Communication Content Relations to Coordination and Trust over Time: A Computer Game Perspective

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ABSTRACT
We research synchronous ad-hoc teams coping with complex tasks in a dynamic virtual computer game environment. We shed light on relations of communication, coordination and trust. We develop a model of coordination and show how coordination evolves over time.

KEYWORDS
Ad-hoc teams, communication, coordination, trust

INTRODUCTION
We research Command and Control (C2) structures for disaster response staff organizations. Disaster response organizations cope with growing mission complexity and dynamics due to new scenarios as terrorism, large blackouts or communication network breakdowns [7]. More urbanization, higher population density and tightly networked infrastructure increased the probability of large-scale disasters in case of emergency due to rippling effects in the urban system.

Such scenarios require collaborating organizations which coordinate by mutual adjustments [35, 51] to meet mission complexity and dynamics. C2 approaches based on close collaboration of entities are required [52]. One concept – C2 teams – is considered to be purposeful to organize such collaboration [17, 45]. We follow Jones and Roelofsma in defining a C2 team "as two or more individuals with specialist and interdependent roles who are necessarily brought together to perform a complex decision-rich task in order to achieve goals that are central to those of the organization" [27]. C2 teams "are primarily used to manage moderate to large-scale events within ill-defined situations, where resources are limited" [45] and circumstances for operation are usually fast-paced and ambiguous. They often cope with ambiguous and frequently changing information from multiple sources according to the dynamics of situations they are operating in [27, 45].

Team composition further exacerbates the task of C2 teams in missions, as they are usually ad-hoc – composed on short notice for a single mission without team history [45]. Work modus is usually synchronous, as the units in the field require immediate decisions for operation.

These team characteristics – synchronous work modus, ad-hocness, task complexity and dynamics are special. Major literature reviews on teams refer to work teams, parallel, project or management teams [12, 37]. In fact, these teams differ in their characteristics as they usually work together for longer, are carefully staffed (at least in theory) and cope with different tasks. Our research is motivated by the increasing relevance of C2 teams in disaster response and the need to understand and assess team communication and coordination to design C2 structures and media for these teams. Our research design, an experimental setting is motivated by the observation that C2 teams and their communication and coordination are hard to study in the field. As the teams we are interested in are so different from the teams that have been studied in scholarly literature we revisit seminal concepts and models with this study.

We simulate a virtual team environment in an experiment setting utilizing the first-person-perspective team-shooter Battlefield II (www.ea.com) - a simulation of military close combat. Our teams playing Battlefield II (BF2) are ad-hoc, play in synchronous mode and cope with a complex and dynamic task.

We aim to understand how such teams coordinate and develop over time. In this respect we analyze how team communication relates to coordination and team trust and how these relations develop. We develop instruments (coding schemes) to find patterns of communication content relevant to coordination and trust development.

THE EXPERIMENT ENVIRONMENT
In summer 2009 we conducted an 'exploratory' experiment to observe synchronous ad-hoc teams consisting of five players with distinct roles playing BF2. Following the definitions of Steinle, exploratory experiment settings offer empirical openness and the ability to develop theories – in contrast to theory testing approaches typically common on experiments [49].

TEAM TASK
Two teams fight each other in 'capture the flag' mode to win a BF2 game that consists of two rounds. The theatre is a virtual urban area with four strategic points like e.g. a mosque. Teams' task is to conquer these points to hoist their flags on them. The objective is to capture or recapture as many strategic points as possible to mark them with the team flag.

Three ways to win a round exists. First, to conquer all strategic points and to kill all enemies gives immediate victory. Second, each team has 200 tickets (points) at the beginning which reduce for a team (1) when it has fewer flags than the opposing team (2) when a teammate is killed. A round ends when one team has zero tickets. The other team wins. A third way to win is to have more tickets after 20 minutes, the maximum round time.

Note, a five players team is unable to capture and defend all strategic points. The game usually seesaws with changes in "ownership" of strategic points forcing teams to change tactics dynamically – to switch from attack to

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defense or regroup and act once as a whole once as two sub-teams. All these actions require coordination.

TEAM COMPOSITION

Our teams consist of three assault-soldiers, one medic and one support-soldier:

Assault-soldiers are heavily armored and equipped with an assault-rifle with grenade function and smoke grenades. Assault-soldiers' mobility is limited by armor.

Medics feature heal-bags (restore teammates' health) and a heart defibrillator (reanimate teammates). They are not armored and very mobile on the battleground. For self-protection medics use a standard assault-rifle and hand grenades.

