity intervention as an effective approach of improving communication regarding reflexivity indicators' review, strategy development and strategy implementation. The improved communication expedited cognitive behaviors and aided in the development of team cognition and ultimately team performance. Neither team reflexivity intervention nor reflexivity in communication was found to have a direct effect on performance. This results stands in line with the review by Moreland and McMinn (2010), indicating team reflexivity, especially guided reflexivity, to be unrelated or sometimes even negatively related to team performance. Yet, assessing the effect of team reflexivity intervention independent of other constructs on performance revealed reflexivity to have a significant effect on performance. Team reflexivity may thus have a more intricate relationship with team performance than previously thought.

Proposition 1: Team reflexivity shows an intricate relationships with team performance.

Indeed, findings reveal that while reflexivity has positive effects on overall communication, the exhibition of cognitive behaviors SA and TMS in communication during the reflexivity intervention show to have positive effects on team performance. This finding is supported by previous research on cognitive behaviors SA and TMS which found positive relationships between the cognitive behaviors and team performance (Endsley, 2001; Liang, Moreland, & Argote, 1995; Richter & Lechner, 2009; Richter & Lechner, 2011; Yoo & Kanawattanachai, 2001). Furthermore, the effects of team reflexivity intervention and reflexivity indicators on team performance improvements were mediated by the cognitive behavior TMS. These results expand research that previously had focused on the sequential mediation role of task and team members models (Konradt et al., 2015) and task knowledge (van Ginkel et al., 2009; van Ginkel & van Knippenberg, 2009). Hence, suggesting that in computer-mediated communication environment, TMS with indicators that yield information regarding team members' expertise, coordination and prioritization of team tasks, cross checking information or providing feedback to have profound influence on team performance. Overall, findings shed more light on the relationship between reflexivity and

team performance in that reflexivity seems to act as a catalyst by increasing overall communication and consequently the volume of cognitive behaviors in communication. Hence, reflexivity interventions that are structured and provide guidance are constructive in expediting cognitive behaviors which ultimately leads to high performing teams.

Proposition 2: Structured team reflexivity interventions provide guidance in increasing communication regarding cognitive behaviors that will enhance team performance.

The results also demonstrate engagement in team reflexivity intervention to be most beneficial for teams that are initially low performing (Schippers et al., 2007), in that they can achieve greater performance improvements. For instance, guidance during the team reflexivity intervention lets teams structure 1) their thought- and interaction processes 2) information regarding the past, present and future task environment relevant for adequate strategy development and 3) the assessment and development of strategies for translation into action. Teams that were already high performing may be less likely to adapt new forms of strategies as the initial performance indicated an adequate strategy to be already in place (Konradt et al., 2015; Schippers et al., 2013). A detailed analysis of the effect of reflexivity indicators on performance revealed strategy development to significantly affect performance outcome. Further, high performance teams engaged in more communication about reviewing their task performance compared to low performance teams. Thus, these teams spend more time on reviewing past task performance to develop strategies and ultimately implement strategies according to task goal (see also case analysis on reflexivity). More emphasis should be placed on the reflexivity transition phase for developing strategies to build upon the results of review in form of guidance or structural outlines.

Proposition 3: Focusing on the results of reviewing task performance during the transition phase of reflexivity guides the team in the development of strategies.

Throughout the team reflexivity intervention, communication about reflexivity occurred in bursts, which progressively decreased across time (i.e., 10 minutes) and eventually ended for most teams before the intervention was over. Some teams even asked for permission to start the second task sooner than planned. Although, teams were denied to start with the second task sooner, this may have stimulated teams to spend time discussing topics unrelated to reflexivity. This is not a new observation, teams have previously been found to discuss topics unrelated to the task rather than reflecting or discussing instructed topics (Moreland and McMinn, 2010). However, task- related communication such as during

reflexivity intervention is important for teams to adapt action and coordination of behaviors (Gevers, van Eerde, & Rutte, 2009; Tschan, McGrath, Semmer, Arametti, Bogenstaetter, & Marsch, 2009). To our surprise, teams not engaging in reflexivity did show communication about reflexivity with a similar pattern to those that engaged in team reflexivity intervention, but to a lesser extent suggesting teams to voluntarily engage in reflexivity. This is contrary to findings of Schippers and colleagues (2013), who suggest that teams are unlikely to reflect on their own. Yet, these teams might have sought clarification about the purpose and aspects of the task (Schippers et al., 2015) that led to some degree of reflexivity and engagement in review, strategy development and strategy implementation. Particular as early conceptualization of team reflexivity included different levels ranging from deep to surface reflexivity (Schippers et al., 2007; West, 2000), teams might enact in a surface level reflexivity, when time permits and an opportunity for discussion is provided. Yet, as the findings present, teams that engage in reflexivity at the surface level fare rather poor regarding exhibition of certain cognitive behaviors and overall performance compared to teams engaging in reflexivity at a deeper level.

Proposition 4: Virtual teams need to emerge in deep levels of reflexivity to heighten the exhibition of cognitive behaviors and overall effect on performance.

Looking at the findings of the effect of the team reflexivity intervention on reflexivity and SA cognitive behavior during the intervention reveals commonalities and difference between both conditions. During all reflexivity phases (i.e., review, strategy development, strategy implementation) teams participating in the team reflexivity intervention compared to teams in the control condition showed to majority information exchange regarding objects, events and their current state, and condition for task related activities, as well as task and team related occurrences for understanding location and relations among events and places (e.g., perception, comprehension). Further, these teams exchanged information to majority regarding actions of their own team (action). During all reflexivity phases, teams that received team reflexivity intervention exhibited higher volumes of the cognitive behavior comprehension. This finding underlines research by Schraagen and Van de Ven (2011) in that team members' comprehension about the situation overcomes the lack of common ground or misunderstandings of information sharing. To majority the same cognitive behaviors across reflexivity phases are displayed for teams participating in team reflexivity, yet indicators for strategy implementation differed especially for cognitive behaviors SA. All cognitive

behaviors were found to be significant higher in teams engaging in the team reflexivity intervention.

The exhibition of higher volumes of the SA cognitive behaviors during strategy implementation implies that these teams may attain higher level team SA allowing for better adaptability and foreseeing possible future events in the team enabling team members' to reconsider possible strategies. Specifically, for high performance teams, SA cognitive behaviors were found to center more on the awareness of the teams' condition and action taken during review while during strategy development the awareness transitions to center on the external environment (see case analysis on reflexivity). Hence, these results demonstrate team reflexivity intervention to increase certain SA cognitive behavior during review, strategy development or strategy implementation, which ultimately benefits team performance. Particularly, as the postulated relationship between SA cognitive behavior and final team performance was found to be positive. These results support Kaber's and Endsley's (1998) notion of implementing training interventions that would enable team members to pass on information and to provide feedback for understanding the situation. Team reflexivity intervention has shown to facilitate increased SA cognitive behaviors in communication and seems to have an effect on performance. It is to note, that the SA cognitive behavior is not a measure of the situation awareness level in teams. Individuals might possess situation awareness but they may or may not share the information with their team members (Kaber and Endsley, 1998).

Proposition 5: Team reflexivity heightens the level of SA cognitive behaviors if an early focus on team conditions and a transition to the external environment during the strategy phases of reflexivity takes place.

Reviewing the findings of the effect of the team reflexivity intervention on reflexivity and TMS cognitive behavior during the intervention reveals differences between those receiving the team reflexivity intervention compared to those who did not. For all three reflexivity phases (i.e., review, strategy development and strategy implementation) teams in the team reflexivity intervention displayed high levels of the cognitive behavior TMS concerning information about team members expertise and status, task coordination and prioritization, accepting or confirming procedural suggestions, or cross checking information, and providing feedback regarding task accomplishments (TMS specialization, coordination, credibility and feedback). This result suggests that these indicators are of great importance during review, strategy development and implementation to aid in the achievement of high

performance. Indeed, findings by Konradt and colleagues (2014) suggest team members' need to first reflect on members' expertise in order to engage in building effective strategies. The high volume of the TMS cognitive behaviors in later reflexivity phases (i.e., strategy development and strategy implementation) may be of necessity to further coordinate actions or changes within the teams' tasks which lets teams adapt more effectively (Gevers et al., 2015; Richter & Lechner, 2011). Specifically the cognitive behavior indicator coordination may give team's access to specialized knowledge (Lewis, 2003). Also previous studies have provided evidence that feedback has positive impact on team processes and overall team reflection (Hinsz, Tindale, & Vollerath, 1997; Konradt et al., 2015; Schippers et al., 2013). This finding contributes to the recent research, in that feedback was elicited in the phases' review, strategy development and strategy implementation, and may thus help to introduce team reflection (Konradt et al., 2015).

Our findings further show that particularly high performance teams exchange more information regarding their expertise, status and mode of expertise (i.e. specialization) as well as displayed higher amounts of cognitive behavior of accepting procedural suggestions and questioning assumption to validate or cross check information (i.e., credibility). The exhibited cognitive behaviors specialization and credibility may ensure the development of sound and feasible strategies. High performance teams seem to spend more time in specializing themselves for the future task (e.g., sharing information about their own capabilities or limitations thereof) and collaboratively validating the development of their strategy (see case analysis reflexivity).

Proposition 6: Team reflexivity heightens the level of TMS cognitive behaviors, which provides the team with an access to specialized knowledge to develop feasible strategies and to coordinate task related activities.

Teams engaging in team reflexivity seem to reach deeper levels of reflexivity in that teams use the time to review initial task performance to develop strategies and to implement these strategies according to task goal. Indeed, deep reflexivity is postulated to involve tackling shared underlying objectives in a joint team task in complex information processing situations (Schippers et al., 2015). Deeper level reflexivity in high performance teams is characterized by asking more questions during strategy development, which may relate to questioning the feasibility of the strategy or assumptions regarding developing a strategy adaptable to the team task. Prior research had already identified questioning to be observable during reflexivity (West, 2000). These results expand on previous finding in that questioning

can particularly be observed during strategy development of high performance teams. Further, high performance teams exchange more information between team members related to reflexivity or cognitive behaviors and requesting and giving instruction to perform tasks (Parush et al., 2014).

Proposition 7: Deeper level reflexivity in high performance teams are characterized by asking more questions during strategy development, requesting information and giving instructions to perform.

Third, the examination of the reflexivity transition and action phases in computer-mediated communication has revealed insight into how team communication of reflexivity occurs and how it is facilitated to enhance performance. The exploration of reflexivity process shift extends theory both the reflexivity phase model and intervention process (Konradt et al., 2014; Marks et al., 2001). With respect to the reflexivity model, our results extend this theoretical framework in more than two ways. First, the study refines the set of process dimensions by a) dividing reflexivity transition phase into two distinct indicators of review and strategy development. The results strongly support this division through the distinct way in which these unfold over time. Second, the temporal nature enacted by teams may benefit from a specific ordering of the reflexivity transition and action phases (i.e., adaptation). Indeed, in high performance teams the action phase (i.e., adaptation) was delayed to after multiple transition phase topics were undertaken. The investigation of reflexivity transition and action phase shifts revealed variations in when reflexivity phase shifts occur in computer-mediated team communication. Further, it provided evidence on when team adaptation occurs and when they are most effective for overall team performance.

Teams enter the transition phase with an increased shift on to reflexivity transition topics review and strategy development during the first quartiles. Across time reflexivity shifts digress from strategy development on to the action phase topic strategy implementation indicating the transition phase has ended. In the following sequence communication centers solely on the action phase until the action phase comes to an end. During this stage, changes in team objective, strategies, and processes, which the team identified during the reflexivity transition phase are translated into action though goal-directed behaviors (West, 2000). Findings on high performance teams lead to conclude that shifts between reflexivity transition phase topics or on to action phases to contribute to overall performance during the first and second quartiles. This stands in line with research by Kennedy and McComb (2014) which suggests better team performance to be more likely achieved by managing the timing

of the initial process shifts; in such a way that teams have their initial transition process shifts during the first and second quartiles of cooperation before the action process begins after midpoint. Looking at the reflexivity transition phase shifts, teams benefited from furthering initial reflexivity transition phase shifts. Topics such as strategy development have previously been found to be salient matters early in team collaboration (Hackman & Wageman, 2005). Indeed, teams that performed poorly and did not participate in the team reflexivity intervention demonstrated less shifts between reflexivity transition phase topics and digressed less from topics of the transition phase on strategy development to the action phase or vice versa. Not just one strategy is appropriate for each problem and thus adaptability and modification of strategies might be necessary to solve problems effectively (Dörner 1978, 1999; Wetzstein & Hacker, 2004). Conclusively, these findings suggest initial discussion about strategy development and returns from the action phase of the topic strategy implementation on to strategy development during the second and third quartile to lead to better performance outcome.

Proposition 8: Virtual teams that shift at a higher rate between transition and action phases of reflexivity will show better performance outcomes.

The investigation of the effect of team reflexivity intervention sheds further light on the temporal display of the volume of reflexivity indicators and cognitive behaviors across tasks. Generally, volume of reflexivity accelerated through the effect of team reflexivity intervention during the time of intervention which involved teams at a deeper level in review, strategy development and strategy implementation. Compared to teams in the control condition, these teams significantly decreased in reflexivity volume during the second task suggesting strategies to be fully adapted. However, for teams in the control condition surface level reflexivity is displayed during the second task, which might be regarded to the factor time, as no time was allocated for getting involved in reflexivity at a deeper level (i.e., review, strategy development and strategy implementation). In general, teams engaging in the team reflexivity intervention exhibited more cognitive behaviors during intervention and the second task compared to teams in the control condition. These teams also exhibit different volumes across time for number of words written of cognitive behaviors. However, for number of messages sent the pattern between conditions was similar except for certain cognitive behaviors (i.e., SAE comprehension and action, SAT comprehension, and TMS coordination) implying these cognitive behaviors to be expedited through team reflexivity intervention to support strategy development and implementation, but then deteriorate during

the second task. The control condition displayed higher volumes of reflexivity indicators during the second task and also exhibited cognitive behaviors during the time of discussion. These findings underline the postulations teams to voluntarily engage in some degree of reflexivity, when time allows, aiding in the development of team cognitive processes.

