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Communicating for success: A quantitative analysis of the mediating effect of enacted complexity on the relationship between communication and team performance

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Abstract

Building on recent theoretical and methodological developments in organizational studies focusing on organizational routines (Hærem, Pentland and Miller, 2015; Hansson, 2018), this thesis aim to explore how three aspects of team communication; Frequency, distribution of communication and use of achievement-oriented language, influence team performance, and if enacted complexity mediates this relationship. The study relies on data gathered from 106 teams, solving a team task in the crisis simulator MindLab. The results of our analysis indicate a positive relationship between the frequency of communication and team performance, and that this relationship is fully mediated by enacted complexity. Further, achievement-oriented language was found to positively correlate with team performance, but this relationship was not mediated by enacted complexity. These findings suggest that we have identified two separate mechanisms governing the relationship between communicative aspects and team performance as we find support for the mediating role of enacted complexity between communication frequency and performance, while achievement oriented language and performance are correlated, but seems uncorrelated with enacted complexity. We found no statistical support for a relationship between team members' distribution of communication, enacted complexity and team performance. Due to the findings, this study extends the organizational routines literature by supporting earlier findings of a positive link between enacted complexity and team performance, in uncertain task environments. Further, this research identifies enacted complexity as a mediator of the relationship between communication frequency and performance, and strengthens the argument for routines as a potential source of flexibility and advantage when performing tasks in uncertain environments.

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Introduction

In today's organizations, teamwork is widely used and teams are often considered a flexible structure that can deal effectively with complex situations and problems (Stachowski, Kaplan & Waller, 2009). Organizations usually set up work in teams with the idea that teams will make better decisions than individuals. The increased use of teams in organizations is often based on the belief that teams are especially proficient in responding to dynamic and complex situations (Burke et al., 2006), and that teams are able to tackle tasks too complex for any individual (Cooke et al., 2000). Therefore, teams are often used when task errors can lead to serious consequences; when the task environment is ill-defined, uncertain and stressful; when multiple decisions have to be made quickly; and when the lives of others depend on the collective insight of individual members (Salas et al., 2008). As teams are used in a wide range of different settings; scholars and practitioners seek to understand why some teams succeed while others do not. This research seek to further our understanding of what characterize the teams who perform better than their peers in uncertain situations, as we ask: Can performance be predicted by how much teams communicate, if team communication is equally distributed among its team-members or by a team's use of words reflecting achievement-orientation? And how do these aspects of communication relate to the complexity of the way teams go about solving their tasks?

Although a range of studies have been conducted to identify the antecedents of team-performance (e.g. Stewart, 2006; Bell, 2007), the traditional view of teams is changing and new theories for understanding team functioning arise as it becomes more and more common for teams to communicate via technology (Maynard & Gilson, 2014). These types of teams are commonly referred to as virtual teams, and have received increasing interest among scholars in the last years. A team is considered more or less virtual based on "the extent to which team members use virtual tools to coordinate and execute team processes" (Kirkman & Mathieu 2005, p. 702). Gilson and colleagues (2015) found that teams are more prone to fail when they are geographically distributed and solve tasks in uncertain environments. One possible explanation is that teams operating in a virtual environment face greater obstacles to share information than teams in

traditional contexts (Hightower et al., 1997; McDonough, Kahn & Barczak, 2001). Therefore, it is of interest for both scholars and practitioners to develop better understanding of how virtual teams' information sharing processes relate to performance in complex settings.

At the core of any virtual team process is communication (Powell, Piccoli & Ives, 2004), and the extent to which teams are able to adapt to their task environments is key to team performance (Daft & Lengel, 1986; Gilson et al., 2015). Analysing aspects of communication may therefore be fruitful when seeking to understand why some teams are better able to perform in complex settings than others. A team's understanding of any complex and uncertain situation is influenced by the knowledge that the team possesses (Cooke, Stout, & Salas, 1997; Stout, Cannon-Bowers, & Salas, 1996). To get a shared understanding of the task and situation, team members need to coordinate and communicate their activities with others who are working towards the same goal (Cooke et al, 2000), especially in teams that have no previous experience together (Beebe & Masterson, 1986). Several studies have showed the importance of communication on team performance (Foushee & Manos, 1981; Jarvenpaa & Leidner, 1999; Sexton & Helmreich, 2000; Maznevski & Chudoba, 2001; Stachowski et al., 2009). And, as communication is a fundamental component of how information is processed at the team level (Salas, Cooke & Rosen, 2008), we might expect that the amount of communication could be a relevant piece when seeking to understand team performance.

Orasanu and Fischer (1992) emphasize how the degree to which a team establishes shared mental models of a problem and the degree to how this is made explicit through communication, is crucial for teams' effectiveness in solving problems. We might therefore expect that when team-members are dependent on each others' information to develop a workable knowledge of the situation, the degree to which most or all team-members share information may have an impact on overall team performance.

Further, the message or content of what is being communicated is key. Some pieces of information are of importance in a specific situation, while some categories of information may be important across a wide variety of settings. An important aspect of reaching a goal is to be clear on which goals are to be reached

and who will take care of what, which have been found to have both coordinative (Hollingshead, 2010) and motivating effects (Locke et al. 1981). In this way, teams communicating about goals and coordination of team efforts may be better suited to reach their goals.

To seek understanding of the relationship of these communicative dimensions and performance, this paper builds on the stream of research focusing on organizational routines as a core construct for understanding organizations (see e.g. Becker 2005; Waller, Gupta & Giambatista 2004). As teams organize their work, routines of how to solve a task are gradually developed. Routines enable team members to create shared understandings of their task and how to solve it, as well as a common ground for how the team communicates when solving their tasks (Feldman & Rafaeli, 2002). These routines may be more or less complex; e.g. due to the nature of the task, fixing a car that won't start is a more complex routine than brushing your teeth. However, while some people will open up the hood of their car, try to detect the problem, and replace a broken part, some other people might try to quick-fix their car by giving it a kick and in this way enact a simpler approach to solving the same problem. The complexity of the way these people go about fixing the car can be referred to as the enacted complexity. As one might expect from the example of the car, the difference in the enacted complexity of the two routines may further have an impact on the success rate. Using pattern recognition techniques, Hansson (2018) found support for a relationship between team performance and task complexity in a similar research project. This paper builds on Hanssons (2018) research by leveraging these newly developed measures of enacted complexity.