Support-soldiers supply teammates with ammunition. They fight with a 'heavy' machine gun or an assault-rifle and hand grenades. Their mobility is limited by heavy armor.

COMMUNICATION DATA ACQUISITION

We capture verbal communication using software called 'teamspeak' (www.teamspeak.com) - a widely used voice chat software. All players have headphones. We capture the video-stream of each player's screen utilizing software called 'Fraps' (www.fraps.com). We merge video and audio as raw material for data analysis.

PARTICIPANTS

All 80 experiment participants were male German Armed Forces officer cadets enrolled as students at the Universität der Bundeswehr München. The students volunteered. We offered neither financial remuneration nor credits. Experiment participants were not familiar with research questions.

EXPERIMENT PROCEDURE

Before competition, we explained game and task and conducted a single player modus training run to enable players to handle their game character.

We conducted two rounds of play (identified as Round 1, Round 2) with two competing teams at a time. We surveyed players after both rounds. Four players were interviewed at the end of each game, two players of each team.

Players were randomly assigned to their teams. The two competing teams played in different laboratories (WI-lab and EC-lab). We identify teams according to the lab-token as 'Team WI' or 'Team EC'.

As we had 80 participants in 16 teams of five players, we conducted 8 games consisting of two rounds.

THEORY

Quality of coordination is widely accepted as predictor of performance [2, 20]. Coordination is "managing dependencies between activities" [34].

Complex tasks call for mutually interdependent actions having intensive dependencies [5, 52]. The activities necessary for task fulfillment are intertwined. Organization separation with clear functionally divided organizational elements cannot capture task demands [51]. This problem face classical staff approaches in military or disaster response. C2 teams, however, bring together functional diversity to meet task requirements. They solve complex tasks in dynamic situations necessitating highly interdependent activities and intensive processes [5, 52] coordinated by mutual adjustments [35, 51]. Interpersonal communication is essential to adjust activities [51].

We are interested in how these teams that cope interdependently with dynamic and complex challenges coordinate to achieve their goals.

The idea of what coordination in a team really is remains pretty diffuse. For example Marks et al. define coordination as "orchestrating the sequence and timing of interdependent actions" [36], p. 363 emphasizing the process to combine activities in a manner to avoid process losses [48]. Rosen and colleagues argue that "in dynamic environments, teams must coordinate their processes adaptively […]. That is, they must change how they organize individual inputs as the demands of the situation change. There are several key behavioral processes that enable this adaptive coordination (e.g., mutual performance monitoring, back-up behavior, team leadership, communication) […]" [44], p. 7. These authors emphasize the result of activities as communication or team leadership as coordination regarding it as emergent [21], observable when things run smoothly within a team. Moreover, they refer to 'teamwork'-activities as analyzed by Salas et al [47]. Teamwork refers to the process that transforms input by team activities in output [42, 47]. Thus, they use coordination and teamwork interchangeably. Hoegl and Gemuenden regard coordination as one distinct element of teamwork. Others are communication, balance of member contributions, mutual support, effort and cohesion – all categories of interaction [23]. The concepts of teamwork and coordination are closely related.

Communication is key to both related constructs – coordination and teamwork. Hoegl and Gemuenden qualify communication as "the most elementary component" of teamwork quality [23]. Salas et al. identify closed-loop communication as one of the main coordination mechanisms for teamwork [47]. Communication breakdowns are severe predictors of lacking coordination [36] and process losses [48]. Intergroup communication enables mutual adjustments and is a crucial facilitator of coordination in complex and dynamic environments [35, 51].

Two modes of coordination exist, an explicit, communication based one and implicit coordination, based on Team Mental Models (TMM) [10, 33, 45]. TMM represent common expectations about the environment and its near future development [30]. When teammates share such expectations, know and trust them, talking about expectations is not longer necessary and communication decreases [9, 33].

We are interested in the relation of communication and coordination. We regard coordination as a result of the team's effort to orchestrate interdependent actions [36, 44] and explore which communication content is related to coordination and how this relation develops over time.

According to Salas et al. closed-loop communication and mutual trust are coordinators of teamwork and closely connected to coordination and team effectiveness [47]. Team members trusting in their team feel the existence of high competency that enables the team to accomplish their tasks and that the team does not harm interests or

rights of individual team members [24, 54]. Therefore, trust in teams is a twofold concept describing a feeling of psychological safety [14] and potency [22].