Proposition 9: Virtual teams will voluntary reflect on the surface level when time is not a factor which aids in some development of cognitive processes.

Research has found that communication decreases with the development of cognitive processes such as TMS (Yoo and Kanawattanachai, 2001). To our surprise both conditions showed deterioration in the display of cognitive behaviors during the second task. Further, our findings suggest that while high volumes of the exhibition of TMS and SA cognitive behaviors during the intervention had a positive effect, communication volume regarding TMS and SA deteriorated as teams developed their TMS and SA over time. Therefore, the direct positive influence on cognitive behaviors SA and TMS in team communications decreased as SA and TMS are developed during reflexivity intervention. Hence, high performance teams seemed to exchange their expertise and background information early in the team development process, here during the reflexivity intervention, which allowed for quick development of a TMS (Yoo and Kanawattanachai, 2001).

Further, with the decrease of the exhibition of the cognitive behaviors, team members are able to better focus on the task at hand as the act of communicating preoccupies team members' ability to perform (e.g., Yoo & Kanawattanachai, 2001). This stands in line with research by Van Dijk and Broekens (2010), who suggested that virtual teams decrease the amount of communication in order to have the ability to perform their task during the team effort. Thus, the exhibition of the cognitive behaviors during communication in the second task served solely as mechanisms to monitor and update relevant information specifically to environmental factors for coordinating and maintaining SA (Kaber & Endsley, 1998), or for team factors to update TMS (Lewis, 2003). These findings also support research by McMillan and colleagues (2004), who stated that team members' selective push information to reduce the communication overhead while at the same time increase the effectiveness of information transfer. Thus, sharing explicitly cognitive behaviors effectively is more likely to lead to a better team understanding through the depiction of team members' activity (see McMillan et al., 2004).

Proposition 10: High performance teams decrease communication entailing cognitive behaviors if these processes develop early in team development phases – during the reflexivity intervention.

Further, these findings reveal that the discrepancies between volume of words written and messages seems to stand in relation with the level of reflexivity teams engage in. For instance, teams engaging in a deep level of reflexivity show higher contribution of cognitive behaviors, specifically during certain times across tasks. On the other hand, teams that engage in surface level reflexivity do not exhibit the depth of communication contribution in form of words written. These findings suggest that besides the extraction of classifier in form of verb indicators and number of tagged utterances, automated text analytics should also consider number of words in utterances to provide information regarding the depth of processing and conversation (Anseel et al., 2009; Konradt et al., 2015). Teams that displayed a deeper level of reflexivity regarding strategy implementation may elicit better adaptation processes resulting in better team effectiveness in complex and unpredictable situations.

Our results contribute to lack of body of knowledge as to which team cognitive constructs are most crucial during the strategy implementation and team adaptation phase (Gevers et al., 2015). Findings suggests that also the occurrence of adaptation plays a role in overall team processes, the content of the adaptation phase through the input of cognitive behavior SA and TMS aid teams most effectively in translating strategy into action. Hence, the cognitive behavior SA and TMS seem to play a central role as they function as inputs and proximal outputs of the adaptation processes (Geves et al., 2015). Overall, our results expand on previous findings by Burke et al. (2006), who conceptualized team adaptation to emerge over time from the unfolding of a recursive cycle of process-oriented phases (i.e., situation assessment, formulation and execution of plans, and team learning). Here, one or more team members use their resources to functionally change goal-directed actions or structures to meet expected or unexpected demands.

Proposition 11: SA and TMS cognitive behaviors play a central role as input and proximal output variables of adaptation processes.

Lastly, the effect of cultural awareness and diversity on communication contribution and performance was investigated. Findings suggest teams that are diverse in form of language or ethnic diversity to have no awareness of cultural diversity in computer-mediated communication environments. However, teams that were culturally aware of ethnic diversity did elicit better team performance compared to teams who stayed unaware. Better

performance in language diverse teams was not found, implying language diversity to have no effect on performance if proficiency has progressed to mediocre or higher language levels. Hence, these findings demonstrate native and non-native English speakers to exhibit the same communication patterns in form of turn taking, word count and turn length in computer-mediated communication environments.

Though contrary to prior research (e.g., Chan et al., 2006), language diverse teams did not show higher amounts of confusion or misunderstandings within the team through communication. However, language uniform teams did elicit higher levels of the cognitive behavior SA projection regarding communication of possible future actions in the team. Language uniform teams may thus be able to reach higher levels of SA regarding their own team factors, which may positively impact performance. Team training can be used to help diverse teams to increase information sharing. Particularly as team reflexivity intervention was found to be beneficial for the engagement and communication contribution of language diverse team members, and contributing to the reflexivity phases' strategy development and strategy implementation.

Proposition 12: Cultural awareness of team diversity leads to higher team performance, and team reflexivity is beneficial for overall communication contribution in ethnic and language diverse teams during strategy development and implementation.

8.2 Potential Limitations and Future Directions

Our investigation of cognitive behaviors and reflexivity in team communication processes has generated multiple insights into how these factors are displayed and facilitated to enhance performance. As with any research, this study has certain limitations that uncover opportunities for future research.

First, this study presents a first approach to identify cognitive behaviors and reflexivity in communication. Limitations of the identification of classifiers might therefore exist in that a) indicative verbs are not contained in the verb classes (i.e., VerbNet), b) a verb exhibits a different syntactic structure. The verbs could thus not be attributed to a cognitive behavior indicator. Finding the best approach toward the automatic identification of cognitive behavior communicated will involve training and testing of the classifiers. Future directions may therefore include the expansion of the types of team communication events analyzed. One highly specific event was analyzed in this dissertation. The analysis of team communications during additional types of events such as in the management, medical or military field may uncover further 'what kind' and 'how' cognitive behaviors and reflexivity

are communicated. The result of future communication event analyses will aid to verify, generalize, and expand and/or alter existing classifies for the identification of cognitive behavior indicators.

Second, this research presents an experimental design to demonstrate causal effects in a controlled lab-setting, by using virtual teams that worked on a fictitious fire-rescue task for a relatively short period of time. Specifically, teams in the present experiment were network structured teams, the task was dynamic, and the communication occurred via computer-mediated communication channels (i.e., a chat system). This may have limited the external validity of the present results. Even though several authors stated results from experimental settings to be generalizable to the fields (e.g., Dipboye, 1990; Konradt et al., 2015; Locke, 1986), it seems of importance to replicate the gained results with teams either operating in organizational structures or displaying different team structures (e.g., over a longer period of time) to increase overall generalizability of these findings. Future research might also want to investigate how cognitive behaviors or the effect of team reflexivity intervention or reflexivity evolve/ develop across a lifecycle of a team and how it relates to team performance longitudinally. Further, this research applied multiple mediated analyses to examine the multiple mediated effects within the theoretical model. With the recent methodological advances in conditional process analysis (Hayes, 2012), future research may want look at examining mediator effects using longitudinal designs to detect patterns of covariation over time and assess construct stability (e.g., Roe, 2014).

As the assigned experimental teams were confronted with a rather evolutionary change in that task 1 did not differ drastically from task 2, the generalizability of our findings is limited. Thus, type of task and task complexity might have an impact on the development of TMS and SA as well as exhibition of these cognitive behaviors in communication. For instance, the cognitive behavior SA might be more observable in environments that are dynamic and difficult to predict (e.g., Uitdewilligen, Waller, & Pitariu, 2013). Future research may want to evaluate other types of tasks with more restrictive constraints (e.g., time pressure; Ancona & Chon, 1996) or varying working conditions to invoke task conditions requiring different processes. Despite these limitations, the NetOpFeuer simulation imitated the complexity, novelty, and uncertainty of real environments, which strengthened the experiment design for observing the effect of team reflexivity intervention on team cognitive process development and team communication.

Fourth, premature conclusions about the role of indicators in the development of cognitive processes may limit our findings. Specifically, it is assumed that cognitive behaviors are the most relevant for examining team cognition and communication contribution. Particularly, cognitive indicators and reflexivity (i.e., transition and action phases) are assumed as observable through messages or communication shifts and to be most important for assessing team regulatory processes. However, other forms of communication such as gestures and vocal intonations augmenting spoken also influence team processes (Cramton, 2001). Though this study facilitated first efforts in capturing cognitive processes in communications, future directions might extend the communication-based approach by integrating nonverbal and para-verbal communication. Further, given that the exhibition of cognitive behaviors in communications decreased to a minimum to maintain or update SA or TMS, future research may want to apply objective communication-based methods together with other developed subjective techniques to gain a bigger picture of cognitive behaviors and reflexivity.

This study provides directions for the specificity of subsequent research and further investigations of the effect of team reflexivity interventions on virtual teams. Future research needs to focus on different reflexivity indicators to determine their effects on emergent states. More emphasis should be placed on cognitive team development across time, such as reflexivity. Because reflexivity might not have a direct influence on team cognition but it may support the development processes. Future research should therefore focus on in-process reflexivity (Moreland & McMinn, 2010). Since the guided reflexivity intervention did facilitate greater SA and TMS cognitive behavior exhibition in team communications, future researchers might want to explore further effects of reflexivity communication on team performance.

8.3 Conclusion

This research herein contributes to the understanding of team performance based on the exhibition of cognitive behavior and reflexivity in communication processes that comprise the proposed theoretical model. Enhancing cognitive behaviors in virtual team environments through automatic methods require an understanding of information communicated by team members. Our analyses of computer-mediated communication data identifies features of information generated during team interaction, and leads to the development of a classification framework to inform design and implementation of software that employs information extraction strategies. Consistent with theoretical propositions, this

research provides evidence that team communication aids as a promising measure for extracting classifiers in gaining insight into the content regarding cognitive behaviors and reflexivity teams communicated. Research on how these cognitive processes can be developed in the early stages of virtual team formation is vital, as virtual teams will become the strategy of choice for many organizations.

Our findings suggest team reflexivity interventions to accelerate the exhibition of cognitive behaviors and reflexivity in communications, thus aiding in the development of team cognition and team performance. Indeed, SA and TMS cognitive behaviors were found to significantly increase performance in teams. This research also proposes team reflexivity intervention to be a beneficial approach to enhance communication contribution regarding strategy development and strategy implementation in teams that are diverse. Further, teams participating in team reflexivity intervention are more likely to be engaged in reflexivity at a deeper level. Engagement in the reflexivity process does not enhance overall performance, but support for the relationship between when initial reflexivity shifts and digression to adaptation occurs align with performance improvement. Thus, teams may benefit more from expedited initial transition phase shifts because of the way discussions on topics regarding review and strategy development are promoted as well as from the recurrence of shifts between reflexivity transition and action phases. This study moves beyond the static to a more dynamic measure for understanding team cognition and demonstrates the opportunities automated communication methods offer researcher for advancing theory and providing directions for future studies.

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APPENDIX A: Installing and Starting the NetOpFeuer 2.0 Simulation

The installation and the starting of NetOpFeuer 2.0 constituted the following procedure. Two simulation folders with one condition per folder were copied into a new folder on the designated lab computer. Each simulation folder included a subfolder (“config”) containing the simulation scenarios and instructions, as well as a subfolder that logged all simulation activities. Several other files, including “Start_NetOpFeuer.bat,” and an online questionnaire link were present in each simulation folder. To run the multi-team member simulation, the “.bat” file was clicked with a double mouse click. This started the simulation. A program window “cmd.exe” was displayed which continued running in the background during the simulation. This window was not closed, as this would have caused a simulation abort. Seconds after, the simulation home screen appeared followed by the actual menu screen. The menu window could be set to full screen mode by clicking the “maximize” icon in the right corner of the window.

The experimenter opened the simulation before the participants started their session to hinder a simulation abort. The menu window displayed the actual interacting surface, most of which was occupied by the field screen. Below the playfield screen on the left hand side were buttons for members “New Game,” “How to Play,” “Instructions,” and “More.” To the right was the chat textbox that allowed communication between team members. On the right side was also a demonstration modus, an information field presenting specific information about the units and the unit status (e.g., percent of forest saved, water tank level, vehicle speed). More simulation information including wind direction, wind speed, and timer were displayed in the right column.

To start the simulation, the button “New Game,” located on the menu screen above the button “Instructions” was clicked by the team members. In the “popped up” simulation entry screen, team members first entered their assigned member’s name and added the assigned participant number (e.g., homer101). One team member was hosting the simulation, and was therefore referred to as the “host.” The host selected the button “Start the game” after which a “Waiting for clients” window appeared. In the chat window the message: “0: host homer101 entered the game” was displayed. The other three team members participating in this simulation were called “clients.” To join the simulation initiated by the host, the clients selected the same simulation as the host and marked the button “Join Game.” Then, the previously gray field “IP of the host” opened up and the clients entered the provided “host

IP” address. This procedure connected the four team members to collaborate in the simulation. Upon entry, the clients clicked the “Join Game” button. In the chat window the message: “1: client elsie102 entered the game,” appeared whereby the clients were numbered by the system in their order of entry (0 = host, 1= 1st client, 2= 2nd client, 3= 3rd client). After all three team members joined the simulation; the host clicked the “OK” button of the “Waiting for clients” window, which started the simulation immediately.