This study explores the relationship between three quantifiable dimensions of communication, enacted complexity and team performance. The three dimensions of communication as touched upon earlier are the frequency of communicative behavior, teams' distribution of communication among team-members and the degree to which team's use achievement-oriented language. This research aims to establish the potential mediating effect of enacted complexity in the relation between the three aspects of communication and team performance. We include enacted complexity as a concept that could add to the

existing literature on communication and team performance, and further strengthen the routines litterature. The researched question proposed, is:

"Is there a relationship between the three communication-dimensions (frequency, distribution, and use of achievement-oriented language) and team performance? And are these relationships mediated by enacted complexity?"

Theory and Hypotheses

Communication and team performance

Communication is considered a key concept in understanding teams and their functioning. In this paper, we borrow Stevens (1950) definition of communication as "the act of conveying intended meanings from one entity or group to another through the use of mutually understood signs and semiotic rules" (Stevens, 1950).

In broad strokes, team-communication can be divided into two functional categories; *socioemotional communicative behavior* and *task communicative behavior* (Bales, 1950). Where socioemotional communicative behaviors are aimed at keeping the relation of the group itself, task communicative behavior is communication aimed at solving the task of the group. Several studies have focused on the socioemotional function, e.g. by studying the effects of relationships, culture and climate on performance (e.g. De Dreu & Weingart, 2003; González-Romá, Fortes-Ferreira, & Peiro, 2009). This study, alongside other studies, focus primarily on the task communicative function. With this focus, communication is often understood as a core feature of how organizations monitor the external environment as well as process information to adapt to the environment (Littlejohn & Foss 2008). Organizations and teams gather, transmit, store and use information which is key for decision-making (Putnam & Cheney 2006).

Through successful task-related communication, teams are able to make use of its collective body of information to solve the task at hand (DeChurch & Mesmer-Magnus, 2010). Research emphasizes that successful teams are able to communicate effectively and share crucial information to solve the problem

(Allen, 1977; Ancona & Caldwell, 1992; Bordia, 1997; Brown & Eisenhardt, 1995). Communication enables the development of a shared understanding of the current problem situation so that all members can have the same understanding of what the problem is, what environmental cues mean, what solution might be tried, and what is expected of various team members (Orasanu, 1990). As communication is a multifaceted phenomenon, we have focused on three dimensions of team-communication that are identified in the literature as relevant to understand task-related communication in teams: Frequency, team distribution of communication, and use of achievement-oriented language. The three dimensions are further explained in the following.

How much: Frequency of communication

One way to measure communication is by measuring the frequency, or volume of communicative actions within a team. The frequency of communication is an interesting variable as it provides an objective measure of the number of intents of conveying a message between team members, per unit of time. Prior research on communication suggests that the frequency, predictability, and the amount of feedback provided in the communication is positively related to team performance (Jarvenpaa et al., 1998; Jarvenpaa & Leidner, 1999; Kayworth & Leidner, 2002; Maznevski & Chudoba, 2001). In a meta-analysis, DeChurch and Mesmer-Magnus (2010) found that frequency of information sharing in teams predicts team performance across all levels of moderators. Moreover, using 'number of words' as an objective measure of verbal communication frequency in cockpits, Sexton and Helmreich (2000) found a positive correlation between communication frequency and performance. Another study of communication in aircraft-crews by Foushee and Manos (1981) similarly found an overall tendency that low-performing teams communicated less than the high performing teams in uncertain situations. We therefore expect to find that more communication relates to higher performance (Hyp1).

Hypothesis 1: The team communication frequency is positively related to team performance

Who talks: Distribution of communication

As it is hypothesized that a higher frequency of team-communication is positively correlated with team performance, it also expected that the balance between team-members amount of communication may have an impact on team performance. While the frequency of communication captures the aggregated amount of communication on a team-level, we are also interested in the distribution of each team's communication between it's team-members. A skewed balance of communication between team-members is expected to cause a lack of potentially important information cues from the low-communicating team-members. As the crisis-management setting consists of highly dependent processes, a skewed balance of communication within a team may signal that important information held by one team-member is never shared, which can result in decisions being made on weak foundations of information. Therefore, due to such team-member interdependencies, it is expected that an evenly distributed communication pattern is needed to support the flow of all important information within the team. We refer to this as the teams' "distribution of communication".

This relationship has, to our knowledge, only been examined in a handful of earlier studies. Inspired by earlier research by Palmer (1989), Fischer and colleagues (2007) studied the communication of teams in a lab-setting and found that in successful teams the communication is more equally distributed while in unsuccessful teams, one or several team members dominated the conversation and thus the team's actions (Fischer et al., 2007). This idea is also reflected in Woolley and colleagues' (2010) study of collective intelligence, where teams with a more equally distributed conversational turn-taking had a higher collective intelligence, a concept that has been shown to predict performance on a range of different tasks (Woolley et. al., 2010; Woolley, Aggarwal & Malone, 2015). Further, Pentland (2012) found patterns of communication (including individual team-members distribution of communication and direction of communication) to be the most important predictor of team success in a comprehensive study of several teams. In general, the mentioned research suggests that teams may benefit from a more or less even distribution of communication among its team-members.

Since the measure of distribution is based on the relative standard deviation, where a higher score of distribution of communication reflects a more skewed communication balance in the team, we expect to find a negative relationship between team distribution of communication and team performance (hyp 2):

Hypothesis 2: The team distribution of communication is negatively related to team performance.

The message: Achievement-oriented language

To understand how team-communication relates to performance, the content of what is communicated (the message), clearly matters. However, the underlying meaning of communicative behavior quite often depends on whom you ask and in what setting, making the analysis of "what is communicated" a difficult area for quantitative research methods. Whereas researchers have sought to analyze and understand the message dimension of communicative behavior qualitatively, attempts to develop quantitative, "objective" measures of communicated content has recently gained popularity with the development of new technology.

Pioneering the technological development of objective measures of communication, Pennebaker and colleagues (Pennebaker et al. 2003; Tausczik & Pennebaker, 2010; Pennebaker et al. 2015) developed the Linguistic Inquiry and Word Count (LIWC). The LIWC is a tool for quantitative analysis of text which is based on a set of dictionaries with words reflecting what is described as psychologically meaningful categories (Pennebaker et al. 2015). With a concept called 'achievement-oriented language' (from now on: AOL), Pennebaker and colleagues (2003) have developed a measure of language that reflects an active intent to coordinate and plan for successful task completion (Gonzales, Hancock & Pennebaker, 2010). This dimension of communication include words such as *try, effort, ability, win* and *goal*, which is expected to reflect that teams are actively taking action to reach a goal.