How is communication related to trust in ad-hoc teams? Communication frequency and trustworthiness are significantly correlated [4, 38, 56], so that more communication predicts higher trust levels. Conversely, high trust levels increase willingness of individuals to exchange accurate and comprehensive information freely and timely within a team [26, 57]. Webber concludes "the early development of a team climate for trust results in effective team communication, coordination and cooperation" [54], p. 207.

We want to understand the relation of communication, coordination and trust in ad-hoc teams. More precisely we aim to observe relations between communication content, team trust and coordination.

MEASURES

To understand team communication, we codify interactions with two distinct coding systems. First, Bales Interaction Process Analysis (IPA) a context free communication classification system developed to analyze group development processes ([3], Figure 1).

Social-Emotional Area: Positive Reactions
1 Shows solidarity, raises other's status, gives help, reward
2 Shows tension release, jokes, laughs, shows satisfaction
3 Agrees, shows passive acceptance, understands, concurs, complies
Task Area: Attempted Answers
4 Gives suggestion, direction, implying autonomy for other
5 Gives opinion, evaluation, analysis, expresses feeling, wish
6 Gives orientation, information, repeats, clarifies, confirms
Task Area: Questions
7 Asks for orientation, information, repetition, confirmation
8 Asks for opinion, evaluation, analysis, expression of feeling
9 Asks for suggestion, direction, possible ways of action
Social-Emotional Area: Negative Reactions
10 Disagrees, shows passive rejection, formality, withholds help
11 Shows tension, asks for help, withdraws out of field
12 Shows antagonism, deflates other's status, defends or asserts self

Figure 1: Coding Scheme IPA according to [3]

IPA 1-3 and IPA 10-12 codify socio-emotional communication – IPA 1-3 positive reactions and IPA 10-12 negative ones. IPA 4-9 codifies task-related communication. IPA 4-6 classifies suggestions or directions (IPA 4), opinions and analyses (IPA 5) and information or confirmation (IPA 6) – IPA 7-9 questions.

Two master students coded team communication. Each communication act was coded in one category. Cohen's kappa (between 0.74 and 0.95) indicated high inter-rater reliability. The first author recoded acts in which the students differed.

As IPA does not capture context, we develop a coding scheme to capture communication routines for team-based and situation-based information. Thus, our coding scheme (Figure 2) distinguishes two main communication aspects (1) team centric communication (TCC) - communication acts as e.g. status information, requests for healing or socio-emotional communication as, e.g., tension releases and (2) enemy-centric communication (ECC), i.e., all information about the enemy.

As situation's dynamics, caused by adaptation and action of the enemy, is important to understand team coordination, we code ECC more detailed applying Endsley's theory of Situation Awareness [15] and its team context application (e.g. [46]) describing how and in which stages a team gets aware of its situational environment. This construct is called Team Situation Awareness (TSA). We distinguish perceiving the environment (Perception), comprehending relevant facts perceived (Comprehension), exchanging relevant projections of future environmental states (Projection) and exchanging information on actions (Action). Teams have to communicate about perception and comprehension of facts, as teammates' views on the battlefield differ. Projection requires processing relevant data and simulating future environmental states. Projections of single teammates are to communicate and converged to become shared and basis for team actions. The code Action captures communication about team action with regard to the enemy as e.g. suggestions or commands.

Code identifier	Sub codes	Code definition	Exemplifications
Enemy-centric communication (ECC)	Perception	Unspecific information about enemies' occurrences	"I killed one" "There is one more"
	Comprehension	Information about enemies that helps to maintain the situational picture of each team-mate esp. due to information about location or relationship to own team	"One more at the hotel" "Attention one is sitting on the roof"
	Projection	Communication of possible future actions of enemies	"All will come to the mosque, again..." "Two come towards you, Player One"
	Action	Information about actions to do with regard to the enemy	"I enter the roof to try to fight them from above" "Throw hand-grenades on them!"
Team-centric communication (TCC)		Information about own status, socio-emotional communication, tension release, coordination without enemy relation, etc. All communication not referring to the enemy	"All to the medic" "Medic, can you heal me?" "To the left, to the wall?" "Hey, we have to capture the flags, now!" "I'm dead"

Figure 2: Coding Scheme

The TSA stages perception, comprehension and projection are ordered [15]. Projections of future states require comprehension and beforehand perception of the situation and its changes. Planning and shared team activities base on Projection. Thus, Action bases on projections and captures coordination attempts regarding enemies.