After the simulation had started, team members selected, with a left mouse click, the assigned unit. Units in NetOpFeuer 2.0 were partially autonomous agents; they needed to be dispatched to specific locations to do their work. Team members had to select the unit, and via mouse click, move to the desired destination. The units automatically attempted to extinguish fire with water when they arrived at a fire. The firefighting units could succeed (extinguishing the fire), run out of water, or be too late and the fire had burned everything in the area (i.e., the area turns black). Both fire-engines and helicopters could refill their water reservoirs at the water towers placed at various locations. At all times the team members could see the exact water level of their own unit in the status information box. Team members could directly interact with each other via chat by entering text in the textbox next to the word “Chat” and click “Send.” Each message sent was associated with the team member number. Their team member name was displayed together with their number upon simulation entry “1: client elsie102 entered the game.” The text was displayed in the window above, and new text appeared in red for 5 seconds. When the simulation was over, the system automatically opened a window. After the team members clicked “OK” at the bottom right in the status window the achieved results were displayed in percentages (e.g., forest saved: 60%, buildings saved: 45%). The simulation was run on a 17-inch monitor with a viewing distance of approximately 50 cm.

APPENDIX B: Questionnaire Items

1.1 Demographics

Please complete the following questions. The information you provide will be kept strictly confidential and will be used only for the purposes of this study.

1. Gender: Male **1** **Female** **2**

2. Age: _____

3. What is your ethnic heritage?

- 1** African American
- 2** American Indian/Alaska Native
- 3** Asian
- 4** Caucasian
- 5** Hispanic /Latino
- 6** Multi-racial
- 7** Native Hawaiian/Pacific Islander
- 8** Other (please specify) _____

4. What is your native language?

- 1** English
 - 2** Other
- Other (please specify):** _____

1.2. Cultural Awareness

1. Where you aware that one or more of your virtual team member's was from a different ethnicity than you?

- 1** Yes
- 2** No

2. Where you aware that one or more of your virtual team member's primary language was not English?

- 1** Yes
- 2** No

1.3. Reflexivity Scale

In task 2 you were asked to complete a firefighting mission. So that we may gain a better understanding of how you and your team completed the mission, please answer the following questions.

Strongly disagree	Disagree	neutral	agree	Strongly agree
1	2	3	4	5

1. The team reviewed its objectives
2. The method used by the team to get the job done was discussed
3. We discussed whether the team is working effectively
4. The team reviewed whether it's getting the job done

APPENDIX C: Use of VerbNet

VerbNet provides a wide range of uses for natural language processing purposes such as verb classification done automatically or manually to identify relation between event participants to verbs or semantic role labeling (Palmer et al., 2010; Verma et al., 2011; Vieweg, 2012). VerbNet is organized hierarchically allowing for verb classes to have a parent class with up to three child classes nested below it. The child class receives all information from the parent class while adding additional information to it. VerbNet classes include for example, name, members of class, syntactic frames to provide thematic roles and the argument position regards to the verb as well as semantic predicates that describe the relation between an event and event participant (Kipper-Schuler, 2005, 2006; Palmer, Hwang, Brown, Kipper-Schuler & Lanffranchi, 2009). In Table 68, for the child class `contiguous_location-47.8-1` all of the roles and frames listed in the parent class apply, however a new frame is included: NP V. Here the frame NP V in the child class does not apply to verbs in the parent class, i.e. Germany and Austria border cannot be said.

Additionally, verbs can oftentimes belong to more than one class as the same verb can describe different events (Kipper-Schuler, 2005, 2006). For instance, the verb `cover` belongs to the `contiguous_location-47.8` class, and the `fill-9.8` class. The meaning of `cover` in the `contiguous_location-47.8` pertains to encompassing as in “the new reporter will be covering New York City”. The meaning of `cover` in the `fill-9.8` class however pertains to a cause to be overlaid with something as in “Clouds are covering the sun.”

Table 68. VerbNet Class contiguous_location-47.8.

Parent Class: contiguous_location-47.8
Members: #45 e.g., border, circle, cover, enclose, overhang, surround
Frame: NP V NP
Roles: Theme [+concrete], Co-Theme [+concrete]
Example: Germany borders Austria.
Syntax: Theme V Co-Theme
Semantics: Contact(during(E), Theme, Co-Theme) Exist(during(E), Theme) Exist(during(E), Co-Theme)
Child class: contiguous_location-47.8-1
Members: # 7 e.g., adjoin, intersect, meet, touch
Frame NP V
Example: Germany and Austria touch.
Syntax: Theme (and) Co-Theme V
Semantics: Contact(during(E), Theme, Co-Theme) Exist(during(E), Theme) Exist(during(E), Co-Theme)
Child class: contiguous_location-47.8-2
Members: # 1 e.g., dominate
Frame NP V
Example: Germany has often dominated.
Syntax: Theme V
Semantics: Contact(during(E), Theme, ?Co-Theme) Exist(during(E), Theme) Exist(during(E), ?Co-Theme)

APPENDIX D: Kappa Calculation Results**1.0 Coding Kappa Calculation of Cognitive Behaviors**

After coders assigned the first pass codes, their agreement using Cohen's κ and Krippendorff's α was computed. Agreement values of SA cognitive behavior indicators for SAE and SAT of the team dataset are listed in Table 69. There was almost perfect agreement between coders for SAE, $\kappa = .887$ (95% CI, .877 - .897), $p < .001$ and $\alpha = .887$ (95% CI, .865 - .910), $p < .001$ for coding 7498 utterances. On the item level Cohen's κ values resulted in substantial to almost perfect agreements between coders for SAE, perception $\kappa = .900$ (95% CI, .886 - .914), $p < .001$, comprehension $\kappa = .870$ (95% CI, .852 - .888), $p < .001$, projection $\kappa = .697$ (95% CI, .605 - .789), $p < .001$ and action $\kappa = .760$ (95% CI, .667 - .793), $p < .001$. On the item level Krippendorff's α values resulted in substantial to almost perfect agreements between coders for SAE, perception $\alpha = .899$ (95% CI, .748 - 1.00), $p < .001$, comprehension $\alpha = .870$ (95% CI, .722 - 1.00), $p < .001$, projection $\alpha = .697$ (95% CI, -.229 - 1.00), $p < .001$ and action $\alpha = .759$ (95% CI, .405 - 1.00), $p < .001$.

There was substantial agreement between coders for SAT $\kappa = .776$ (95% CI, .762 - .790), $p < .001$ and $\alpha = .776$ (95% CI, .734 - .810), $p < .001$ for coding 7498 utterances. On the item level Cohen's κ values resulted in substantial to almost perfect agreements between coders for SAT, perception $\kappa = .791$ (95% CI, .764 - .818), $p < .001$, comprehension $\kappa = .780$ (95% CI, .756 - .804), $p < .001$, projection $\kappa = .802$ (95% CI, .737 - .867), $p < .001$ and action $\kappa = .735$ (95% CI, .711 - .759), $p < .001$. On the item level Krippendorff's α values resulted in substantial to almost perfect agreements between coders for SAT, perception $\alpha = .791$ (95% CI, .554 - 1.00), $p < .001$, comprehension $\alpha = .780$ (95% CI, .542 - .943), $p < .001$, projection $\alpha = .802$ (95% CI, .152 - 1.00), $p < .001$ and action $\alpha = .734$ (95% CI, .493 - .908), $p < .001$.

Cohen's κ and Krippendorff's α values of TMS cognitive behavior indicators of the team dataset are listed in Table 69. There was almost perfect agreement between coders, $\kappa = .922$ (95% CI, .914 - .930), $p < .001$ and $\alpha = .922$ (95% CI, .910 - .936), $p < .001$ for coding 7498 utterances. On the item level Cohen's κ values resulted in substantial to almost perfect agreements between coders for TMS, specialization $\kappa = .906$ (95% CI, .900 - .912), $p < .001$, coordination $\kappa = .898$ (95% CI, .882 - .914), $p < .001$, confusion $\kappa = .641$ (95% CI, .580 - .702), $p < .001$, credibility $\kappa = .899$ (95% CI, .881 - .917), $p < .001$, and feedback $\kappa = .922$ (95% CI, .900 - .944), $p < .001$. On the item level Krippendorff's α values resulted in

substantial to almost perfect agreements between coders for TMS, specialization $\alpha = .906$ (95% CI, .792 - .974), $p < .001$, coordination $\alpha = .898$ (95% CI, .744 - 1.00), $p < .001$, confusion $\alpha = .641$ (95% CI, .079 - .750), $p < .001$, credibility $\alpha = .899$ (95% CI, .730 - 1.00), $p < .001$ and feedback $\alpha = .922$ (95% CI, .649 - 1.00), $p < .001$. Overall, no substantial difference in agreement scores between Cohen's κ and Krippendorff's α were found, except for the 95% confidence interval scores.

Table 69. Intercoder Reliability of all Variables.

<i>Variable</i>	<i>Cohen's Kappa*</i>	<i>Krippendorff's alpha*</i>	<i>n</i>
Task/non-task related communication	.98	.98	8844
Situation Awareness Environment (SEA)	.89	.89	7498
Perception	.90	.90	
Comprehension	.87	.87	
Projection	.70	.70	
Action	.76	.76	
Situation Awareness Team (SAT)	.78	.78	
Perception	.79	.79	
Comprehension	.78	.78	
Projection	.80	.80	
Action	.74	.73	
Transactive Memory System (TMS)	.92	.92	
Specialization	.91	.91	
Coordination	.90	.90	
Confusion	.64	.64	
Credibility	.90	.90	
Feedback	.92	.92	
Speech Act Behavior	.84	.84	
Request	.89	.89	
Announcement	.84	.84	
Question	.95	.95	
Reply	.81	.81	
Comment	.75	.75	
Confirmation	.85	.85	
Read-back	-		

*values are rounded to two decimals.

1.1 Coding Kappa Calculation of Speech Act Behaviors

After coders assigned the first pass codes, their agreement using Cohen's κ and Krippendorff's α were computed. Cohen's κ and Krippendorff's α values of speech act behaviors of the team dataset are listed in Table 69. There was almost perfect agreement between coders, $\kappa = .845$ (95% CI, .835 - .855), $p < .001$ and $\alpha = .845$ (95% CI, .823 - .867), $p < .001$ for coding 7498 utterances. On the item level Cohen's κ values resulted in substantial

to almost perfect agreements between coders for speech act behavior, request $\kappa = .885$ (95% CI, .865 - .905), $p < .001$, announcement $\kappa = .836$ (95% CI, .822 - .973), $p < .001$, question $\kappa = .949$ (95% CI, .939 - .959), $p < .001$, reply $\kappa = .817$ (95% CI, .799 - .835), $p < .001$, and comment $\kappa = .750$ (95% CI, .726 - .774), $p < .001$, confirmation $\kappa = .848$ (95% CI, .826 - .870), $p < .001$, and no agreement was provided for read-back. On the item level Krippendorff's α values resulted in substantial to almost perfect agreements between coders for speech act behavior, request $\alpha = .885$ (95% CI, .6886 - 1.00), $p < .001$, announcement $\alpha = .835$ (95% CI, .724 - .936), $p < .001$, question $\alpha = .949$ (95% CI, .827 - 1.00), $p < .001$, reply $\alpha = .817$ (95% CI, .663 - .933), $p < .001$, comment $\alpha = .749$ (95% CI, .525 - .953), $p < .001$, confirmation $\alpha = .848$ (95% CI, .602 - 1.00), $p < .001$, and no agreement for read-back, $p > .05$. Overall, no substantial difference in agreement scores between Cohen's κ and Krippendorff's α were found, except for the 95% confidence interval scores.

1.2 Coding Kappa Calculation Verbs and Verb Tense

After coders assigned the fourth phase codes, their agreement using Cohen's κ and Krippendorff's α was computed. Cohen's κ values of leveraged verbs of the team dataset are listed in Table 70. There was almost perfect agreement between coders for leveraged verbs, $\kappa = .974$ (95% CI, .968 - .980), $p < .001$ and $\alpha = .973$ (95% CI, .917 - 1.00), $p < .001$ for coding 7498 utterances. There was also almost perfect agreement between coders for verb tense $\kappa = .965$ (95% CI, .959 - .970), $p < .001$ and $\alpha = .965$ (95% CI, .949 - .979), $p < .001$ for coding 7489 utterances. On the item level Cohen's κ values resulted in almost perfect agreements between coders for leveraged verb tense, present tense $\kappa = .955$ (95% CI, .945 - .965), $p < .001$, past tense $\kappa = .971$ (95% CI, .965 - .977), $p < .001$, future tense $\kappa = .929$ (95% CI, .911 - .947). On the item level Krippendorff's α values resulted in almost perfect agreements between coders for present tense $\alpha = .955$ (95% CI, .866 - 1.00), $p < .001$, past tense $\alpha = .971$ (95% CI, .920 - 1.00), $p < .001$, and future tense $\alpha = .929$ (95% CI, .767 - 1.00), $p < .001$. No substantial difference in agreement scores between Cohen's κ and Krippendorff's α were found, except for the 95% confidence interval scores.

Table 70. Intercoder Reliability, Percentages and Means of all Variables.

<i>Variable</i>	<i>Cohen's Kappa*</i>	<i>Krippendorff's alpha*</i>	<i>n</i>
Verb	.97	.97	
Verb Tense	.96	.96	7498
Present Tense	.96	.96	
Past Tense	.97	.97	
Future Tense	.92	.92	

*values are rounded to two decimals.