Researchers argue that key performance-related activities, such as planning, task orientation and shared understanding of the goal, are expected to be

reflected through AOL (Turner & Parker, 2004). It is therefore expected that AOL relates to higher performance (Gonzales, Hancock & Pennebaker, 2010; Sexton & Helmreich, 2000). Sexton and Helmreich (2000) found support for this assumption as they found that the use of achievement oriented words was strongly related to fewer errors and higher performance, in flight teams. Surprisingly however, in another study Gonzales, Hancock and Pennebaker (2010) found a negative relationship between the use of AOL and performance and argued that it might be that the use of AOL increases when teams struggle. The conflicting results suggest that further examination of AOL as an objective measure of communicated content is needed. Following the theoretical underpinnings and Sexton and Helmreich's (2000) research supporting the notion of a positive relationship, we expect that AOL is positively related to team performance (hyp 3).

Hypothesis 3: Teams' use of achievement-oriented language is positively related to team performance.

Enacted Complexity

The concept of 'organizational routines' plays an important role in organization science-literature (Feldman & Pentland 2003). Organizational routines have been conceptualized in a range of ways, with Nelson and Winter's (1982) evolutionary approach as one of the more popular ones, dominating the field. Nelson and Winter present the routine as a 'gene' resulting from a once satisfactory solution to a problem that is repeated with little consciousness and is highly stable. If the routine fails to produce a satisfactory outcome, a routine is abandoned and it is replaced by another routine.

Feldman and Pentland (2003) challenged Nelson and Winter's conceptualization of routines, arguing that routines can be a source of flexibility and change, as routines cannot be understood without acknowledging the agency of the actors performing the routine. Their 'performative' approach suggests that the term routine refers to both its ostensive aspect (the structure of the routine) and its performative aspect (the actual performance of a set of behaviors making up the routine). The interplay between these aspects creates an opportunity for

change by continuous selection and retention of actions. Kesting (2006) explains how this may come about by arguing that routines refer to the patterns of action related to the intention of bringing about a formerly known state repeated times. In this way, routines are the actions taken to reach some state again, but the exact actions taken may differ from time to time, hence variation and change.

This paper follows the tradition of the 'performative' approach and thus adopt Feldman and Pentland's definition of organizational routines as "repetitive, recognizable patterns of interdependent actions, involving multiple actors" (Feldman & Pentland, p. 96, 2003). We further follow Pentland, Hærem and Hillison (2010) argument that since routines cannot be observed on the generative deep level, the surface-level patterns of actions are suggested as the level of analysis.

A core construct in studying routines is complexity (e.g. Thompson, 1967; Perrow, 1967; Hærem, Pentland, & Miller, 2015). While the term task complexity has been used to describe the task as separated from the task doer (E.g.: Hackman 1969; Wood 1986; Campbell, 1988), recent research on organizational routines (e.g.: Hærem, Pentland & Miller 2015; Hansson 2018) have introduced 'enacted complexity' to acknowledge enactment and sensemaking. Following the earlier example of the two different approaches to "fix" a car, we see that the complexity of the task as it is performed is not simply inherent in the task itself, but the way the task is enacted. The enacted complexity is in this way a measure of the complexity of the way in which an individual or a team goes about solving a task (Haerem, Pentland, & Miller, 2015). By detecting and counting all strings of actions that lead to attainment of a task, we get a measure of the number of various ways a task is enacted. Enacted complexity can in this way be defined as *"the number of paths in the network of events that lead to the attainment of task outcomes"* (Haerem et al., 2015).

Hærem, Pentland and Miller (2015) argue that as several actors work together on a task, each action serves as an information cue which may spur new actions, and each information cue is subject to interpretation by its observers. Therefore, a pattern of actions come about through several interpretations of information cues. The complexity of the routine undertaken is therefore a matter of prior actions. In this view, enacted complexity provides insight and

understanding into the number of possible paths that a certain task can be solved, given the action was already taken by the team or task doer (Hansson, 2018).

Enacted complexity and performance

Following the logic of contingency theory, an organization's performance depends on its ability to respond effectively to the requirements of its environment (Lawrence & Lorsch 1967; Thompson 1967). In this way, an organization exposed to a large set of different inputs needs a large repertoire of actions to be able to deal effectively with the inputs from each situation at hand (Feldman, 2000; Weick, Sutcliffe & Obstfeld, 2008). However, the organization also needs to match the requirements of the situation with the optimal actions from its repertoire of actions, which can be a more or less mindful selection process (Levinthal & Rerup 2006). In a stable and transparent situation, the same response can be used each time a similar situation is detected, and this selection can be "routinized" to increase efficiency (March & Simon, 1958). In a stable and transparent setting, teams may therefore increase effectiveness by reducing enacted complexity, which is sometimes referred to as SOPs (Standard Operating Procedures).

However, in a complex setting with a wider range of different inputs and ambiguous causal relationships, exploring several possible ways of responding to a situation may be necessary to find the appropriate response (Weick, Sutcliffe & Obstfeld 2008). Teams that enact various actions and explore more ways to go about a problem, may gain insight and therefore improve outcomes in unfamiliar task environments (Kaufmann & Raaheim, 1973; Rudolph, Morrison, & Carroll, 2009; Weick & Sutcliffe, 2015). Higher enacted complexity may therefore lead to higher performance in complex settings.

Examining and comparing the patterns of action in an invoice-processing-routine (simple setting) and a crisis-management game (complex setting), Hansson (2018) found support for this model, as increased enacted complexity was positively related to performance in the complex setting, but negatively related to performance in the simple setting. Therefore, it seems that in complex setting, teams may benefit from exploring the complexity of the task.

Communication frequency, enacted complexity and team performance

Weick (1995; 2012) points to how groups of people engage in collective sensemaking through communication and that this lay the grounds for further actions. Moreover, Hærem, Pentland and Hillison (2015) argue that information cues "provide a mechanism through which events are related" (p. 452). Based on these perspectives it is expected that a higher volume of communication enables more information cues to be attended to in the collective sensemaking-process, which enables better decisions to made.