To measure team trust we asked players to assess "To what extent do you trust your team-mate?"[1] on a seven point Likert-scale from 7 "no trust at all" to 1 "a great deal of trust" [13].

Coordination was measured using players' assessment of the question[2] "Did the team handle the task to coordinate and adopt all players and their skills (e.g. healing, supply, grenades)?" on a seven point Likert-scale with 1 meaning

[1] The question was translated from German from "Wie viel Vertrauen hast Du in Deine Mitspieler?" 1 – kein Vertrauen; 7 – sehr viel Vertrauen

[2] "Habt ihr folgende Aufgaben wahrgenommen? Koordination und Einsatz der Spieler und ihrer Fähigkeiten (z.B. Heilung, Versorgung, Granateinsatz)". 1 – gar nicht; 7 – immer

"not at all" and 7 "always". Both measures feature high face validity [29] as our participants as officer cadets have the linguistic abilities to assess trust and coordination as both concepts are important in military leadership. We measured trust and coordination after each round via survey.

To get a comprehensive understanding of players' perspectives, we conducted two interviews in each team at the end of Round 2. Per team, we interviewed one talkative, leader-like player and one inactive player, not leading. Thus, we conducted 32 interviews. Beneath topics as perceived task complexity or virtualness of the environment (both not part of that contribution) we asked participants whether they perceived a development within the team from Round 1 to Round 2: "Did you observe some development within your group?"[3] We aimed at understanding the subjective experiences of the players [39].

As this research is exploratory we triangulate interview statements, theory and results from codings and survey to get a deep understanding of the relations of communication, trust and coordination in ad-hoc teams.

OBSERVATIONS OF OUR INTERVIEWEES

We briefly summarize our findings from interviews. First, the positive attitude towards the development of team coordination in the interview responses is noticeable. E.g. although Team EC, Game 2 lost both rounds, both interviewees observed improvements in team play. The leader-like player stated, "Initially in Round 1 everybody was alone, then coordination and performance increased. In Round 2 was lots of coordination, although it went badly."[4] His teammate analyzed, "In Round 2 a plan was created and we communicated much more".

Actually, only two interviewees criticized team development. From Team EC, Game 1, which won Round 1 but lost Round 2, the leader-like player praised coordination and communication in Round 1 but criticized that the teammates did not follow directions and coordination worsened in Round 2. In Team EC, Game 7, which lost both rounds ahead of time, the inactive player observed negative team development. All other 30 interviewees observed positive team development.

Quite homogenous was the observation that aspects of coordination and communication are of great concern for team development as 27 of 32 interviewees spoke about both concepts. 24 of them explicitly estimated development of coordination and communication as being positive.

The players analyze how communication, trust and coordination interact. The leader-like player in Team WI, Game 4 assessed communication had improved coordination. This coincides with the leader-like player in Team EC, Game 6 who stated Round 2 was coordinated better. The reason was more communication.

[3] "Konntest du eine bestimmte Entwicklung innerhalb der Gruppe feststellen?"

[4] All interview statements were given in German and translated by the first author.

The leader-like player of Team WI, Game 8 argued that due to increasing team communication the trust level increases over time. He added in Round 1 was communication and planning negatively affected because players did not knew each other and had not yet confidence in the abilities of teammates.

The players emphasized that teammates have to get accustomed to each other to become a team. E.g. leader-like player from Team WI, Game 1 stated in Round 1 players did not respond to each other, whereas in Round 2 was said 'I go here and there' and three others followed immediately without further orders - reducing communication.

We learn from interviews 1) the interviewees largely observed positive team development from Round 1 to 2; 2) aspects of communication and coordination are perceived by our participants to play a major role for team development; 3) communication is perceived to be crucial for coordination; 4) communication is perceived to be crucial for trust development; 5) our experiment participants are aware to reflect their approaches of communication and coordination to adjust them and 6) our participants took gaming serious and had the ambition to play well.

The interviewees revealed factors for team development, which are either discussed in literature. We had the impression that our teams actively and intentionally utilized communication to coordinate and support trust development.

The subsequent two result sections dedicate to relations of (1) communication and coordination, (2) trust and communication. We consider in each result section first the overall numbers and then compare Round 1 and Round 2 to assess development over time.

RELATIONS OF COMMUNICATION AND COORDINATION

In accordance to literature and interviewees' perceptions, communication and coordination are correlated significantly (Table 1). We analyze the relation of 'attempted answers' (IPA 4, 5, 6) and coordination and of coordination and TCC/ ECC.