1.3 Coding Kappa Calculation Reflexivity

After coders assigned the first pass codes, their agreement using Cohen's κ and Krippendorff's α were computed. Cohen's κ and Krippendorff's α values of reflexivity indicators of the team dataset are listed in Table 71. There was almost perfect agreement between coders for reflexivity, $\kappa = .960$ (95% CI, .954 - .966), $p < .001$ and $\alpha = .960$ (95% CI, .930 - .984), $p < .001$ for coding 7498 utterances. On the item level Cohen's κ values resulted in substantial to almost perfect agreements between coders for review $\kappa = .986$ (95% CI, .978 - .994), $p < .001$, strategy $\kappa = .922$ (95% CI, .908 - .940), $p < .001$, strategy implementing $\kappa = .907$ (95% CI, .891 - .923), $p < .001$. On the item level Krippendorff's α values resulted in substantial to almost perfect agreements between coders for SAE, review $\alpha = .986$ (95% CI, .924 - 1.00), $p < .001$, strategy $\alpha = .922$ (95% CI, .805 - 1.00), $p < .001$, strategy implementation $\alpha = .906$ (95% CI, .722 - 1.00). No substantial difference in agreement scores between Cohen's κ and Krippendorff's α were found, except for the 95% confidence interval scores.

Table 71. Intercoder Reliability of Reflexivity.

<i>Variable</i>	<i>Cohen's Kappa*</i>	<i>Krippendorff's alpha*</i>	<i>n</i>
Reflexivity	.94	.94	7498
Review	.98	.98	
Strategy Development	.92	.92	
Implementing Strategy	.91	.91	

APPENDIX E: Case Analysis

1.0 Case Selection Analysis

Detailed case analyses were conducted to examine team communication for cognitive behaviors and reflexivity based on overall team performance. The 62 teams were assigned to low and high performance teams based on the following categories: a) lower than mean performance of the sample at Task 2; b) higher than the mean performance at Task 2. Although, teams underwent experimental interventions (i.e., team reflexivity intervention) this phase of research focuses solely on performance measures. The effect of reflexivity intervention on cognitive behaviors and performance is discussed in Chapter Seven (7). Of the 62 teams, 14 teams were assigned to the low performance team category with a performance mean below 60% and 14 teams were assigned to the high performance team category with a performance mean above 67%. Volume of cognitive behaviors was observed in low versus high performance teams at the team level. Therefore, volume of cognitive behaviors was aggregated by summing messages sent for each team. A computational method for analysis was chosen based on whether assumption of normality and homogeneity of data was met.

1.1 Case Analysis of Cognitive Behaviors in High vs. Low Performing Teams

Case analysis was used to answer the hypotheses questions whether SA and TMS cognitive behaviors in team communication vary in regard to team performance (Hypotheses 1.1 and 1.2). Independent *t*-test tests were conducted to assess the exhibition of cognitive behavior in communication between high and low performance teams. Some of the cognitive behaviors did not meet the normal distribution assumption ($p < .05$) and were hence, assessed with the Mann-Whitney- U test (Mann & Whitney, 1947). Homogeneity of variance was met for all variables ($p > .05$) hence using Mann-Whitney U test was justified. Table 72 shows that both high performance teams and low performance teams displayed substantial number of SAE cognitive behaviors in team communication, and an independent t- test revealed no significant performance difference between teams of SAE cognitive behavior perception ($t(26) = -.17, p = .87$). Also no significance between low and high performance teams was found for SAE comprehension ($p = .83$), projection ($p = .11$) or action ($p = .23$). As can be seen from Table 72, high performance teams seem to display more SAE cognitive behavior action in comparison to low performance teams, however statistical significance was not achieved.

Results indicated SAT cognitive behavior perception to vary marginally between performance teams in communication ($U = 54, p = .042, r = -.38$). Teams who display a higher volume of SAT cognitive behavior perception are likely to perform better. On the other hand, no significant variation between teams of SAT cognitive behavior comprehension ($p = .94$), projection ($p = .59$) and action ($p = .13$) were found. Although no significance was achieved, high performance teams seem to exhibit more cognitive behaviors of comprehension and action.

Table 72. Cognitive Behaviors Exhibition in High vs. Low Performing Teams.

Category	High Performance Teams		Low Performance Teams	
	Cognitive Behavior Utterances	M (SD) Mdn	Cognitive Behavior Utterances	M (SD) Mdn
SAE				
Perception	218	15.6(10.3) 15.5	227	16.2(10.3) 14.0
Comprehension	186	13.3(13.6) 11.5	177	12.6(10.2) 12.0
Projection	17	1.3(1.3) 1.0	7	0.5(0.8) 0.1
Action	130	9.3(9.9) 6.0	74	5.3(4.0) 4.0
SAT				
Perception	127	9.1(5.1) 9.0	77	5.5(3.9) 4.0
Comprehension	162	11.6(6.4) 10.0	159	11.4(8.9) 8.5
Projection	14	1.0(2.1) 0.1	24	1.6(2.8) 0.1
Action	272	19.4(9.5) 17.5	189	13.5(10.4) 8.5
TMS				
Specialization	423	30.2(11.5) 29.5	376	26.9(13.2) 24.5
Coordination	270	19.3(8.1) 20.0	176	12.6(7.7) 12.0
Confusion	12	0.9(1.0) 0.6	11	0.8(1.4) 0.1
Credibility	145	10.4(6.4) 10.0	093	6.6(5.6) 5.5
Feedback	93	6.6(3.8) 5.5	82	5.9(5.0) 4.5

No significant variation of TMS cognitive behavior specialization in performance categories was found ($t(26) = 0.72, p = .49$). Teams that show cognitive behavior of coordination perform significantly better ($t(26) = 2.25, p = .03, d = -.85$). No significant variation of TMS cognitive behavior confusion ($p = .71$), credibility ($p = .10$) and feedback ($p = .37$) between low and high performance teams was found. Although not significant, high performance

teams seem to display more TMS cognitive behavior credibility in comparison to low performance teams. The case analysis revealed types of cognitive behaviors displayed in high versus low performance teams, similarities of cognitive behaviors between teams and significant differences, supporting Hypothesis 1.1 and 1.2 partially.

1.2 Case Analysis of Speech Act Behaviors

The same case analysis selection of low and high performance team categories was used as prior described.

1.2.1 Case analysis of Speech Act Behaviors in High vs. Low Performing Teams

Case analysis was used to answer the hypothesis 1.3 whether speech act behaviors in team communication vary in regard to team performance. The influence of reflexivity intervention on speech act behaviors and performance is discussed in later sections. The data did not justify the normal distribution assumption. Therefore, Mann-Whiney- U tests were conducted to assess cognitive behavior differences between low and high performance teams (Mann & Whitney, 1947). Homogeneity of variance was met for all variables ($p > .05$).

Table 73. Speech Act Behaviors in High vs. Low Performing Teams.

Category	High Performance Teams		Low Performance Teams	
	Speech Act Behavior Utterances	M (SD)	Speech Act Behavior Utterances	M (SD)
Speech Act Behavior				
Request	193	13.8(7.9)	120	8.6(5.4)
Announcement	620	44.3(16.9)	632	45.1(21.2)
Question	204	14.6(7.3)	200	14.3(8.2)
Reply	288	20.6(10.8)	247	17.6(7.8)
Comment	179	12.8(10.6)	167	11.9(11.1)
Confirmation	146	10.4(5.4)	120	8.6(6.3)

Table 73 displays that both high performance teams and low performance teams displayed substantial speech act behaviors, yet no significant performance effect of speech act behavior request ($p = .05$), announcement ($p = .93$), question ($p = .66$), reply ($p = .38$), comment ($p = .68$) and confirmation ($p = .30$) was found. Residual analysis revealed that speech act behaviors request, reply and confirmation were more present in high performance teams. Results of high and low performance teams indicated no significant difference of speech act behaviors request, announcement, question, reply, comment and confirmation, rejecting hypothesis 1.3.

1.3 Case Analysis of Reflexivity

Case analysis was used to answer the original hypothesis 1.4 whether reflexivity volume in team communication varied in regard to team performance. Three case analyses examinations concluded that reflexivity communication volume, as well as cognitive and speech act behaviors in reflexivity communications volume were acceptable concerning team performances categories (i.e., high versus low performance teams). The same procedure to selecting teams was conducted as for previous case analyses. Although, teams underwent experimental interventions (i.e., team reflexivity intervention) this phase of research focuses solely on performance and reflexivity communication volume measures. Chapter Seven (7) discusses the effect of reflexivity intervention on reflexivity communication and performance. Of the 60 teams, 14 teams were assigned to the low performance team category with a performance mean below 60% and 14 teams were assigned to the high performance team category with a performance mean above 67%. The data of reflexivity communication volume was aggregated to the team level by summing number of messages sent.

1.3.1 Case Analysis of Reflexivity Communication in High vs. Low Performing Teams

Mann-Whitney-U test was conducted to assess differences across reflexivity (i.e., review, strategy development and strategy implementation) in communication between high versus low performance teams (Mann & Whitney, 1947). All variables met ($p > .05$) the homogeneity of variance. Table 74 shows that both high performance teams and low performance teams displayed substantial number of reflexivity indicators in team communication, and a marginal significant performance differences of review was revealed ($U = 55, p = .048, r = -.37$), indicating high performance teams ($Mdn = 31.5$) to review more compared to low performance teams ($Mdn = 17.5$). Further, higher performance teams display significantly more communication about strategy development ($Mdn = 16; U = 51, p = .030, r = -.41$) compared to low performance teams ($Mdn = 7.5$). However, no significant difference between teams was found for strategy implementation in high performance teams compared to low performance teams, $p = .35$. Strategy development, which appears during the transition phase, seems to be a contributing factor for high performance teams. Lower performance teams reflect during the transition phases, but seem (according to descriptive results) to show less emphasis on the development of strategies during the phase which may contribute to adaption or implementation of strategies not suitable for the task environment or team thereof. Table 74 presents for Means, Standard Deviations and Median for high versus low performance Teams for reflexivity communicated.

Table 74. Reflexivity in High vs. Low Performing Teams.

Category	High Performance Teams		Low Performance Teams	
	Reflexivity Utterances	M (SD) Mdn	Reflexivity Utterances	M (SD) Mdn
Reflexivity				
Review	478	34.1(15.9) 31.5	336	24.0(17.7) 17.5
Strategy Development	236	16.9(10.8) 16.0	116	8.3(5.6) 7.5
Strategy Implementation	194	13.9(8.6) 17.5	173	12.4(11.9) 9.5

1.3.2 Case Analysis of Exhibited Cognitive Behaviors for High vs. Low Performing Teams

In this section, a case analysis was conducted to assess the exhibition of cognitive behaviors during team reflexivity communication between high versus low performance teams. Mann-Whitney-U test was computed to analyze differences between high and low performance teams across reflexivity indicators in communication displaying cognitive behaviors (Mann & Whitney, 1947). In cases of data not being justified for the assumption of homogeneity, which was tested with a non-parametric Levene's test, the Mood's Median test was conducted using Chi-Square as the test statistic (Brown & Mood, 1951). SAE cognitive behaviors perception ($p = .77$) and comprehension ($p = .63$) did not differ significantly in volume in review between low and high performance teams. Yet, these cognitive behaviors were more like to appear in review in high performance teams, see Table 75. Cognitive behavior projection also didn't differ significantly between performance teams ($p = .15$). However, descriptive result in the Table 75 show SAE cognitive behavior projection to be higher in review in high performance teams compared to low performance teams. Also no significance was found for SAE cognitive behavior action ($p = .18$). Results reveal SAT cognitive behavior perception to be significant different ($U = 54.5, p = .038, r = -.39$). High performance teams ($Mdn = 2$) display more cognitive behavior perception during review compared to low performance teams ($Mdn = 0$). SAT cognitive behavior comprehension ($p = .14$) and projection ($p = .15$) to be communicated in a similar volume by low versus high performance teams. The Mood's Median test revealed high performance teams to have higher volume of cognitive behavior action during review compared to low performance teams, with a significant effect $\chi^2(1) = 6.09, p = .04, \phi = .47$.

TMS cognitive behavior specialization ($p = .37$) and coordination ($p = .09$) did not differ significantly in volume in review between low and high performance teams. No significant difference was found for the volume of cognitive behavior confusion ($p = .07$)

credibility ($p = .55$) or feedback ($p = .87$) in review in high versus low performance teams. Descriptive results in Table 75 show TMS cognitive behavior credibility and feedback to be higher in review in high performance teams compared to low performance teams.

According to the Mood's Median test, a significance was found for SAE cognitive behavior perception ($\chi^2(1) = 9.33, p = .006, \phi = .58$). High performance teams display a significantly higher volume of cognitive behavior perception in strategy development. SAE cognitive behaviors comprehension ($p = .31$), projection ($p = .14$) and action ($p = .84$) did not differ significantly in volume in strategy development between low and high performance teams. Yet, these cognitive behaviors are more like to appear during strategy development in high performance teams in comparison to low performance teams. Similar results were found for SAT cognitive behaviors in relation to team performance. SAT cognitive behaviors perception ($p = .07$), comprehension ($p = .17$), projection ($p = .52$) and action ($p = .05$) did not differ significantly in volume in strategy development between low and high performance teams.

Further, marginal significance was found for TMS cognitive behavior specialization ($U = 55.5, p = .044, r = -.38$) and credibility ($U = 59.5, p = .049, r = -.37$). High performance teams show a significantly higher volume of cognitive behavior specialization ($Mdn = 2$) during strategy development and credibility ($Mdn = 1.5$) compared to low performance teams (specialization $Mdn = 1$; credibility $Mdn = 0$). TMS cognitive behavior coordination ($p = .08$), confusion ($p = .52$) and feedback ($p = .32$) did not differ significantly in volume in strategy development between low and high performance teams. Still, these cognitive behaviors are more likely to appear during strategy development in high performance teams in comparison to low performance teams, see Table 75.