In complex and ambiguous situations, the need for communication is greater as organizations typically increase their flow of information to cope with ambiguity in complex settings (Putnam and Cheney 2006). Increased communicative behavior is in this perspective a way in which teams mitigate the information processing needs of increased complexity (Campbell, 1988; Marks et al., 2001). With ambiguity increases the need to reach decisions, as one cannot rely on 'automated responses' (Klarner et al. 2013), and with multiple potential approaches increases the need for communication to negotiate and make tradeoffs (Campbell 1988).

Studying 19 teams of emergency department staff solving a simulation of an unexpected event, Marlys K. Christianson (2017) found that effective teams monitor, interpret and share new information cues more than than low-performing teams, and, that the high performing teams further tested plausible interpretations and solutions to the problem more and as an ongoing activity. This suggests that teams facing complex situations or tasks benefit from testing various patterns of action to find the most effective situation, and that communication is an important part of this collective sensemaking process, spurring more complex enactments of the task. Following this logic, an increased amount of communication among team team-members is expected to be positively related to team performance, mediated by enacted complexity.

Hypothesis 4: The relationship between team communication frequency and team performance is mediated by enacted complexity.

Distribution of communication and enacted complexity

Following the argument regarding hypothesis 2; that imbalanced team communication will be negatively related to team performance, we further examine whether this relationship is mediated by enacted complexity. It is expected that teams with imbalanced communication miss out on potentially important information-cues from their low-performing team-members, making the team less able to collectively make sense of the complexity of the situation, leading to lower enacted complexity. The argument builds on the underlying assumption that the team-members are mutually dependent on each other's input, thus requiring all team-members to share their knowledge with their team-mates. Greater spread in the team-members distribution of communication is therefore expected to be negatively related to performance, mediated by enacted complexity.

> *Hypothesis 5: The relationship between the distribution of communication among team members and team performance is mediated by enacted complexity.*

Achievement-oriented language and enacted complexity

The last hypothesis can be drawn from the work of Weick, Sutcliffe and Obstfeld (2008) on HRO's and mindful organizing. They suggest that many organizational disasters happen due to a narrow focus on organizational objectives which creates "blind spots" of attention. In these "blind spots" small errors can escalate and turn into disasters (Weick, Sutcliffe & Obstfeld 2008).

The literature on functional fixedness (e.g. Adamson 1952) and creative problem solving (e.g. Isaksen & Treffinger 1985), have presented experimental research showing effects similar to those Weick and colleagues later explained through a sensemaking lens. One of the most influential experiments was conducted by Karl Duncker and Lees (1945) and several researchers have adopted and tweaked their experiments. Duncker argued that people have a cognitive bias, which makes it hard for people to see the potential ways to use objects in unfamiliar ways. A well-known example of a study examining this effect is the

candle problem. In the candle problem, the participants are presented the problem of attaching a candle to the wall, with a box of nails and some matches as the only available resources. The experiment is designed so that the most effective solution to the problem, is to make sense of the available box of nails, not only as the nails themselves (the most obvious sense), but also as a potential "platform" for the candle to stand on. Building on Duncker's research, Glucksberg (1962) found that individuals getting monetary rewards performed worse than those who did not get rewards. This may imply that as people become more focused on the achievement of the task, the ability/willingness to apply various strategies are reduced.

In similar fashion, we expect AOL to reflect a team's narrow focus on achieving goals, rather than exploring potential various strategies. Following this logic, we hypothesize that AOL will be negatively related to teams' enacted complexity, and in this way enacted complexity will mediate a negative relationship between AOL and team performance.

Hypothesis 6: The relationship between achievement-oriented language and team performance is negatively mediated by enacted complexity.

The research question and hypotheses give us the mediation research model displayed in Figure 1.

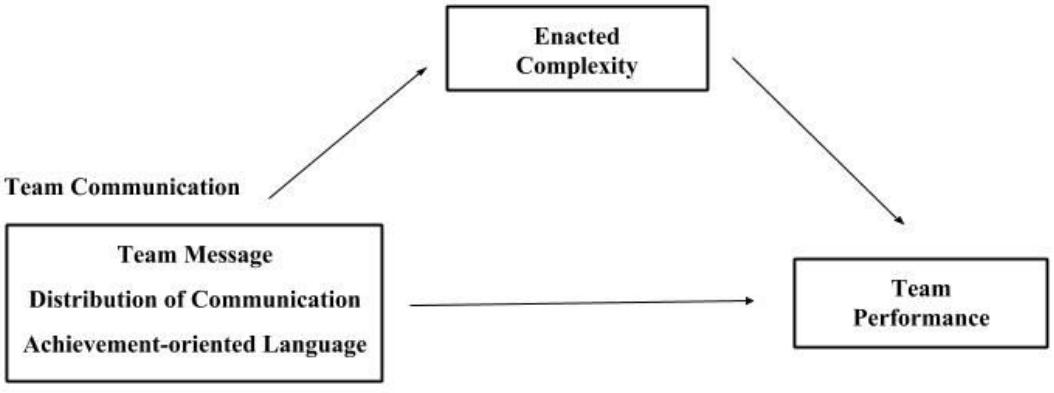

Figure 1.
Research Model

Method

Procedure

To answer the research question this study conducted a quasi-experiment to investigate the mediating effect of enacted complexity on communication and team performance. To study the hypotheses we conducted a controlled lab-simulating of a complex situation. The lab simulation enables a controlled environment that allows us to control the material resources, the dependencies and the task-related information each team-member possess from the beginning, and to observe and record all actions, including all communication between the team-members.

The setting for the lab-experiment is a crisis management computer game developed by Thovald Hærem in cooperation with military officers from the Norwegian Airforce Academy, called MindLab. Each participant was assigned to a randomized team. The randomly selected teams were then instructed to act as counter-terrorist teams with the primary task of defending a set of oil-rigs located in the North Sea. To defend the oil-rigs the teams had to detect the presence of unidentified objects, identify whether the objects were friendly or not, and intercept unfriendly objects before they entered a critical area. Each team played two rounds of the simulation, with different scenarios each time.

All team members in the simulation have access to a common operational picture on their computer screens. This operational picture consists of a map showing the different team members, fishing vessels, terrorists (disguised as civilian fishing vessels), the oil rigs and the resources available to the players. Each team member controls one of the three different characters: Orion plane, patrol boat or frigate. Each of the characters have different characteristics; the Orions have the highest detection capacity; the patrol boats have the best information search capacity; and the frigates are the only resource capable to attack.

To coordinate, the participants have an internal email-function where they can communicate (written language only). This email-interface also provides the team members with preformatted messages; mission orders, intelligence updates,

detection and information search messages and communication between participants. The email-function is the only way team members can communicate.