Table 1: Correlations of Communication and Coordination

	Coordination and adoption of players and skills	
	Coefficient of correlation	Sig. (2-sided)
Total communication	0.54**	.001
Socio-emotional communication	0.05	.80
Task-oriented communication	0.59**	.001
IPA 4: Gives suggestion, direction	0.47**	.006
IPA 5: Gives opinion, evaluation	0.38*	.03
IPA 6: Gives orientation, information	0.48**	.006
Team-centric communication (TCC)	0.47**	.007
Enemy-centric communication (ECC)	0.44*	.012
Perception	0.17	.35
Comprehension	0.46**	.009
Projection	0.21	.24
Action	0.33	.067
* p<0.05; ** p<0.01		

Task-oriented communication with sub-classes IPA 4, IPA 5 and IPA 6 is strongly correlated to coordination. Teams with high amounts of giving directions (IPA 4), analyses (IPA 5) and information (IPA 6) perceive to be

better coordinated than those with low amounts. Actually, communication coded IPA 4 is qualified to manage interdependencies explicitly. Team-centric communication (TCC) and enemy-centric communication (ECC) are both significantly correlated with coordination. Action is not significantly correlated (as IPA 4) with coordination, but Comprehension is.

The interviewees assessed coordination increased in Round 2 due to more communication. Our participants assessed coordination in Round 1 survey with a mean of 4.01 (SD=0.9) and in Round 2 with mean of 5.11 (SD=0.65). Coordination increased significantly ($F(1,30)= 15.62$, $p<0.01$). Communication frequency, measured in communication acts per minute, was not significantly higher in Round 2 (Round 1: Mean=18.11, SD=4.52 vs. Round 2: Mean=20.78, SD=4.86; $F(1,30)=2.58$, n.s). So, interviewees' perception of improved coordination was in line with survey assessment but not valid regarding communication increase. However, we discuss relations of communication content and coordination to understand why coordination was assessed as being higher in Round 2.

Table 2: Correlations of Communication and Coordination comparing Round 1 and Round 2

	Coordination and adoption of players and skills		
	Round 1	Round 2	
	$r_{Round\ 1}$ Sig. (2-sided)	$r_{Round\ 2}$ Sig. (2-sided)	p^a ($r_{Round\ 1}$-$r_{Round\ 2}$)
Total communication	0.46 .08	0.54* .03	0.39
Socio-emotional communication	0.21 .44	0.07 .79	0.36
Task-oriented communication	0.46 .07	0.59* .015	0.32
IPA 4: Gives suggestion, direction	0.46 .07	0.20 .46	0.23
IPA 5: Gives opinion, evaluation	0.12 .66	0.57* .02	0.09
IPA 6: Gives orientation, information	0.37 .16	0.47 .065	0.38
Team-centric communication (TCC)	0.47 .06	0.46 .07	0.49
Enemy-centric communication (ECC)	0.18 .5	0.51** .004	0.17
Perception	0.29 .27	0.31 .24	0.48
Comprehension	0.16 .56	0.57* .02	0.11
Projection	0.08 .77	-0.03 .91	0.39
Action	0.04 .87	0.28 .29	0.26

* $p<0.05$; ** $p<0.01$

[a] $r_{Round\ 1}$ and $r_{Round\ 2}$ are transformed into Fisher Z scores. Then computation of $p(z_1-z_2)$ (see for details [11])

Table 2 details changes in correlation coefficients of coordination and communication between both rounds. With this second step of analysis we compare Round 1 and 2. The second column (Table 2) depicts correlation coefficients for Round 1 and Round 2. The most right column informs about the probability that the difference of correlation coefficients is zero (no development regarding the relationship of respective communication content and coordination [11]).Comparing Round 1 correlations of coordination and total communication ($r=0.46$, n.s.) and task-oriented communication ($r=0.46$, n.s.) with Round 2 ($r=0.54$, $p<0.05$ and $r=0.59$, $p<0.05$ respectively) a non-significant increase is observable. Our interviewees perceived that with increased communication coordination increased as well. This relation becomes significant in Round 2. Moreover, as the correlation coefficient of socio-emotional communication and coordination is near zero in both rounds, coordination is solely related to task-oriented communication.

Surprising is the strong decrease in correlation of IPA 4 and coordination (Round 1: $r=0.46$, n.s. vs. Round 2: $r=0.20$, n.s). Teams with a high amount of communication acts coded directions (explicitly coordinating) do not feel better coordinated in Round 2. The opposite development is observable for IPA 5 and coordination (Round 1: $r=0.12$, n.s. vs. Round 2: 0.57, $p<0.05$). IPA 5 codifies communication acts analyzing the situation important for shared team understanding.