SAE cognitive behaviors perception ($p = .15$), comprehension ($p = .38$), projection ($p = .96$) and action ($p = .15$) did not differ significantly in volume in strategy implementation between low and high performance teams. Yet, these cognitive behaviors are more like to appear in review in high performance teams. No significant difference was found for the volume of SAT cognitive behaviors perception ($p = .76$), comprehension ($p = .78$), projection ($p = .92$) or action ($p = .70$) in strategy implementation in high versus low performance teams.

Table 75. Cognitive Behaviors in Reflexivity in High vs. Low Performance Teams.

Reflexivity Indicator	Category	High Performance Teams		Low Performance Teams	
		Cognitive Behavior Utterances	M (SD) Mdn	Cognitive Behavior Utterances	M (SD) Mdn
Review	SAE				
	Perception	21	1.5(2.1) 0.5	16	1.1(1.6) 0.5
	Comprehension	20	1.4(2.4) 0.0	10	0.7(1.1) 0.0
	Projection	7	0.5(1.6) 0.0	0	0.0(0.0) 0.0
	Action	10	0.7(1.6) 0.0	2	0.1(0.4) 0.0
	SAT				
	Perception	38	2.7(3.0) 2.0	15	1.1(1.9) 0.0
	Comprehension	22	1.6(2.7) 1.0	13	0.9(2.4) 0.0
	Projection	7	0.5(1.6) 0.0	0	0.0(0.0) 0.0
	Action	31	2.2(1.8) 2.0	6	0.4(0.6) 0.0
	TMS				
	Specialization	73	5.2(4.5) 4.5	54	3.9(3.9) 2.5
	Coordination	26	1.9(3.3) 1.0	9	0.6(0.9) 0.0
	Confusion	8	0.6(1.6) 0.0	0	0.0(0.0) 0.0
	Credibility	21	1.5(2.3) 0.0	15	1.1(2.0) 0.0
	Feedback	31	2.2(2.8) 1.5	28	2.0(2.7) 1.0
Strategy Development	SAE				
	Perception	13	0.9(1.1) 0.5	2	0.1(0.5) 0.0
	Comprehension	31	2.2(2.9) 1.0	15	1.1(1.5) 0.0
	Projection	5	0.4(0.6) 0.0	1	0.1(0.2) 0.0
	Action	21	1.5(1.9) 0.0	20	1.4(1.7) 1.0
	SAT				
	Perception	15	1.1(1.6) 0.0	2	0.1(0.4) 0.0
	Comprehension	44	3.1(3.2) 2.5	19	1.4(1.8) 1.0
	Projection	4	0.3(0.8) 0.0	1	0.1(0.3) 0.0
	Action	78	5.6(3.4) 5.0	39	2.8(1.7) 2.5
	TMS				
	Specialization	39	2.8(2.7) 2.0	13	0.9(1.1) 1.0
	Coordination	135	9.6(6.1) 8.5	81	5.8(4.6) 5.5
	Confusion	3	0.2(0.6) 0.0	1	0.1(0.3) 0.0
	Credibility	32	2.3(2.8) 1.5	6	0.4(0.9) 0.0
	Feedback	6	0.2(0.6) 0.0	5	0.4(0.9) 0.0

Reflexivity Indicator	Category	High Performance Teams		Low Performance Teams	
		Cognitive Behavior Utterances	M (SD) Mdn	Cognitive Behavior Utterances	M (SD) Mdn
Strategy Implementation	SAE				
	Perception	9	0.6(1.0) 0.0	2	0.1(0.4) 0.0
	Comprehension	48	3.4(6.0) 1.0	18	1.3(1.9) 0.5
	Projection	2	0.1(0.5) 0.0	1	0.1(0.3) 0.0
	Action	47	3.4(6.8) 1.0	13	0.9(1.7) 0.0
	SAT				
	Perception	5	0.4(0.9) 0.0	4	0.3(0.6) 0.0
	Comprehension	70	5.0(4.2) 4.5	92	6.6(6.9) 5.0
	Projection	12	0.9(1.8) 0.0	14	1.0(2.1) 0.0
	Action	77	5.5(4.8) 5.0	76	5.4(5.6) 4.5
	TMS				
	Specialization	101	7.2(5.6) 6.5	104	7.4(6.3) 7.0
	Coordination	45	3.2(2.9) 2.5	43	3.1(3.4) 2
	Confusion	3	0.2(0.6) 0.0	1	0.1(0.3) 0.0
	Credibility	15	1.1(1.6) 0.0	7	0.5(1.0) 0.0
	Feedback	3	0.2(0.6) 0.0	0	0.0(0.0) 0.0

Residual analysis revealed high performance teams to show a higher volume of cognitive behavior perception and action during strategy implementation compared to low performance teams whereas low performance teams displayed more SAT cognitive behavior comprehension and projection. TMS cognitive behaviors specialization ($p = .91$), coordination ($p = .61$), confusion ($p = .52$), credibility ($p = .24$) and feedback ($p = .15$) did not differ significantly in volume during communication about strategy implementation between low and high performance teams. Descriptive results in Table 75 show TMS cognitive behavior confusion to be higher in strategy implementation in high performance teams compared to low performance teams. See Table 75 for Means, Standard Deviations and Median for cognitive behaviors exhibited in high versus low performance teams across reflexivity phases.

1.3.3 Case Analysis of Exhibited Speech Act Behavior for High vs. Low Performing Teams

In this section, a case analysis was conducted to assess the exhibition of speech act behaviors during team reflexivity communication between high versus low performance teams. A Mann-Whitney-U test analysis of speech act behaviors across reflexivity indicators was computed to assess the difference between low and high performance teams (Mann & Whitney, 1947). Homogeneity of variance was met for all three variables ($p > .05$). See Table 76 for Means, Standard Deviations and Median for speech act behaviors exhibited in high versus low performance teams. Speech act behaviors requests ($p = .11$), announcements ($p = .27$), questions ($p = .81$), replies ($p = .62$), comments ($p = 1.00$) and confirmations ($p = .34$) did not differ significantly in volume in review between low and high performance teams. Still, residual analysis revealed confirmations and requests being communicated more in high performance teams compared to low performance teams. No significance of volume was found for requests ($p = .15$), announcements ($p = .05$), reply ($p = .18$), comments ($p = 1.00$) and confirmations ($p = .07$) in strategy development between low and high performance teams. A significant difference was found for high performance teams ($Mdn = 3.5$), indicating that high performance teams ask more questions during strategy development, ($U = 48.5, p = .021, r = -0.44$) compared to low performance teams ($Mdn = 1.0$). Also not statistical significant, high performance teams' seem also to display during strategy development the speech act behaviors confirmation in comparison to low performance teams. Furthermore, results indicated no significant difference between team performance and volume of speech act behavior during strategy implementation, requests ($p = .33$), announcements ($p = .91$), questions ($p = .11$), reply ($p = .07$), comments ($p = .55$) or confirmations ($p = .15$). High performance teams seem to display higher volume of speech act behavior reply and confirmation during strategy implementation compared to low performance teams. Conclusively, the hypothesis 1.4 was partially supported.

Table 76. Speech Act Behavior in Reflexivity in High vs. Low Performance Teams.

Reflexivity Indicator	Category	High Performance Teams		Low Performance Teams	
		Speech Act Behavior Utterances	M (SD) Mdn	Speech Act Behavior Utterances	M (SD) Mdn
Review	Speech Act Behavior				
	Request	13	0.9(1.1) 1.0	5	0.4(0.6) 0.0
	Announcement	69	4.9(3.2) 4.5	52	3.7(3.8) 3.0
	Question	24	1.7(1.4) 1.5	22	1.6(1.4) 1.5
	Reply	30	2.1(2.3) 1.0	28	2.0(2.6) 1.0
	Comment	2	0.1(0.4) 0.0	2	0.1(0.4) 0.0
	Confirmation	17	1.2(1.3) 1.0	17	0.8(1.1) 0.0
Strategy Development	Speech Act Behavior				
	Request	73	5.2(3.5) 6.5	45	3.2(2.5) 3.0
	Announcement	41	2.9(1.9) 2.5	23	1.6(1.6) 1.5
	Question	54	3.9(2.0) 3.5	26	1.9(2.4) 1.0
	Reply	26	1.9(1.6) 1.5	16	1.1(1.4) 0.5
	Comment	2	0.1(0.4) 0.0	2	0.1(0.4) 0.0
	Confirmation	21	1.5(1.9) 1.0	9	0.6(1.2) 0.0
Strategy Implementation	Speech Act Behavior				
	Request	33	2.4(2.7) 1.5	17	1.2(1.3) 1.0
	Announcement	98	7.0(4.9) 6.5	98	7.0(4.9) 6.0
	Question	6	0.4(0.6) 0.0	18	1.3(1.9) 1.0
	Reply	46	3.3(2.7) 3.0	32	2.3(4.8) 0.5
	Comment	2	0.1(0.4) 0.0	1	0.1(0.3) 0.0
	Confirmation	23	1.6(2.7) 0.0	4	0.3(0.6) 0.0

APPENDIX F: Directory and Definition of Semantic Roles

A directory of semantic roles and their definitions are presented below for understanding of classifiers' semantic roles. Semantic Roles were based on VerbNet. For clarity, a Participant refers to an Entity involved in a state or event. An Undergoer is a Participant in a state or event that is not the instigator of an event/ state. For further semantic roles see visit VerbNet Guidelines (http://verbs.colorado.edu/verb-index/VerbNet_Guidelines.pdf; Palmer et al., 2009; Palmer et al., 2010).

Semantic roles identified for cognitive behaviors and reflexivity indicators:

Role	Definition
Actor	Participant that is the instigator of an event/state
Agent	Actor in an event initiating and carrying out the event intentionally.
Attribute	Undergoer that is a property of an entity or entities.
Beneficiary	Undergoer in a state or an event that is potentially dis/-advantaged by the event or state.
Co-Agent	Agent who is acting in coordinating with another agent while participating in the same event.
Co-Patient	Patient that participates in an event with another patient, both participate equally.
Co-Theme	Theme that participates in an event or state with another theme; both participate equally.
Destination	Physical Location.
Destination	Goal that is concrete
Experiencer	Patient that is aware of an event undergone (specific to events of perception).
Goal	
Initial Location	Concrete location or source that indicates where an event or state begins
Instrument	Undergoer in an event that is manipulated by an agent, and with which an intentional act is performed; it exists independently of the event.
Location	Place that is concrete.
Patient	Undergoer in an event experiencing change of state, location or condition. Involved or directly affected by other participants.
Pivot	Theme that participates with high centrality to the event with another.
Recipient	Destination
Recipient	Destination of Goal
Result	A goal of the event by the patient.
Result	Goal that has been reached
Source	Place that is a starting point of action.
Stimulus	Cause in an event or object that elicit a response (specific to events of perception)
Theme	Entity that is central to an event or state. It does not have control over the way the event is occurring and is not changed by the event. It is characterizes as being in a certain condition or position throughout the state.
Topic	Theme that transfers information/ content to another participant (specific event of communication)

APPENDIX G: Classification System of Cognitive Behaviors

Classification System of Cognitive Behavior Situation Awareness of the Environment (SAE)

SAE – Perception		
Syntactic Structure	Frames	Semantic Roles
	NP V NP V ADJ NP V ADV NP V NP NP V S NP V S_INF NP V S_ING	Actor V Theme Agent V Patient Agent V Result Agent V Theme Agent V Theme {+SC_TO_INF} Agent V Theme {+Be_SC_ING} Agent V Theme {with} Instrument Experiencer V Stimulus Patient V Patient V Result Theme V
Verb Class	appear- 48.1.1, become-109.1, begin – 55., contribute- 13.2, convert-26.6.2, defend-85, destroy-44, disappearance-48.2, discover-84, enforce - 63 escape- 51.1, exist – 47., get-13.5.1, light_emission-43.1, murder-42-1, other_cos-45.4, roll – 51.3.1, see-30.1, sight-30.2, stop-55.4	
Verb Tense	Past, Present	
Speech Act Behavior	Announcement, Question, Reply	
Copular verbs	is, are, was, were, appear, become, get, run, look	
Auxiliary verbs	is, are, was, were, have, had	
Others	-	
SAE-Comprehension		
Syntactic Structure	Frames	Semantic Roles
	NP V NP Location NP V NP PP.Co-Patient NP V NP PP.Destination NP V NP PP.Instrument NP V NP PP.Instrument Location NP V NP PP.Location NP V NP PP.Source NP V NP PP.Theme NP V NP S_INF Location NP V NP.Destination NP V NP.Initial Location NP V NP.Patient NP V NP.Theme PP NP V PP NP V PP.Co-Patient NP V PP.Destination NP V PP.Destination NP NP V PP.Location NP V S_INF PP.Location NP V S_ING PP.Location NP V Theme PP.Location NP.Instrument V NP Location NP.location V PP.theme NP.Theme V PP.Location PP.location V NP	Agent V Patient PP.Location {+loc} Location V Theme Actor V Theme {+Path} Location Agent V {Against before into on to onto } Destination Theme Agent V {on Upon} Destination Agent V Destination Agent V Destination {with} Theme Agent V Location Agent V Patient {off off of from} Co-Patient Agent V Patient {with} Instrument Agent V Patient {with} Instrument PP.Location Agent V PP.Location Agent V Theme { against, before into on to onto} Destination Agent V Theme {+SC_TO_INF} Location Agent V Theme {From for on} Source Agent V Theme Destination {adverb of Location here/there} Agent V Theme Location Agent V Theme PP.Destination AgentVTheme {+Be_SC_ING} Location Experiencer V Location Experiencer V Theme Location Instrument V Patient PP.Location Location V {with} Theme Patient V {from} Co-Patient Patient V {off off of from} Co-Patient