The scenarios challenge the individuals with issues related to team monitoring, information exchange and coordination for a collective team strategy to solve the tasks. At the beginning of each round, each player has very limited information and are unaware of specific critical areas to protect. The information has to be deducted using information distributed among all three team members. In addition, any individual player cannot carry out all three tasks (detection, search, and interception) crucial to the game by themselves. Therefore, each member has to draw on one another's resources and information to complete the task successfully. MindLab provides a log of behavior where each action is logged as one integer in a sequence array and all communication between team members is logged there, too.

Participants

The data collected contained 168 participants, divided into 56 teams. Each team conducted the simulation two times (with two scenarios in each simulation), and these different simulations are handled as different observations. After accounting for missing or incomplete data, the total sample size was 159 participants divided into 53 teams, giving a net total of 106 observations (N=106). All participants were undergraduate students attending the Norwegian Business School BI. Before the participants took part in the study, they were informed about the goal of the experiment, and confirmed that all data would be kept confidential, only accessible to the research group and to be used for research purposes.

After the participants finished the lab simulation, they were asked to fill out a questionnaire measuring different control variables and other variables not included in this specific analysis.

Measures

All variables in this study were measured from the log of communication and teams' actions in MindLab. All scores are calculated on a team level.

Team Messages: Communication-frequency is operationalized as the total number of sent messages between team-members in each team, during the simulation period of 20 minutes. To sample the frequency of communication, we counted each message sent from a player to another, using Microsoft Excel's COUNTIF-formula. Messages are chosen as unit of analysis (rather than frequency of words, sentences or letters), because each message represents an individual intended action to communicate some information to the other team members, whereas the frequency of words, sentences or letters are expected to be more affected by the individuals' writing styles.

The in-game e-mail function allowed a player to choose whether to send a message to one or both the other players, although the content was the same the latter case was counted as two messages. The system-generated messages were filtered out from the count with the Excel-formula. As we are concerned with the performance of the teams, rather than the performance of the individual players, the individual team-members' message-counts are summarized to form a team communication frequency-variable.

Distribution of Communication: To measure the 'Distribution of Communication' of each team we counted the number of sent messages by each team-member, and compared it to the total number of sent messages within the team. The distribution of communication variable is computed as the relative standard deviation (also referred to as 'coefficient of variation'). The relative standard deviation is defined as the ratio of the standard deviation to the mean (Newbold, Carlson & Thorne, 2010) and is therefore a measure of variability in relation to the mean of a team's number of sent messages. Unlike the Standard Deviation, the relative standard deviation is not directly affected by the size of the data-set, in this case; the volume of the communication, and is therefore better suited for comparing the spread of various data-sets (Newbold, Carlson & Thorne, 2010). The variable Distribution of Communication is in this way a reflection of the degree of dispersion within in each team, expressed as a percentage, in so that higher values signals a team with less balanced communication patterns.

Achievement-oriented language: Achievement Oriented language (AOL) was measured using LIWC 2015 (Linguistic Inquiry and Word Count), developed by Pennebaker and colleagues (2015). Several studies have found the LIWC

categories to be valid across dozens of psychological domains, and empirical results using LIWC demonstrate its ability to detect meaning in a wide variety of experimental settings, including to show attentional focus, emotionality, social relationships, thinking styles, and individual differences (Tausczik & Pennebaker, 2010). The LIWC is based on a set of dictionaries that are made from what Pennebaker and colleagues (2015) describe as 'psychologically meaningful categories'. The LIWC analyze text according to the chosen categories and provide scores reflecting the relative use of the chosen categories (Tausczik & Pennebaker, 2010).

The category AOL includes words such as *try, effort, ability, win,* and *goal*. Although the categories are intended to be 'psychologically meaningful' and have proven to be related to other psychological concepts, the LIWC-measures themselves should not be considered a direct measure of any underlying concept, but as a measure of a specific aspect of the communication itself, because the measures are contextually dependent (Tausczik & Pennebaker, 2010). Thus, AOL is in this study 'simply' considered a measure of the use of AOL rather than as an attempt to measure any underlying psychological concepts.

Enacted Complexity: The measure of enacted complexity is modeled as a network of actions performed by all the team members in each team. We base our measure on Hærem, Pentland and Miller's description: "task complexity is indexed by the number of paths in the network of events that lead to the attainment of task outcome" (Hærem, Pentland & Miller 2015, p. 452). In this way, if a team explore various ways of reaching their goals (of identifying and interrupting terrorists, in our study), they will have enacted a more complex task than a team doing the minimum of tasks required to reach their goals. As the players go about playing the simulation-game, the actions they take are recorded. These actions are then analyzed as nodes in a network of actions making up a routine (e.g. the routine of detecting, searching for information and engage an enemy ship). By counting the number of paths within the network of actions that lead to the end goal, we find a measure of how many ways of going about solving the task a team has undertaken. This provides us with a measure of the team's enacted complexity.

Team Performance: The team performance score is based on the speed and succeeding of detecting, info searching and attacking the terrorist vessels. These two different scores are added to provide an overall team performance score. Points are subtracted if a team attacks friendly objects or attack objects without having positively identified the attacked objects as a terrorist. The Team Performance score goes from 0 to 900, and teams can get detracted points for attacking non-terrorist vessels. As the two different scenarios are analyzed as two separate sets of observations, the team performance score was calculated separately for each scenario.

Statistical procedure

To test for potential confounding variables and multicollinearity, a correlation test was conducted with all the variables of interest. We included two demographic variables; team average age and gender distribution, as age and gender have been demonstrated to influence team mechanisms, communication and performance (Smith et al.,1994; Tsui & Gutek, 1999; Barrick et al., 2007).

To test our hypothesis, we followed Preacher and Hayes (2004, 2008), Williams and MacKinnon's (2008) and MacKinnon and colleagues (2002) recommendations, using bootstrapping estimation method (Process analysis) to analyze the mediation. Process analysis is argued to better fit observed-variable (Hayes, Montoya & Rockwood, 2017), and to be a more suitable approach to mediation analysis compared to the more traditional regression technique (Baron & Kenny, 1986). This is because, as described by Preacher and Hayes (2004), the process does not impose the assumption of normally distributed data, it provides better control for type 1 errors.