We argue that due to the development of Team Mental Models (TMM), the influence of directions and orders is less important on coordination than the influence of giving analysis and offering information (IPA 6).

TCC/ ECC development supports this argument. TCC is correlated twice scarcely above the significance level. However, correlation of ECC increased to become strongly significant in Round 2 ($r=0.51$, $p<0.01$). The increase on correlation of Comprehension (rich information about enemy) and coordination is even stronger (Round 1: $r=0.16$, n.s. vs. Round 2 $r=0.57$, $r<0.05$).

A shift from explicit to implicit TMM supported coordination explains the relational changes of communication content and coordination [16, 33]. Teams in Round 1 have to coordinate explicitly, communicating especially TCC and IPA 4 to support coordination. Due to repeated team actions in the beginning, stimulated by exchanged information and explicit coordination, routines and standard operating procedures (SOPs) establish, supported by team specific language development. The development of routines and team specific language as coordinators are described in literature [19, 53]. The players learn which teammate can support in which situation and who can offer which skills and abilities. All this knowledge gets shared within the team and accessible from TMM. Scholars observed such developments in teams [32] and couples [55]. In our teams the impact of TMM in Round 1 is yet limited. Communication still concentrates more on the team itself and less on the enemy. This indicates that our teams are not yet able to establish a high degree of shared awareness. Correlation of ECC and coordination is still pretty low in Round 1. Note, teams do communicate about the enemy. But unlike in Round 2, teammates in Round 1 cannot automatically react and act getting information about an enemy, as crucial routines are not yet established. All actions/ reactions are coordinated explicitly requiring communication time, and cognitive effort for teammates. In our setting communication serves three functions in Round 1. It develops TMM, coordinates explicitly and develops TSA (see Figure 3).

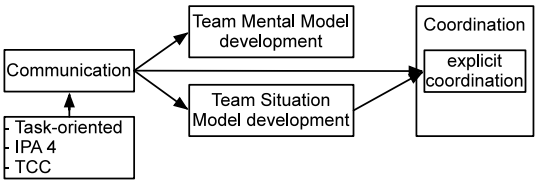

Figure 3: Round 1 explicit coordination

In Round 2, communication content comprising giving analyzes, information and Comprehension is significantly correlated to coordination. Increases of these correlation coefficients point to improved TMM (explaining the reduced impact of IPA 4 with Round 1: $r=0.46$, $p<0.08$ vs. Round 2: $r=0.20$, n.s.) and increasing effort to maintain TSA. The need to exchange situation-based information is continually high as the situation change all time due to enemy actions. ECC in accordance to TMM is able to coordinate team action (Figure 4) implicitly.

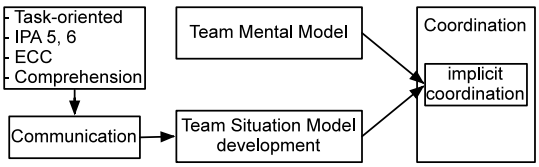

Figure 4: Round 2 implicit coordination

Information coded Comprehension or IPA 5/ 6 serve as stimulus that with TMM routines creates 'obvious' courses of action and coordinates the team [30, 40]. Thus, communication becomes more efficient with TMM development as pre-condition [16]. A communication act as, e.g., 'Enemy at the left side' is able to coordinate team action when the TMM offers SOPs for that situation. That does not necessarily reduce overall communication as Macmillan et al. observe [33].

Literature suggests more communication enables better coordination [18, 41]. We argue situations' dynamics predict communication frequency. Thus, teams in Round 1 communicate to coordinate explicitly, to maintain TMM and to maintain TSA as good as possible. In Round 2 more communication is 'invested' to maintain TSA as TMM reduces communication for explicit coordination. This leads to Figure 4 depicting the coordination model of Round 2.

CORRELATIONS OF COMMUNICATION AND TRUST

Our interviewees stated that trust develops during game play due to communication. One interviewee perceived that some trust in abilities and skills of other teammates is necessary to support planning and coordination.

Communication and team trust are significantly correlated (Table 3; $r=0.56$, $p<0.01$). The interviewees emphasize the cognitive aspect of trust and highlight trust in potency – in skills and competence [31]. This observation is supported by the strong correlation of task-oriented communication and trust ($r=0.54$, $p<0.01$).