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		Theme V {{+loc}} Location Theme V {at in with} Location Theme V {spatial} location Theme V Co-Theme Theme V Destination Theme V Initial Location Theme V Location <+adv_loc> Theme V Patient Destination Theme V PP_Initial Location Theme V Source Theme V Theme Destination (here, there)
Semantic Roles		
Verb Class	appear- 48.1.1, begin – 55.1, bring-11.3, contiguous_location- 47.8, contribute-13.2, convert-26.6.2, defend-85, escape- 51.1, exist – 47.1, fill-9.8, focus-87.1, get-13.5.1, help-72, keep – 15.2, leave – 51.2, light_emission-43.1, lodge-46, murder-42-1, put_direction 9.4, put_spatial-9.2, put-9.1, roll – 51.3.1, separate-23.1, spatial_location-47.6, split-23.2	
Verb Tense	Present	
Speech Act Behavior	Announcement, Request, Reply	
Copular verbs	Is, are, appear, get, keep, look	
Auxiliary verbs	Is, are, have	
Others	Directional descriptive words(right, left, top, middle, bottom, upper, lower, north, south, east, west, corner, edge, center, area, part, portion, section, zone)	
SAE – Projection		
Syntactic Structure	Frames	Semantic Roles
	NP V NP V ADV NP V NP NP V NP PP.Destination NP V NP PP.Goal NP V NP PP.Instrument NP V NP PP.Location NP V NP PP.Source NP V NP PP.Theme NP V NP.Destination NP V NP.Patient NP V NP.Theme NP V PP NP V PP.Destination NP NP V PP.Location NP.Patient V NP.Theme V NP.Theme V PP.Location PP.location V NP	Actor V Theme Actor V Theme {+Path} Location Agent V Agent V {on Upon} Destination Agent V Destination Agent V Destination {with} Theme Agent V Location Agent V Patient Agent V Patient {with} Instrument Agent V Theme Agent V Theme {From for on} Source Agent V Theme {to} Goal Agent V Theme Destination {adverb of Location here/there} Agent V Theme Source Location V {with} Theme Patient V Theme V Theme V {{+loc}} Location Theme V {at in with} Location Theme V Location Theme V Location <+adv_loc> Theme V PP_Initial Location Theme V Source
Verb Class	appear- 48.1.1, begin – 55.1, build – 26.1, destroy-44, escape- 51.1, fill-9.8, future_having-13.3, get-13.5.1, hit- 18.1, light_emission-43.1, reach – 51.8, remove – 10.1, roll – 51.3.1	
Verb Tense	Future, Present	
Speech Act Behavior	Announcement	
Copular verbs	Appear, get, look	
Auxiliary verbs	Will, shall, going to/gonna	
Others	-	

SAE – Action		
Syntactic Structure	Frames	Semantic Roles
() indicate that frames and semantic roles appear with and without ().	(NP) V (NP) V ADJ (NP) V ADV (NP) V NP (NP) V NP ADV (NP) V NP Location (NP) V NP PP.Destination (NP) V NP PP.Instrument (NP) V NP PP.Instrument Location (NP) V NP PP.Location (NP) V NP PP.Predicate (NP) V NP PP.Source (NP) V NP PP.Theme (NP) V NP PP.Theme S_ING (NP) V NP Result (NP) V NP S_INF (NP) V NP S_INF Location (NP) V NP to be ADJ (NP) V NP.Destination (NP) V NP.Initial Location (NP) V NP.Theme (NP) V PP (NP) V PP.Destination NP (NP) V PP.Location (NP) V PP.Theme (NP) V S (NP) V S_INF (NP) V S_ING (NP) V S_ING PP.Location (Theme) V (NP.Instrument) V NP	(Actor) V Theme (Actor) V Theme {+Path} Location (Agent) V (Agent) V {Against before into on to onto } Destination Theme (Agent) V {Direction} Trajectory (Agent) V {on Upon} Destination (Agent) V Destination (Agent) V Destination {with} Theme (Agent) V Location (Agent) V Location {for} Theme (Agent) V Patient (Agent) V Patient {with} Instrument (Agent) V Patient {with} Instrument PP.Location (Agent) V PP.Location (Agent) V Result (Agent) V Theme (Agent) V Theme { against, before into on to onto} Destination (Agent) V Patient PP.Location (Agent) V Theme {for} Predicate (Agent) V Theme {From for on} Source (Agent) V Theme {ing} (Agent) V Theme {ing} Location (Agent) V Theme {to_INF} (Agent) V Theme ADV (Agent) V Theme Destination (Agent) V Theme Destination {adverb of Location here/there} (Agent) V Theme Location (Agent) V Theme Predicate {to_INF} (Agent) V Theme Result (Experiencer) V Stimulus (Instrument) V Patient PP.Location (Location) V Theme (Patient) V Result (Pivot) V Theme {ing} (Pivot) V Theme {to_INF} (Pivot) V Theme {to be} (Theme) V (Theme) V {{+loc}} Location (Theme) V {at in with} Location (Theme) V {from} PP (Theme) V {spatial} location (Theme) V Initial Location (Theme) V Location (Theme) V Location <+adv_loc> (Theme) V PP_Initial Location (Theme) V Source
Verb Class	appear- 48.1.1, become-109.1, bring-11.3, cooperate-73.3, defend-85, escape-51.1, exist – 47., fill-9.8, forbid-67, get-13.5.1, help-72, keep – 15.2, leave – 51.2, lodge-46, murder-42-1, obtain -13.5, push-12.1, put-9.1, reach – 51.8, roll – 51.3.1, run – 51.3, rush – 53.2, search-35.2, see-30.1, sight-30.2, tell-37.2, try – 61, use – 105, want – 32.1	
Verb Tense	Present	
Speech Act Behavior	Request, Announcement	

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Copular verbs	Appear, become, get, keep, run
Auxiliary verbs	Can, should, do, need, have
Others	-

Classification System of Cognitive Behavior Situation Awareness of the Team (SAT)

SAT – Perception		
Syntactic Structure	Frames	Semantic Roles
	NP V NP V ADJ NP V ADV NP V NP NP V NP (PP.Theme) NP V NP PP.Instrument NP V NP S_INF NP V NP S_ING NP V NP.Patient NP V NP.Theme NP V S NP V S_INF NP V S_ING NP V Theme	Actor V Theme Agent V Agent V {at on} Patient Agent V Instrument Agent V Patient Agent V Patient {into} Results Agent V Patient {with} Instrument Agent V Patient {with} Instrument Agent V Patient Result {to_INF} Agent V Result Agent V Theme Agent V Theme Agent V Theme {be+ing} Agent V Theme{with} Instrument Experiencer V Stimulus Patient V Patient V Result Pivot V Theme {ing} Pivot V Theme {to_INF} Pivot V Theme {to be} Theme V Theme V Source Theme V {in} Attribute Theme V Attribute Theme V Attribute {to_inf}
Verb Class	appear- 48.1.1, become-109.1, begin – 55.1, bring-11.3, butter – 9.9, carry-11.4, contribute- 13.2, convert-26.6.2, disappearance-48.2, discover-84, enforce – 63, escape- 51.1, force59, get-13.5.1, hit- 18.1, hold- 15.1, keep – 15.2, obtain - 13.5, put-9.1, roll – 51.3.1 , run – 51.3, search-35.2, see-30.1, seem-109-1, want – 32.1	
Verb Tense	Past, Present	
Speech Act Behavior	Announcement, Question, Reply	
Copular verbs	Be-form, appear, become, get, keep, run, look	
Auxiliary verbs	Be-form, have, had	
Others	Personal Pronoun (I, you, we, us), Possessive Adjective (my, your, our)	
SAT – Comprehension		
Syntactic Roles	Frames	Semantic Roles
	NP V NP (PP.Theme) NP V NP PP NP V NP PP.Co-Patient NP V NP PP.Destination NP V NP PP.Instrument NP V NP PP.Location NP V NP PP.Predicate NP V NP PP.Source NP V NP S_INF Location NP V NP S_INF NP V NP.Destination NP V NP.Patient NP V NP.Theme NP V NP.Theme PP NP V PP NP V PP.Co-Patient NP V PP.Destination NP V PP.Destination NP	Actor V Theme Actor V Theme {+Path} Location Agent V Agent V {Against before into on to onto } Destination Theme Agent V {at on} Patient Agent V {on Upon} Destination Agent V {spatial} Location Agent V Destination ({with} Theme) Agent V Instrument Agent V Location Agent V Location {for} Theme Agent V Patient Agent V Patient {off off of from} Co-Patient Agent V Patient {with} Instrument Agent V PP.Location Agent V Theme

	NP V PP.Location NP V S_ING NP V S_ING PP.Location NP V Theme PP.Location NP.Theme V PP.Location PP.location V NP V NP PP.Instrument	Agent V Theme {against, before into on to onto} Destination Agent V Theme {for} Predicate Agent V Theme {From for on} Source Agent V Theme {ing} Location Agent V Theme {to towards} Destination Agent V Theme Destination {adverb of Location here/there} Agent V Theme Initial Location Agent V Theme Location Agent V Theme PP.Destination Agent V Theme Predicate {to_INF} Experiencer V Location Experiencer V Theme Location Location V Theme Patient V {off off of from} Co-Patient Theme V {at in with} Location Theme V Co-Theme Theme V Destination Theme V Location <+adv_loc> Theme V PP_Initial Location Theme V Source Theme V Theme Destination (here, there)
Verb Class	appear- 48.1.1, bring-11.3, butter – 9.9, carry-11.4, contiguous_location- 47.8, contribute- 13.2, defend-85, escape- 51.1, focus-87.1, get-13.5.1, help-72, hit-18.1, keep – 15.2, lodge-46, other_cos-45.4, put-9.1, roll – 51.3.1 , run – 51.3, search-35.2, separate-23.1, sight-30.2, split-23.2, use - 105	
Verb Tense	Present	
Speech Act Behavior	Announcement, Request, Reply	
Copular verbs	Be-form, appear, get, keep, run, look	
Auxiliary verbs	Be-form, have	
Others	Personal Pronoun (I, you, we, us), Possessive Adjective (my, your, our), directional descriptive words(right, left, top, middle, bottom, upper, lower, north, south, east, west, corner, edge, center, area, part, portion, section, zone)	
SAT- Projection		
Syntactic Structure	Frames	Semantic Roles
	NP V NP V ADV NP V NP NP V NP PP NP V NP PP.Destination NP V NP PP.Goal NP V NP PP.Instrument NP V NP PP.Location NP V NP PP.Recipient NP V NP PP.Source NP V NP PP.Theme NP V NP S_INF NP V NP S_INF Location NP V NP S_ING NP V NP To Be NP NP V NP.Destination NP V NP.Patient NP V NP.Theme (PP) NP V NP.Topic NP V PP NP V PP.Co-agent PP.Theme	Actor V Theme ({+Path} Location) Agent V ({at, in, on }) Agent V {at on} Patient Agent V {on Upon} Destination Agent V {spatial} Location Agent V {to} Recipient Agent V {with} Co-Agent {at, in, on } Theme Agent V Destination ({with} Theme) Agent V Instrument Agent V Location Agent V Location {for} Theme Agent V Patient Agent V Patient {into} Results Agent V Patient {with} Instrument Agent V Patient Result {to_INF} Agent V PP.Location Agent V Theme Agent V Theme {+SC_TO_INF} Agent V Theme {From for on} Source Agent V Theme {ing}

	NP V PP.Destination NP NP V PP.Instrument NP V PP.Location NP V PP.Theme NP V S_INF NP V S_INF PP.Location NP V S_ING NP V S_ING PP.Location NP V that S NP V What/How/That S NP V What/How/That S_INF NP.Patient V NP.Theme V NP.Theme V PP.Location PP.location V NP V NP PP.Instrument	Agent V Theme {that} Agent V Theme {to be} Predicate Agent V Theme {to_inf} Agent V Theme {to} Goal Agent V Theme Destination {adverb of Location here/there} Agent V Theme Location Agent V Theme Source Agent V Topic {what, how, that} ({+ inf}) AgentVTheme AgentVTheme {+Be_SC_ING} (Location) AgentVTheme{with} Instrument Experiencer V Stimulus Location V Theme Patient V Theme V Theme V {at in with} Location Theme V Location <+adv_loc> Theme V PP_Initial Location Theme V Source
Verb Class	appear- 48.1.1, begin – 55.1, begin – 55.1, bring-11.3, conjecture-29.5, cooperate-73.3, escape- 51.1, fill-9.8, force-59, future_having-13.3, get-13.5.1, help-72, hit- 18.1, hold- 15.1, keep – 15.2, lodge-46, obtain -13.5, other_cos-45.4, put-9.1, roll – 51.3.1, run – 51.3, say – 37.7, search-35.2, sight-30.2, try – 61	
Verb Tense	Future	
Speech Act Behavior	Announcement	
Copular verbs	Be-form, appear, get, help, keep, run, feel	
Auxiliary verbs	Will, shall, going to/ gonna	
Others	Personal Pronoun (I, you, we, us), Possessive Adjective (my, your, our), directional words(right, left, top, middle, bottom, upper, lower, north, south, east, west, corner, edge, center, area, part, portion, section, zone)	
SAT – Action		
Syntactic Structure	Frames	Semantic Roles
	NP)* V (NP) V ADJ (NP) V ADV (NP) V NP (NP) V NP ADV (NP) V NP Location (NP) V NP PP.Destination (NP) V NP PP.Instrument (NP) V NP PP.Instrument Location (NP) V NP PP.Location (NP) V NP PP.Predicate (NP) V NP PP.Source (NP) V NP PP.Theme (NP) V NP PP.Theme S_ING (NP) V NP Result (NP) V NP S_INF (NP) V NP S_INF Location (NP) V NP to be ADJ (NP) V NP.Destination (NP) V NP.Initial Location (NP) V NP.Theme (NP) V PP (NP) V PP.Attribute	(Actor) V Theme (Actor) V Theme {+Path} Location (Agent) V (Agent) V {Against before into on to onto } Destination Theme (Agent) V {at on} Patient (Agent) V {Direction} Trajectory (Agent) V {on Upon} Destination (Agent) V {spatial} Location (Agent) V Destination (Agent) V Destination {with} Theme (Agent) V Instrument (Agent) V Location (Agent) V Location {for} Theme (Agent) V Patient (Agent) V Patient {with} Instrument (Agent) V Patient {with} Instrument PP.Location (Agent) V Patient PP.Location (Agent) V PP.Location (Agent) V Result (Agent) V Theme (Agent) V Theme { against, before into