The process analysis calculates the influence of the independent variable (IV) on the dependent variable (DV) through the mediating variable (MV) (Preacher & Hayes, 2008). This analysis repeats the process several times, and in this way constructs an empirical sample for the distribution between all the variables. This distribution is then used to calculate the confidence intervals for the indirect effect of IV on DV, through MV. Interpretations of the goodness of fit of the mediations are concerned with whether the confidence interval passes zero,

which indicates non-significant results. When zero is not within the confidence intervals, there may be support for mediation (Preacher & Hayes, 2004).

Results

Descriptive Analysis

Table 1 reports descriptive statistics and correlations between all the variables, including control variables to detect potential gender or age differences.

While distribution and frequency of communication are highly correlated, none of the correlations exceeds .70, which is the critical value for multicollinearity (Field, 2013; Pallant, 2013). This indicates that multicollinearity is not a problem. As illustrated in Table 1, the number of males in the teams correlates positively with the TM (amount of Team Messages) and negatively with DoC (distribution of communication). In this way, the teams with more males send more messages and have a more evenly distributed communication pattern between team members. Further, TM correlates negatively with DoC, and positively with AOL, EC (enacted complexity) and TP (team performance). Lastly, AOL and EC both correlate positively with TP. No other correlations were significant.

However, the correlation matrix only gives an indication of the relationships found in the dataset (Field, 2013). To test our hypothesis, regression analysis is needed. Hence, Preacher and Hayes (2004) bootstrapping estimation method, or process analysis, was applied to test the mediation hypotheses.

Table 1.

Descriptives Statistics and Correlations

Variables	M	SD	1	2	3	4	5	6	7
1. No. of Males	1.94	0.97	-						
2. Age Average	22.71	3.44	0.05	-					
3. TM	44.15	23.45	0.34**	0.16	-				
4. DoC	0.59	0.31	- 0.27**	- 0.12	- 0.64**	-			
5. AOL	43.59	33.73	0.02	0.15	0.30**	- 0.19	-		
6. EC	56.95	27.84	- 0.04	- 0.05	0.32**	- 0.05	0.09	-	
7. TP	567.15	76.74	0.05	- 0.09	0.19*	- 0.04	0.39**	0.24*	-

TM = Team Messages; DoC = Distribution of Communication; AOL = Achiventented oriented language; EC = Enacted Complexity; TP = Team Performance

N= 106. *p<.05 **p<.01

Process Analysis

The tests were conducted with a 95% confidence interval. All the results can be seen in Table 2. The results indicate that the team's frequency of communication is positively associated with team performance. The process analysis reported a direct positive relationship between communication frequency and team performance (see Table 2), which supports hypothesis 1: "The team communication frequency is positively related to team performance". Further, the results indicate that enacted complexity fully mediates the relationship between communication frequency and team performance (see Table 2), which supports hypothesis 4: "The relationship between team communication frequency and team performance is mediated by enacted complexity"

Regarding hypothesis 2: "The team distribution of communication is negatively related to team performance." and hypothesis 5: "The relationship between the distribution of communication among team members and team performance is mediated by enacted complexity". The process analysis revealed a direct relationship between the distribution of communication and team performance, and no indirect relationship between enacted complexity, distribution of communication and team performance (see Table 2). Further, the 95% confidence interval range from negative to positive, indicating no significant mediation between the distribution of communication and team performance, through enacted complexity. Therefore, hypotheses 2 and 5 were not supported.

Regarding hypothesis 3: "Teams' use of achievement-oriented language is positively related to team performance", the result shows a significant positive relation between AOL and team performance, thus supporting hypothesis 3 (see Table 2). However, regarding the full mediation-model, the 95% confidence interval range from negative to positive, indicating no significant mediation between AOL and team performance, through enacted complexity. Therefore, hypothesis 6: "The relationship between achievement-oriented language and team performance is negatively mediated by enacted complexity", is not supported.

Table 2.

Influence of Communication on Team Performance through Enacted Complexity

									95% CI	
Independent variable (IV)	Mediating variable (MV)	Dependent variable (DV)	Influence of IV on MV (a)	Influence of MV on DV (b)	Total influence (c)	Direct influence (c´)	Point estimate /indirect influence (a x b)	SE	Lower	Upper
1. TM →	EC	TP	.3769**	.5586*	.6026 *	.3921	.2105	.1110	.0248	.4519
2. DoC →	EC	TP	-.0461	.6612*	-.0654	-.0349	-.0305	.0562	-.1426	.0824
3. AOL →	EC	TP	.0546	.5866*	.6008**	.5688**	.0320	.0402	-.0442	1197

5000 bootstrap samples; TM = Team Messages; DoC = Distribution of Communication; AOL = Achiventented oriented language; EC = Enacted Complexity; TP = Team Performance

*p<.05 **p<.01

Post-hoc analysis of a curvilinear relationship

Earlier research has reported finding a curvilinear relationship between communication-frequency and performance (e.g.: Leenders et al., 2003; Patrashkova-Volzdoska et al., 2003). The explanation is that communication allows the flow of important information, but that too much communication can lead to information overload and thus compromise performance (Kennedy, McComb & Vozdolska 2011). To test for a potential curvilinear relationship, we conducted a post-hoc analysis of both a logarithmic and linear function of the communication-frequency and performance-relationship. We found that when allowing for a curvilinear relationship, the R square changed from .038 ($p = .034$) for the linear function, to .042 ($p = .046$) for the logarithmic function. These minor differences suggest an insignificant increase in explanatory power when allowing for a curvilinear relationship.

Although earlier research has found support for a curvilinear relationship, we expect that the situational constraints of our experiment, such as the 20-minute time-limit and the uncertainty of the complex situation creating a great need for information, reduces the probability that teams will communicate more than what is beneficial. Moreover, the richness of the media might influence the likelihood that teams "over-communicate". Hærem, Valaker, Rau & Bakken (2018) found that teams tend to contextualize (i.e adding explanatory information to the core message) when using rich, rather than lean media types. Therefore, as the lean, internal mail-system was the only communication-medium available to the teams in the crisis management setting, the medium might further reduce the likelihood of over-communication.

Discussion

The aim of this study is to bring further knowledge to the relationships between communication, enacted complexity and team performance. Using Preacher and Hayes' (2004, 2008) process-analysis, we found support for three out of the six proposed hypotheses, suggesting that the frequency of communication and use of AOL is positively related to team performance and that enacted complexity fully mediates the relationship between communication frequency and team performance. In the following we discuss the interpretations and implications of the findings, starting with the direct relationships between the three aspects of communication, before discussing the mediating role of enacted complexity, and lastly, discussing some of the possibilities and implications of using quantitative measures of organizational processes.