Influence of socio-emotional communication on trust is not as strong as anticipated ($r=0.32$, n.s.) although the correlation of positive socio-emotional communication (IPA 1-3) is significant ($r=0.43$, $p<0.05$).

Table 3: Correlations of Communication and Trust

	How strong do you trust your teammates?	
	Coefficient of correlation	Sig. (2-sided)
Total communication	0.56**	.001
Socio-emotional communication	0.32	.08
Task-oriented communication	0.54**	.001
IPA 1-3: positive reactions	0.43*	.013
IPA 4: Gives suggestion, direction	0.58**	.001
IPA 6: Gives orientation, information	0.54**	.002
Team-centric communication (TCC)	0.38*	.033
Enemy-centric communication (ECC)	0.60**	.000
Perception	0.22	.22
Comprehension	0.43*	.013
Projection	0.42*	.016
Action	0.61**	.000
* p<0.05; ** p<0.01		

Surprising is the strong correlation of giving direction (IPA 4) and trust ($r=0.58$, $p<0.01$). Here our study differs from current scholarly literature. E.g. directions and job satisfaction are negatively correlated as directions restrain autonomy [1]. Additionally, a manager basing leadership prior on directions implements a control-based leadership-style detrimental to trust [6, 50]. However, these findings ground on studying dyads of managers and subordinates. In our teams shared leadership evolved as our teams had no designated structure in advance [43]. Leader-like behavior as giving directions occurred according to the needs of situation. When one player was with regard to his perspective or his experiences in gaming able to make suggestions or give directions, he did. Thus, leader-like behavior rotated within the team what Jarvenpaa and Leidner qualify as positive leadership related to high trust levels [25]. Moreover, especially in early game phases the players became more secure in actions of their own and actions of the team when directions instruct them. Teammates can easily assess which task another teammate can handle and how motivated he is when he got instructions to do things. This transparency increases trust.

Trust was assessed in the surveys to be higher in Round 2 (Round 1: Mean=4.46, SD=0.88 vs. Round 2: Mean=5.45, SD=0.85; $F(1,30)=10.44$, $p<0.01$).

Additionally, correlation of total communication and trust increases in Round 2 to be significant (Table 4). More communication increases trust but trust also seems to increase the willingness to communicate [8, 56]. A positive feedback loop increases communication and trust in our teams.

The relation of trust and social-emotional communication surprises. In Round 1 socio-emotional communication strongly correlates to trust ($r=0.7$, $p<0.01$). This relationship is dominated by positive reactions (IPA 1-3: $r=0.83$; $p<0.01$). Negative reactions (IPA 10-12) are neither positively nor negatively correlated to trust. In Round 2 positive reactions are not correlated to trust ($r=0.29$; n.s.). The decline is significant. What does that mean? To trust a team captures two aspects: an affective – feeling safe within the team and a cognitive to feel potency of the team [24, 54]. Safety is created best by positive reactions as agreement and showing acceptance (IPA 3) or by jokes and tension release (IPA 2). Jarvenpaa and Leidner observed this pattern within their virtual teams, too. Social communication and showing

enthusiasm characterized high trust teams in the beginning of the observation [25].

Table 4: Correlations of Communication and Trust comparing Round 1 and Round 2

	How strong do you trust your teammates?		
	Round 1	Round 2	
	$r_{Round\ 1}$ Sig. (2-sided)	$r_{Round\ 2}$ Sig. (2-sided)	p^a ($r_{Round\ 1}$-$r_{Round\ 2}$)
Total communication	0.43 .097	0.59* .016	0.289
Socio-emotional communication	0.70** .003	0.21 .43	0.048*
Task-oriented communication	0.29 .28	0.61* .013	0.148
IPA 1-3: positive reactions	0.83** .000	0.29 .28	0.012*
IPA 4: Gives suggestion, direction	0.51* .044	0.49 .056	0.473
IPA 6: Gives orientation, information	0.31 .25	0.63** .009	0.142
Team-centric communication (TCC)	0.26 .33	0.45 .08	0.289
Enemy-centric communication (ECC)	0.44 .09	0.63** .009	0.246
Perception	0.43 .09	0.22 .41	0.273
Comprehension	0.11 .69	0.51* .045	0.124
Projection	0.39 .14	0.24 .36	0.335
Action	0.49 .053	0.56* .024	0.403

* $p<0.05$; ** $p<0.01$

[a] $r_{Round\ 1}$ and $r_{Round\ 2}$ are transformed into Fisher Z scores. Then computation of $p(z_1-z_2)$