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	<p>(NP) V PP.Co-Patient (NP) V PP.Destination NP (NP) V PP.Location (NP) V PP.Theme (NP) V S (NP) V S_INF (NP) V S_ING (NP) V S_ING PP.Location (Theme) V (NP.Instrument) V NP</p>	<p>on to onto} Destination (Agent) V Theme {+Be_SC_ING} Location (Agent) V Theme {+SC_TO_INF} Location (Agent) V Theme {for} Predicate (Agent) V Theme {From for on} Source (Agent) V Theme {ing} (Agent) V Theme {ing} Location (Agent) V Theme {to_INF} (Agent) V Theme ADV (Agent) V Theme Destination (Agent) V Theme Destination {adverb of Location here/there} (Agent) V Theme Location (Agent) V Theme Predicate {to_INF} (Agent) V Theme Result (Agent) V Theme{with} Instrument (Experiencer) V Stimulus (Instrument) V Patient PP.Location (Location) V Theme (Patient) V (Patient) V {from} Co-Patient (Patient) V Result (Pivot) V Theme {ing} (Pivot) V Theme {to be} (Pivot) V Theme {to_INF} (Theme) V (Theme) V {{+loc}} Location (Theme) V {at in with} Location (Theme) V {from} PP (Theme) V {IN} Attribute (Theme) V {spatial} location (Theme) V Attribute (Theme) V Attribute {rs_to_inf} (Theme) V Location (Theme) V Location <+adv_loc> (Theme) V PP_Initial Location (Theme) V Source</p>
Verb Class	appear- 48.1.1, become-109.1, begin – 55.1, bring-11.3, escape- 51.1, exist – 47.1, fill-9.8, forbid-67, get-13.5.1, hit- 18.1, keep – 15.2, lodge-46, obtain -13.5 put-9.1, roll – 51.3.1, search-35.2, see-30.1, seem-109-1, separate-23.1, sight-30.2, try – 61, use – 105, want – 32.1	
Verb Tense	Present	
Speech Act Behavior	Announcement, Request, Reply	
Copular verbs	Appear, become, get, keep, seem	
Auxiliary verbs	Can, should, do, need, have	
Others	Personal Pronoun (I, you, we, us), Possessive Adjective (my, your, our)	

Classification System of Cognitive Behavior Transactive Memory System (TMS)

TMS - Specialization		
Syntactic Structure	Frames	Semantic Role
	NP V NP V ADJ NP V ADV NP V NP NP V NP ADV NP V NP PP.Destination NP V NP PP.Location NP V NP PP.Predicate NP V NP PP.Recipient NP V NP PP.Source NP V NP PP.Theme NP V NP S_INF Location NP V NP S_INF NP V NP to be ADJ NP V NP To Be NP NP V NP.Destination NP V NP.Theme (PP) NP V NP.Topic NP V PP NP V PP.Co-agent PP.Theme NP V PP.Instrument NP V PP.Destination NP NP V PP.Location NP V PP.Theme NP V S NP V S_INF NP V S_INF PP.Location NP V S_ING NP V S_ING PP.Location NP V that S NP V What/How/That S NP V What/How/That S_INF NP.Theme V NP.Theme V PP.Location	Actor V Theme ({+Path} Location) Agent V ({at, in, on }) Agent V {Against before into on to onto } Destination Theme Agent V {on Upon} Destination Agent V {spatial prep} Location Agent V {to} Recipient Agent V {with} Co-Agent {at, in, on } Theme Agent V Destination ({with} Theme) Agent V Location ({for} Theme) Agent V PP.Location Agent V Result Agent V Theme Agent V Theme ({+_TO_INF} Location) Agent V Theme {against, before into on to onto} Destination Agent V Theme {for} Predicate Agent V Theme {from for on} Source Agent V Theme {-ing} Agent V Theme {that} Agent V Theme {to be} Predicate Agent V Theme {to_inf} Agent V Theme ADV Agent V Theme Destination ({adverb of Location here/there}) Agent V Theme Location Agent V Theme PP.Destination Agent V Theme Predicate {to_INF} Agent V Topic Agent V Topic {what, how, that} (+ INF) Agent V Theme Agent V Theme {+Be_SC_ING} (Location) Agent V Theme{with} Instrument Experiencer V Stimulus Patient V Result Pivot V Theme {_ING} Pivot V Theme {_TO_INF} Pivot V Theme {to be} Theme V Theme V {at in with} Location Theme V Location {here, there} Theme V PP_Initial Location Theme V Source
Verb Class	appear- 48.1.1, begin – 55.1, bring-11.3, butter – 9.9, contiguous_location- 47.8 cooperate-73.3, defend-85, escape- 51.1, exist – 47.1, fill-9.8, future_having-13.3, get-13.5.1, help-72, herd 47.5, hit- 18.1, keep – 15.2, lodge-46, meet-36.3, mix-22.1, obtain -13.5, put-9.1, reach – 51.8, roll – 51.3.1 , search-35.2, separate-23.1, try – 61, use – 105, want – 32.1	
Verb Tense	Present	
Speech Act Behavior	Request, announcement, question	

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Copular verbs	Be-form, become, get, keep, run	
Auxiliary verbs	Be-form, have, had, can, should, do, need	
Others	Personal Pronoun (I, you, we, us), Possessive Adjective (my, your, our)	
TMS - Coordination		
Syntactic Structure	Frames	Semantic Role
	NP V NP V ADV NP V NP (PP.Theme) NP V NP ADV NP V NP PP NP V NP PP.Destination NP V NP PP.Instrument NP V NP PP.Location NP V NP PP.Predicate NP V NP PP.Source NP V NP PP.Theme NP V NP S_INF Location NP V NP S_INF NP V NP to be ADJ NP V NP.Destination NP V NP.Theme NP V PP NP V PP.Co-Agent NP V PP.Co-agent PP.Theme NP V PP.Co-Patient NP V PP.Destination NP NP V PP.Location NP V PP.Patient NP V PP.Theme NP V S_INF NP V S_INF PP.Location NP V S_ING NP V S_ING PP.Location NP V Theme NP V together NP.Theme V NP.Theme V PP.Location NPVPP.Instrument PP.location V NP V NP PP.Instrument	Actor V Theme ({+Path} Location) Agent V Agent V ({with}) Co-Agent Agent V {Against before into on to onto } Destination Theme Agent V {at on} Patient Agent V {at, in, on } Agent V {on Upon} Destination Agent V {with} Co-Agent {at, in, on } Theme Agent V Destination ({with} Theme) Agent V Instrument Agent V Location ({for} Theme) Agent V Patient ({with} Instrument) Agent V PP.Location Agent V Theme Agent V Theme (Together) Agent V Theme {against, before into on to onto} Destination Agent V Theme {for} Predicate Agent V Theme {from for on} Source Agent V Theme {ing} (Location) Agent V Theme {to towards} Destination Agent V Theme {to_INF} (Location) Agent V Theme Destination {adverb of Location here/there} Agent V Theme Initial Location Agent V Theme Location Agent V Theme Predicate {to_INF} Agent V Theme {+Be_ING} (Location) Agent V Theme{with} Instrument Location V Theme Patient V Patient V {from} Co-Patient Patient V {together} Patient V {with into to} Co-Patient Pivot V Theme {_ING} Pivot V Theme {_TO_INF} Pivot V Theme {to be} Theme V Theme V {at in with} Location Theme V Co-Theme Theme V Location ({here, there}) Theme V PP_Initial Location Theme V Source
Verb Class	appear- 48.1.1, begin – 55.1, bring-11.3, butter – 9.9, contiguous_location- 47.8 cooperate-73.3, defend-85, escape- 51.1, exist – 47.1, fill-9.8, future_having- 13.3, get-13.5.1, help-72, herd 47.5, hit- 18.1, keep – 15.2, lodge-46, meet-36.3, mix-22.1, obtain -13.5, put-9.1, reach – 51.8, roll – 51.3.1 , search-35.2, separate-23.1, try – 61, use – 105, want – 32.1	
Verb Tense	Present	
Speech Act Behavior	Request, Announcement, Question	

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Copular verbs	Be-form, appear, get, keep	
Auxiliary verbs	Be-form, have, had, can, should, do , need	
Others	-	
TMS - Confusion		
Syntactic Structure	Frames	Semantic Role
	NP V NP NP V NP V for NP NP V How, What S/_INF NP V How, Whether, What S / _ING NP V How, Why, What, That S NP V NP PP.Theme NP V NP To Be NP NP V NP.Recipient NP V NP.Topic NP V PP.Location NP V PP.Stimulus NP V PP.Theme NP V S NP V S_ING NP V that S NP V Topic How, what S/_INF	Agent V Agent V How, What {+inf} Agent V Recipient Agent V Recipient Topic {how, what, whether} Agent V Theme Agent V Theme {that} Agent V Theme {to be} Predicate Agent V Topic Agent V Topic How, What {+inf} Experiencer V Experiencer V {at, of, over} Stimulus Experiencer V {for} Theme Experiencer V Stimulus Experiencer V Stimulus {How, Why, What, That} Experiencer V Theme Stimulus V Stimulus V Experiencer
Verb Class	amuse-31.1, comprehend-87.2, conjecture-29.5, inquire – 37.1.2, marvel 31.3, search-35.2, see-30.1, transfer_mesg-37.1, wish-62	
Verb Tense	Past, Present	
Speech Act Behavior	Question	
Copular verbs	Feel	
Auxiliary verbs	Be-form, have, had, do, need	
Others	Question descriptive words (What, where, who, why, how)	
TMS - Credibility		
Syntactic Structure	Frames	Semantic Role
	NP V NP V ADJ NP V How, That, What S NP V How, What S/_INF NP V NP NP V NP PP.Location NP V NP PP.Material NP V NP PP.Recipient NP V NP PP.Source NP V NP PP.Theme NP V NP S_INF NP V NP S_ING NP V NP to be ADJ NP V NP To Be NP NP V NP.Topic NP V PP.Attribute NP V PP.Location NP V PP.Stimulus NP V PP.Theme NP V PP.Theme S/S_INF NP V PP.Theme whether, what, if S NP V S_INF NP V S_ING NP V That S NP V Topic How, what S/_INF	Agent V Agent V {about/with} Theme Agent V {to} Recipient Agent V How, What {+inf} Agent V Location Agent V Location {for} Theme Agent V Patient Agent V Patient {into} Results Agent V Patient Result {to_INF} Agent V Recipient Agent V Recipient Topic Agent V Result ({from out_of, for}) Agent V Theme Agent V Theme {From for on} Source Agent V Theme {how, that, what} Agent V Theme {ing} Agent V Theme {that} Agent V Theme {to be} Predicate Agent V Theme {to_inf} Agent V Topic Agent V Topic {what, how, that} Agent V Topic {what, how, that} + INF Agent V Topic How, What {+inf} Agent V whether, what, if Experiencer V

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	NP V What/How/That S NP V What/How/That S_INF NP V whether, what, if	Experiencer V {at, of, over} Stimulus Patient V Result Pivot V Theme { _ING} Pivot V Theme {to be} Pivot V Theme {TO_INF} Theme V Theme V ({IN}) Attribute Theme V Attribute { _to_inf} Theme V Location Theme V Source
Verb Class	accept – 77, become-109.1, conjecture-29.5, correspond-26.1, create 26.4, force-59, get-13.5.1, marvel 31.3, order-60, patent-101, say – 37.7, search-35.2, seem-109-1, transfer_mesg-37.1, try – 61, want – 32.1	
Verb Tense	Present	
Speech Act Behavior	Confirmations, Reply	
Copular verbs	Be-form, become, get, seem	
Auxiliary verbs	Be-form, have, had, do, need	
Others	Confirmation descriptive words (bad/ bad idea, great, yes, yeah, exactly, good/ good idea, like, okay/ok, right, sure, true) , Personal Pronoun (I, you, he, she, it)	
TMS - Feedback		
Syntactic Structure	Frames	Semantic Role
	NP V NP V ADJ NP V ADV NP V for NP NP V NP NP V NP PP.Destination NP V NP PP.Instrument NP V NP PP.Location NP V NP PP.Recipient NP V NP PP.Source NP V NP S_INF NP V NP S_INF Location NP V NP S_ING NP V NP to be ADJ NP V NP together NP V NP.Destination NP V NP.Patient NP V NP.Theme NP V NP.Theme PP NP V PP NP V PP.Attribute NP V PP.Co-Agent NP V PP.Co-agent PP.Theme NP V PP.Co-Patient NP V PP.Destination NP V PP.Destination NP NP V PP.location NP V PP.Theme NP V PP.Theme S_ING/_INF NP V S NP V S_INF NP V S_ING NP.location V PP.theme NP.Patient V PP.location V NP	Agent V ({with}) Co-Agent Agent V {Against before into on to onto } Destination Theme Agent V ({at, in, on }) Agent V {IN} Theme Agent V {on Upon} Destination Agent V {with} Co-Agent {at, in, on } Theme Agent V Destination Agent V Location Agent V Patient Agent V Patient {into} Results Agent V Patient {with} Instrument Agent V Patient Result {to_INF} Agent V PP.Location Agent V Result Agent V Theme Agent V Theme (Together) Agent V Theme { against, before into on to onto} Destination Agent V Theme {From for on} Source Agent V Theme {to} Recipient Agent V Theme Destination ({adverb of Location here/there}) Agent V Theme Location Agent V Theme PP.Destination Experiencer V ({for}) Theme Experiencer V Stimulus Location V ({with}) Theme NP V NP.Theme Patient V Patient V {from} Co-Patient Patient V Result Pivot V Theme { _ING} Pivot V Theme { _TO_INF} Pivot V Theme {to be} Stimulus V Stimulus V Experiencer