Three aspects of communication

Frequency

The results support the findings of prior studies (e.g. Roberts & O'Reilly, 1976; Foushee & Manos, 1981; Sexton & Helmreich, 2000) as we find a significant relationship between communication frequency and team performance. While most earlier research have been concerned with oral communication, we have focused on written communication and established a similar effect. Establishing support for this effect in written communications is of interest as virtual teams are frequently used (Jarvenpaa & Leidner, 1999; Dulebohn & Hoch, 2017) and text communication is an important part of team communication in modern organizations (Coleman, 1997; Dulebohn & Hoch, 2017).

Following contingency theory, it was expected that the complex and ambiguous nature of the task at hand would create a need for information for teams to be able to solve the task of detecting fishing vessels, searching the vessels for potential terrorists and attack the identified terrorist-ships. The interdependent nature of the roles of the three players on each team (no player could carry out all three parts of the routine) would further create a need for coordination of the team-members efforts, thus a need for communication. The

findings from the simulated setting seem to illustrate that teams who communicate more are better able to share relevant information and coordinate their efforts than teams who communicate less, in such situations.

Distribution of communication

As we expected that teams with a higher frequency of communication would process more relevant information and coordinate better, we further expected that teams where all members contributed with inputs would benefit, as we expected all members to hold information relevant to the rest of their team-members. Put differently, we expected that teams with team-members reluctant to communicate their knowledge might miss out on important information, regardless of the total amount of communication within the team.

We found no support for the proposed hypothesis of a negative relationship between teams' distribution of communication and performance. The hypothesis assumed that an equal distribution of communicative behavior within the team is "optimal" for team performance, which may be inaccurate and dependent on the given situation. In the scenario played out in the experiment, the Orion-plane's single purpose is to detect fishing vessels so that the patrol boat can search for confirming/disconfirming evidence for a potential terrorist-attack. However, as a fishing vessel is detected it also shows on all the team-members' radars, thus the Orion-player may not have to write this information in the integrated-mail function. Teams may further decide to appoint a coordinative role to one of the players, thus creating an unbalanced communication-pattern, yet potentially effective coordinative function, in this way violating the underlying assumptions of the hypothesis (hyp 2).

It is also noteworthy that we found in the descriptive analysis that male-dominated teams have higher communication frequency and a more distributed communication within the team. We may expect that this stems from men in general being more familiar with playing games similar to the simulated scenario. Reviewing the literature on gender differences in amount of talk, James and Drakich (1993) found that the gender-research have shown inconsistent results, and argued that different social settings pose different cultural expectations of status and expertise which impact the gender differences. This

poses another argument that may explain why we find that male-dominated teams communicate more, as men may be culturally expected to be used to strategy and war games, and in this way experience a higher level of social expectations to contribute with their opinions than the female participants.

Further, it is noticeable that teams with higher frequency of communication also show lower distribution of communications, and thus a more evenly distributed communication in the teams. This can be seen from the reported correlation of TM and DoC ($r = -.064$, $p < .01$). This could be because in teams that communicate more all team participant feel the importance of communicating information and that they have the possibility to communicate. The high frequency of communication may create a team climate were the participants experience openness to communicate their information. In teams with lower communications, team members can possibly feel constrained by the low communication and thus communicate less.

Achievement-oriented language

Using the LIWC-framework (Pennebaker et al. 2003; Tausczik & Pennebaker, 2010; Pennebaker et al. 2015), we found that teams who use more AOL also get higher performance-scores.

AOL may drive performance by increasing team coordination, as use of AOL may reflect that team members are explicit about goals, task-completion and what needs to be done. As teams using AOL may be better at creating a shared understanding of their common goals, division of labor and potential dependencies among team-members.

However, Pennebaker and colleagues (2015) argue that the LIWC is based on "psychologically meaningful categories", where AOL include words like try, effort etc.. In this way, it might be that the strong correlation between performance and use of AOL may be explained by individuals' achievement orientation (see e.g.: Atkinson & Feather, 1966) or other motivation-related concepts, rather than its relation to teams' coordination-abilities. As the LIWC framework provides no guidelines on how to interpret the results across different situations and the total list of words used to measure AOL is kept secret, it is somewhat difficult to interpret the nuances of these findings.

The mediating role of enacted complexity

While task complexity has been a core construct in the organization literature for some time, the concept of enacted complexity is a product of recent streams of research on organizational routines, focusing on the performative aspect of routines. By bringing in the performative aspect of routines, the complexity of a routine depends on the complexity of the way the team goes about solving a task, referred to as enacted complexity.

It follows the logic of enacted complexity that team's enacting higher complexity will be less 'efficient', in a strict sense that these teams will be 'wasting' efforts on suboptimal ways of solving the task as they try various patterns of action. Explained differently, one may say that each time a team solves a task in a more complex way than is really needed, the team is not maximizing its efficiency. However, we found support for the contradicting hypothesis that the teams enacting higher complexity would perform better than their peers enacting lower complexity. The underlying reasoning for this hypothesis is two folded: Firstly, in the ambiguous and complex setting of the scenario, enacted complexity is expected to relate to a more open sensemaking process, as the teams have not settled on "one right way" but explore potential ways forth. Secondly, enacting higher complexity is expected to support the information gathering of the team, in this way providing the team with a greater set of information to consider when making decisions. The complexity of the situation is therefore considered an important moderator of this relationship, as supported by Hansson (2018). While it might make sense to "stick with what is known to work" in a stable and simple setting, our findings suggest that it is more beneficial to openly explore various ways of solving tasks in complex settings like the scenario examined here.

Several studies have reported finding a positive relationship between the frequency of communication and performance (e.g. Foushee & Manos, 1981; Jarvenpaa et al., 1998; Jarvenpaa & Leidner, 1999; Sexton & Helmreich, 2000; Kayworth & Leidner, 2002; Maznevski & Chudoba, 2001), but to our knowledge no study has established what kinds of team-level, behavioral patterns that mediate this relationship. Our findings contribute to further understand this

relationship as we found that enacted complexity fully mediates the relationship between communication frequency and performance.