Once, team trust was developed, the influence of positive reactions decreases significantly. Jarvenpaa and Leidner suggest the following behavior: "Successful transition from social to procedural to task focus" [25]. The influence of social communication on trust development decreases over time. The influence of task-related communication increases. We observe a shift in trust development from psychological safety needs to potency needs. With ongoing time players assess their teammates abilities and skills better. Thus, expectations about communication and actions ground on observations of prior team phases and trust in potency establishes. This happens on the basis of task-oriented communication explaining the decrease in influence of positive reactions on trust. This explains the strong increase in correlation of IPA 6 and trust (Round 1: r=0.31, n.s. vs. Round 2: r=0.63, $p<0.01$) and ECC and trust (Round 1: r=0.44, n.s. vs. Round 2: r=0.63, $p<0.01$).

With TMM development, teammates know whose skills and competencies are trustworthy. When TMMs take over functions of implicit coordination it remains crucial to exchange information about the rapidly changing environment to maintain TSA. Players focus much more on ECC. They trust in their teams when information exchanges take place able to maintain their situational picture with ECC, Comprehension and Action become correlated to trust.

Scholars argue that task-oriented communication decreases over time as TMM develops [28, 33]. Kanawattanachai and Yoo argue that one central aspect of task-oriented communication is expertise location within a team. This relationship is crucial only in early team phases [28]. With TMM developed these parts of task-oriented communication enabling expertise location are not longer required, which would justify decreasing communication [33]. However, in environments with a high rate of change communication about situation as Comprehension coded communication remains crucial and its impact increases in relation to TCC. On the base of a feeling of safety within the team, grounded in the exchange of positive communication in the beginning, and the knowledge about who is responsible in the team for what and who can offer which skills, the perceived importance of TCC decreases while the perceived importance of ECC increases explaining high correlations of ECC and trust in Round 2.

DISCUSSION AND LIMITATIONS

Battlefield 2 as platform to research synchronous ad-hoc teams coping with complex tasks in dynamic environments is promising. It allows for observation and communication recording and participants liked it. We observed development in the relation of communication, coordination and trust in very short time. Although team adaptation in other contexts takes longer [28], we argue that due to the narrow context of gaming team development requires less time. The perceptions of our interviewees corroborate development from Round 1 to Round 2 took place. Participants assessed coordination and trust to be significantly higher in Round 2 indicating team development.

We show the relationship between communication content and coordination change significantly. In the beginning correlation of IPA 4 and TCC on coordination was observable pointing to explicit coordination driven by communication. In Round 2 the relation changed. Correlation of coordination and IPA 4 decreased. Analyzes and giving information become significantly correlated to coordination in Round 2. A strong increase in correlation of Comprehension and coordination was observable. Enemy-related communication was important on coordination in Round 2. Teams in Round 2 coordinate implicitly on the basis of TMM developed largely in Round 1. Teams put more effort in TSA development and ECC gets more important in Round 2.

We validate Jarvenpaa and Leidner's observations for trust development. They observed that positive reactions (IPA 1-3) in the beginning of team life predict high trust levels but that its influence decrease over time [25]. We observed the same pattern. In Round 1 correlation of IPA 1-3 and trust was highly significant decreasing significantly in Round 2. Instead of, the correlation of task-oriented communication and trust became significant in Round 2. As Jarvepaa and Leidner stated: "those teams that did not become strongly focused in their communication on the task reported low levels of trust at the end" [25]. Accordingly, trust and communication of commands and direction (IPA 4) is correlated, albeit the influence of IPA 4 communication acts on trust seems to decrease over time. As the teammates become more familiar with team processes lesser directions are necessary for coordination. The team trusts their processes then.

We argue in accordance to Jones and George that trust in the sense of safety fosters teammates' willingness to disseminate information freely among team members [26]. Otherwise, when team members feel insecure whether their input is valued they are less willing to share information [47]. But information sharing is essential to develop trust in the sense of potency. Team members have to assess who can handle which task and who is able to support with which skills. That supports TMM development. That explains high correlations of IPA 6 and Comprehension with trust in Round 2.

Our research reveals how communication content is related to trust and coordination over time. However, some limitations exist. First, our study was exploratory and research was not hypotheses testing. We suggest relations to be further explored and tested. One goal could be to understand trust development in relation to communication content with a clear distinction of safety and potency. Another goal could be to measure TMM development explicitly to understand TMM development in relation to communication content.

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