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		Theme V Theme V {{+loc}} Location Theme V {IN} Attribute Theme V Attribute Theme V Attribute {_to_inf} Theme V Destination Theme V Location (<+adv_loc>) Theme V PP_Initial Location Theme V Source Theme V Theme Destination (here, there)
Verb Class	amuse-31.1, appear- 48.1.1, become-109.1, breathe-40.1, bring-11.3, contribute- 13.2, cooperate-73.3, destroy-44, disappearance-48.2, escape- 51.1, exist – 47.1, force59, fulfilling-13.4, get-13.5.1, help-72, herd 47.5, light_emission-43.1, meet-36.3, obtain -13.5, other_cos-45.4, performance-26.7, put_spatial-9.2, put-9.1, see-30.1, seem-109-1, separate-23.1, succeed- 74, want – 32.1, wish-62	
Verb Tense	Past, Present	
Speech Act Behavior	Announcement	
Copular verbs	Be-form, become, get, seem	
Auxiliary verbs	Be-form, have, had, can, could, should, did	
Others	Feedback descriptive words (awesome, bad, better, best, effectively, good, great, impossible, bad/good job, performance, productive, teamwork, together, successful, suck, unrealistic)	

APPENDIX H: Classification System of Reflexivity

Classification System of Reflexivity

Reflexivity – Review		
Syntactic Structure	Frames	Semantic Roles
	NP V	Actor V Theme ({+Path} Location)
	NP V ADJ	Agent V
	NP V ADV	Agent V ({with}) Co-Agent
	NP V for NP	Agent V {about/with} Theme
	NP V NP	Agent V {Against before into on to onto }
	NP V NP ADVP	Destination Theme
	NP V NP 1[apart]	Agent V {at, in, on }
	NP V NP PP.Co-Patient	Agent V {on Upon} Destination
	NP V NP PP.Destination	Agent V {with} Co-Agent {at, in, on } Theme
	NP V NP PP.Instrument	Agent V Destination
	NP V NP PP.Location	Agent V Location {for} Theme
	NP V NP PP.Material	Agent V Patient
	NP V NP PP.Source	Agent V Patient {into} Results
	NP V NP PP.Theme	Agent V Patient {off off of from with} Co-Patient
	NP V NP S_INF	
	NP V NP S_INF Location	Agent V Patient {with} Instrument
	NP V NP S_ING	Agent V Patient Result {to_INF}
	NP V NP to be ADJ	Agent V PP.Location
	NP V NP To Be NP	Agent V Recipient
	NP V NP.Destination	Agent V Recipient Topic
	NP V NP.Initial Location	Agent V Result ({from out_of, for})
	NP V NP.Patient	Agent V Theme
	NP V NP.Theme (PP)	Agent V Theme {_ing}
	NP V PP.Attribute	Agent V Theme {against, before into on to onto} Destination
	NP V PP.Co-Agent	
	NP V PP.Co-Agent PP.Theme	Agent V Theme {From for on} Source
	NP V PP.Co-Patient	Agent V Theme {that}
	NP V PP.Destination NP	Agent V Theme {to be} Predicate
	NP V PP.Location	Agent V Theme Destination {adverb of Location here/there}
	NP V PP.Theme	Agent V Theme Location
	NP V PP.Theme S/S_INF	Agent V Theme PP.Destination
	NP V PP.Theme whether, what, if S	Agent V Topic
	NP V S_INF	Agent V whether, what, if
	NP V S_ING	Experiencer V {for} Theme
	NP V That S	Experiencer V Location
	NP V Theme PP.Location	Experiencer V Theme (Location)
	NP V whether, what, if	Location V ({with} Theme)
	NP.location V PP.theme	Patient V
	NP.Patient V	Patient V {off off of from} Co-Patient
	NP.Theme V	Patient V Result
	NP.Theme V PP.Location	Pivot V Theme {_ING/_INF}
	PP.location V NP	Pivot V Theme {to be}
		Theme V
		Theme V {IN} Attribute
		Theme V {spatial} location
		Theme V Attribute {rs_to_inf}
		Theme V Initial Location
		Theme V Location <+adv_loc>
		Theme V Source
Verb Class	Amalgamate-22.2, appear- 48.1.1, become-109.1, bring-11.3, conjecture-29.5, contribute- 13.2, cooperate-73.3, correspond-26.1, create 26.4, disappearance-48.2, focus-87.1, force-59, get-13.5.1, help-72, leave – 51.2, light_emission-43.1, meet-36.3, obtain -13.5, occurrence-48.3, order-60, other_cos-45.4, put-	

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	9.1, reach – 51.8, rehearse-26.8, roll – 51.3.1, search-35.2, seem-109-1, split-23.2, want – 32.1, wish-62	
Verb Tense	Past, Present	
Speech Act Behavior	Announcement	
Cognitive Behavior	SAE(Perception, Comprehension), SAT(Perception, Action), TMS (Specialization, Feedback)	
Copular verbs	is, are, was, were, appear, become, get, run, look, seem	
Auxiliary verbs	is, are, was, were, have, had, do, did	
Others	Review descriptive words (awesome, bad, better, best, effectively, good, great, impossible, bad/good job, performance, productive, teamwork, together, successful, suck, unrealistic)	
Reflexivity - Strategy		
Syntactic Structure	Frames	Semantic Roles
	NP V	Actor V Theme
	NP V ADJ	Actor V Theme {+Path} Location
	NP V ADV	Agent V
	NP V for NP	Agent V {about/with} Theme
	NP V NP	Agent V {Against before into on to onto }
	NP V NP ADV	Destination Theme
	NP V NP ADVP	Agent V {at on} Patient
	NP V NP {apart}	Agent V {at, in, on }
	NP V NP PP	Agent V {on Upon} Destination
	NP V NP PP.Co-Patient	Agent V {with} Co-Agent {at, in, on } Theme
	NP V NP PP.Destination	Agent V Destination
	NP V NP PP.Goal	Agent V Instrument
	NP V NP PP.Instrument	Agent V Location ({for} Theme)
	NP V NP PP.Location	Agent V Patient
	NP V NP PP.Predicate	Agent V Patient {off off of from with} Co-Patient
	NP V NP PP.Source	Agent V Patient {with} Instrument
	NP V NP PP.Theme	Agent V PP.Location
	NP V NP S_INF Location	Agent V Result
	NP V NP S_INF	Agent V Theme ({+SC_TO_INF} Location)
	NP V NP to be ADJ	Agent V Theme ({ing} Location)
	NP V NP {together}	Agent V Theme (Together)
	NP V NP.Initial Location	Agent V Theme { against, before into on to onto} Destination
	NP V NP.Patient	Agent V Theme {for} Predicate
	NP V NP.Theme (PP)	Agent V Theme {From for on} Source
	NP V PP	Agent V Theme {to_inf}
	NP V PP.Attribute	Agent V Theme {to} Goal
	NP V PP.Co-agent PP.Theme	Agent V Theme ADV
	NP V PP.Co-Patient	Agent V Theme Destination {adverb of Location here/there}
	NP V PP.Destination NP	Agent V Theme Location
	NP V PP.Location	Agent V Theme Predicate {to_INF}
	NP V PP.Location	Agent V whether, what, if
	NP V PP.Theme	AgentVTheme ({+Be_SC_ING} Location)
	NP V PP.Theme S/S_INF	AgentVTheme{with} Instrument
	NP V PP.Theme whether, what, if S	Experiencer V ({for}) Theme
	NP V S_INF	Experiencer V Location
	NP V S_INF PP.Location	Experiencer V Stimulus
	NP V S_ING	Experiencer V Theme Location
	NP V S_ING PP.Location	Location V Theme
	NP V Theme PP.Location	Patient V
	NP V whether, what, if	Patient V {off off of from} Co-Patient
	NP.Patient V	Patient V Result
	NP.Theme V	Pivot V Theme {to be}
	NP.Theme V PP.Location	Pivot V Theme {TO_INF/ _ING}
	PP.location V NP	
	PP.Location V NP	

		Theme V Theme V {{+loc}} Location Theme V {IN} Attribute Theme V {spatial} location Theme V Attribute { _to_inf} Theme V Co-Theme Theme V Initial Location Theme V Location <+adv_loc> Theme V Source
Verb Class	Amalgamate-22.2, appear- 48.1.1, become-109.1, begin – 55.1, bring-11.3, contiguous_location- 47.8, cooperate-73.3, correspond-26.1, defend-85, escape- 51.1, focus-87.1, future_having-13.3, get-13.5.1, help-72, herd 47.5, hit-18.1, keep – 15.2, leave – 51.2, occurrence-48.3, other_cos-45.4, put-9.1, reach – 51.8, roll – 51.3.1 , search-35.2, seem-109-1, sight-30.2, split-23.2, try – 61, use – 105, want – 32.1, wish-62	
Verb Tense	Present, Future	
Speech Act Behavior	Announcement, Request, Question	
Cognitive Behavior	SAE (Comprehension, Action), SAT (Comprehension, Action), TMS (Coordination)	
Copular verbs	Is, are, appear, become, get, keep, seem	
Auxiliary verbs	Is, are, can, should, do, need, will, shall, going to/gonna	
Others		
Reflexivity – Strategy Implementation		
Syntactic Structure	Frames	Semantic Roles
	NP V NP V ADJ NP V ADV NP V NP NP V NP ADV NP V NP ADVP NP V NP PP NP V NP PP.Destination NP V NP PP.Instrument NP V NP PP.Location NP V NP PP.Predicate NP V NP PP.Source NP V NP PP.Theme NP V NP S_INF Location NP V NP S_INF NP V NP To Be NP NP V NP.Initial Location NP V NP.Theme NP V PP NP V PP.Attribute NP V PP.Destination NP NP V PP.Location NP V PP.Location NP V PP.Theme NP V PP.Theme S/S_INF NP V PP.Theme whether, what, if S NP V S NP V S_INF NP V S_ING NP V S_ING PP.Location NP V that S NP V whether, what, if NP.Theme V NP.Theme V PP.Location	Actor V Theme ({+Path} Location) Agent V Agent V {about/with} Theme Agent V {Against before into on to onto } Destination Theme Agent V {at on} Patient Agent V {on Upon} Destination Agent V Destination Agent V Instrument Agent V Location ({for} Theme) Agent V Patient Agent V Patient {with} Instrument Agent V PP.Location Agent V Result Agent V Theme Agent V Theme { against, before into on to onto} Destination Agent V Theme {for} Predicate Agent V Theme {From for on} Source Agent V Theme {ing} Agent V Theme {ing} Location Agent V Theme {that} Agent V Theme {to be} Predicate Agent V Theme {to_inf} Agent V Theme ADV Agent V Theme Destination {adverb of Location here/there} Agent V Theme Location Agent V Theme Predicate {to_INF} Agent V whether, what, if Experiencer V Stimulus Location V Theme Patient V Result Theme V Theme V {{+loc}} Location

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	PP.location V NP V NP PP.Instrument	Theme V {IN} Attribute Theme V {spatial} location Theme V Attribute ({rs_to_inf}) Theme V Co-Theme Theme V Initial Location Theme V Location <+adv_loc> Theme V PP_Initial Location Theme V Source
Verb Class	Appear- 48.1.1, become-109.1, bring-11.3, conjecture-29.5, contiguous_location- 47.8, correspond-26.1, defend-85, escape- 51.1, get-13.5.1, help-72. hit- 18.1, judgment-33.1, keep – 15.2, leave – 51.2, obtain - 13.5, occurrence-48.3, put-9.1, reach – 51.8, roll – 51.3.1 , search-35.2, see-30.1, seem-109-1, try – 61, use - 105	
Verb Tense	Future, Present	
Speech Act Behavior	Announcement	
Cognitive Behavior	SAE (Comprehension, Action), SAT (Comprehension, Action), TMS (Specialization, Coordination)	
Copular verbs	Appear, become, get, keep, seem	
Auxiliary verbs	Is, are, do, can, need, will, shall, going to/gonna,	
Others	-	

**Erklärung gemäß § 9 (3) der Promotionsordnung der Fakultäten Humanwissenschaften
und Geistes- und Kulturwissenschaften**

Ich erkläre, dass ich die vorgelegte Dissertation selbständig angefertigt, dabei keine anderen Hilfsmittel als die im Quellen- und Literaturverzeichnis genannten benutzt, alle aus Quellen und Literatur, einschließlich des Internets, wörtlich oder sinngemäß entnommenen Stellen als solche kenntlich gemacht und auch die Fundstellen einzeln nachgewiesen habe.

Bamberg, den 02.26.2017