Examining the content-dimension of the communication, using the LIWC-category 'AOL', we found no support for the proposed hypothesis of a relationship between the use of AOL and enacted complexity. However, we found support for a significant, positive relationship between AOL and performance. Taken together, these results indicates that we have been able to identify two separate aspects of communication that serves different functions in supporting team's ability to perform in complex settings, as the teams using more AOL get higher performance, but through some other unknown mechanism than enacted complexity. Speculating on potential mediating mechanisms of the relationship between AOL and performance we may argue that using AOL in itself represents a more efficient way of organizing, e.g. by linking each suggestion or comment to the way it relates to achieving the goal. Another explanation may be found in motivation theory: Schultheiss (2013) found that the LIWC-category AOL converged with content-coding measures of implicit motives for achievement (e.g. Atkinson & Feather, 1966). In this way, AOL might be reflecting individual motives or attributes linked to the drive to achieve, which correlates with higher performance, but is unrelated to the enactment of the complexity of the task.

Objective measures of routines and communication

This study makes use of quantitative measures of communication and routines that are developed to enable 'objective' analysis of communicative behavior and organizational routines. By using quantitative measures of aspects of communication we find these measures can provide new insights into our understanding of organizing.

To measure the frequency of communication we tested measuring number of words, characters and messages. As expected, our results suggested stronger relationships using number of messages as frequency variable. Earlier research on recorded vocal cockpit discussions have used number of words as unit of analysis (e.g. Foushee & Manos, 1981), which seems fruitful as vocal language is less structured than messages, making it harder to separate one sentence from the next, etc. However, when examining written messages from an e-mail-function, we

have the possibility to count the number of sent messages. It is expected that this provides a more reliable way of counting communication, as each time a message is sent is likely to represent an intent to provide a certain piece of information in a specific time and place. Although, Gonzales, Hancock, and Pennebaker (2012) suggests word-count as a robust measure of communication frequency, we argue that counting the number of sent messages can provide a more precise measure of intentional information-sharing in settings with written, two-way communication.

By comparing each team-member's frequency of communication to team-total frequency of communication we computed each team's relative standard deviation of communication to provide a team-level variable for comparing the teams' distribution of communication. To our knowledge, this way of measuring team-level communicative patterns have not been conducted earlier, and thus represent a potential new dimension to consider for future researchers. We did not find a significant relationship between this measure of communication-symmetry and performance, however. A possible explanation is that we based our hypothesis on the underlying assumption that less variance resembles a more efficient distribution of communicative actions, while this may not be the case. Varying interdependencies between the different roles in the team may require more information sharing between some roles than others, in this way breaking the assumption that equal distribution among team-members' communication is the ultimate distribution.

To try and measure the contents of a message we relied on Pennebaker and colleagues' (2015) Linguistic Inquiry and Word Count (LIWC). In this study, we looked at the use of AOL (Achievement Oriented Language) and found support for the hypothesis of a positive relationship between AOL and team performance. However, Pennebaker and colleagues do not provide a clear argument for what underlying concept the AOL may represent, as this is expected to be situational (Tausczik & Pennebaker, 2010). Which leaves us with a problem of interpreting the results; is AOL a measure of the authors' personal attributes, group dynamics or 'simply' a measure of the degree to which the selection of words are used? In this study it seems equally fruitful to see AOL as a measure of underlying individual attributes such as personality, or as a product of group processes. Thus,

further research is needed to develop a greater understanding of the potential and limitations of the use of "objective" measures of communication content.

To measure enacted complexity we relied on a recently developed algorithm proposed by Hansson (2018), which counts the number of potential paths in a network of actions, leading to the desired outcome. Finding that this measure of enacted complexity mediates the relationship between communication frequency and performance we further support the notion that this measure is a valuable tool when studying organizational phenomena.

Limitations and future research

Like most research, this study has some limitations which are important to take into consideration when interpreting the results. The quasi-experimental setting allowed us to increase control over potential confounding variables such as prior knowledge sharing within teams and non-monitored communication. It further gave us the opportunity to determine the situation to be identical for all playing teams and to randomly assign participants. Nevertheless, the chosen method for data collection does not provide statistical support to claims about causality (Field, 2013; Bryman & Bell, 2015). In other words, this paper cannot conclude on the direction of the relationship between the different variables. Therefore, it could be that the amount of communication and the use of achievement oriented language affect enacted complexity, or the other way around. This is a general problem of studying communication, as it may always be both the product of and cause of another variable.

The demographic-dimensions of the population-sample is also noteworthy. Most of the participants were in the age group 18-30, with an average team age of 22 years. The sample therefore consisted of a rather homogenous group, which may limit the generalizability of the present findings. A larger sample size and a broader age range could improve this issue.

Further, this research did not take individual psychological attributes into account. Even though this was outside the scope of this research, we do not know whether the communicative patterns are explaining variance in enacted complexity or performance that may be related to aspects such as personality traits, which have been found to affect team performance and communication

(Bradley & Hebert, 1997; Van Vianen, & De Dreu, 2001). Further research could include these aspects to get a broader understanding of whether different psychological attributes can predict or affect the relationship between communication, enacted complexity and team performance.

Due to conflicting results of previous research (i.e. Gonzales, Hancock & Pennebaker, 2010), the relationship between AOL and team performance should be further investigated in order to create a better understanding of the psychological mechanisms behind AOL and its effect on team performance. Further, a better understanding of "what is measured" is needed for AOL to become a robust measure of communication.

Further research could also add more nuanced aspects of communication, and see how different aspects of communication are related to enacted complexity and performance, to get a broader picture of the relationship between communication aspects and patterns of actions.

Conclusion

This study contributes to the organizational routines, communication and team performance literature by establishing enacted complexity as a core concept in understanding how team communication relates to team performance.

There are several reasons why this is of value. First of all, a deeper understanding of how teams function in uncertain and complex environments and what factors increase performance is of importance for managers and leaders looking to facilitate the performance of such teams. Secondly, the concept of organizational routines and enacted complexity are increasingly relevant concepts within the field of organizational studies. Third, because (to our knowledge) there are no quantitative studies linking dimensions of communication with enacted complexity and team performance. The research design and methods for data collection enabled us to quantitatively capture core aspects of team communication and task enactment. This allows us to use mediation-analysis to establish potential relationships between the three dimensions of communication, team's enacted complexity and team performance.

The study finds support for a mediating effect of enacted complexity, and strengthens the arguments for routines as a source of flexibility and change. Based

on the results of this study, organizations could facilitate teams solving tasks in complex and uncertain environments to increase communication and to explore more ways of solving the task.

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