The role of teamwork on team performance in extreme military environments: an empirical study

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Abstract

Purpose – The purpose of this study is to explore the extent to which teamwork (developed either during an initial training phase or during a subsequent deployment phase) is influenced by the nature of the team's environment (extreme vs non-extreme) and the extent to which teamwork is one of the explaining mechanisms for team performance.

Design/methodology/approach – Data was collected from 60 teams at 2 time-points: training phase in The Netherlands or Germany and deployment phase (in locations such as Afghanistan and Bosnia-Herzegovina).

Findings – This study's results indicate that when teams consider working in extreme environments, they develop higher levels of teamwork as compared to teams expecting to work in non-extreme environments. These differences remain stable also during the deployment phase, such that teams operating in extreme environments will continue to have higher levels of teamwork as compared to teams operating in non-extreme environments.

Originality/value – With this study, the authors contribute to the teamwork quality research stream by empirically studying how teamwork quality develops in unique military contexts such as extreme environments. Studies in such contexts are relatively rare.

Keywords Teamwork, Time, Team performance, Extreme environment, Military teams

Paper type Research paper

Teams operate in a variety of contexts, from stable, predictable environments, to extreme environments. In extreme environments, events occur or are likely to occur such that they exceed an organization's or a team's capacity to prevent them. At the same time, those events may result in impactful or intolerable physical, psychological or material

The authors wish to commemorate the contribution of Ad Vogelaar, who passed away after the field work and primary analyses had been conducted.

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consequences to the organizational members (Hannah *et al.*, 2009). Teams working for disaster responses, military teams in war zones and teams working in polar expeditions are just a few examples of teams that typically deal with extreme environments.

Teamwork has been found to be an important precursor of team performance in studies that have been conducted in relatively stable, regular organizational contexts (LePine *et al.*, 2008). We define teamwork as group member's interactions/interdependent acts that convert inputs to outcomes through cognitive, verbal and behavioral activities that are directed toward the achievement of a common goal (Marks *et al.*, 2001). Teamwork includes both processes (such as backup behaviors and performance monitoring) as well as emergent states (such as trust and shared mental models). However, when it comes to the study of teamwork in extreme environments, empirical evidence is rather scant, partly because of the difficulties associated with studying such teams and the lack of their immediate accessibility (Driskell *et al.*, 2018). One exception is the special issue on teamwork in extreme environments proposed by Maynard *et al.* (2018).

Understanding how teamwork unfolds in teams operating in extreme environments and how teamwork affects team performance in such situations is nevertheless highly relevant. Task achievement of teams in extreme environments is oftentimes connected with the endangering of the team members' lives or the ones of proximal or more distant others. Poor team performance in such contexts can have severe consequences. At the same time, we cannot just assume that teams in extreme environments function just the same as teams in regular environments (Driskell *et al.*, 2017). Understanding the role of teamwork and how it can be enhanced in extreme environments is thus essential.

In this paper, we build on more recent adaptations of the input-mediator-output-input model to the context of extreme environments (Driskell *et al.*, 2017) to explore the role of the environment as an input (extreme vs non-extreme) on the development of teamwork (as a process) and team performance (as an outcome) in a military setting. Military teams are action teams that often perform complex, time-limited tasks in demanding, sometimes life-threatening environments (Chen *et al.*, 2005; Kozlowski and Ilgen, 2006; Rasmussen and Jeppesen, 2006; Salas *et al.*, 2000). This is therefore a relevant setting for the purpose of our study. While following a temporal logic of teamwork (Tuckman, 1965; Marks *et al.*, 2001), we measure teamwork at two different time points (T1, or training phase and T2, during military missions), distinguishing between missions that take place in either extreme situations or in regular, non-threatening circumstances. With our study, we aim to find answers to the following research questions:

RQ1. To what extent teams knowing to be working in the future in extreme environments develop better levels of teamwork as opposed to teams knowing to be working in regular, non-threatening environments?

RQ2. To what extent these initial teamwork differences remain stable also during the military missions in extreme vs non-extreme environments?

RQ3. What is the role of teamwork (T1 and T2) in predicting team performance in extreme environments?

With this study, we aim to bring a couple of contributions to the development of teams and groups research. First, we are aiming to get a better understanding of the effects of extreme environment as an environment-level input factor on teamwork development in an *in vivo* setting. As it has been recently emphasized, "what we don't know regarding teams in extreme environments far exceeds what we do know" (Driskell *et al.*, 2017) and at the same

time we must explore and understand whether teams do behave differently, depending on the type of environment they are operating in.

Second, while looking at teamwork in extreme environments vs non-extreme environments at two different time points we are also contributing to the understanding of teams as dynamic systems. Organizational teams exist over time, having "a past and an expected future that influences their present" (Harrison *et al.*, 2003, p. 634). However, teamwork has oftentimes been studied from a static, cross-sectional perspective (Harrison *et al.*, 2003; Mathieu *et al.*, 2017). Our study comes to contribute to the study of teams as dynamic entities and responds at the same time to more recent calls for studying teams while using a multi-period framework (Humphrey and Aime, 2014; Mathieu *et al.*, 2017).

Theory and hypotheses

Teamwork

In line with Eby *et al.* (1999) and also Marks *et al.* (2001), we define and operationalize teamwork as a global unitary construct that consists of various facets or clusters. These facets are highly interrelated, which creates difficulties in parceling teamwork in separate sub-constructs. Previous studies identified high correlations between these subdimensions (Campion *et al.*, 1993; Campion *et al.*, 1996) and as a consequence they were oftentimes measured and studied as a unitary construct (Janz *et al.*, 1997).

For this study, we include four teamwork facets that have proven to be highly relevant for the coordination and execution of team tasks (Salas *et al.*, 2005) and that exemplify the mutual or reciprocal action or influence among team members in action teams. These facets are mutual performance monitoring, backup behavior, shared mental models and mutual trust.

Mutual performance monitoring is defined as the ability of teams to "keep track of fellow team members' work while carrying out their own to ensure that everything is running as expected and to ensure that they are following procedures correctly" (McIntyre and Salas, 1995, p. 23). Backup behavior represents the extent to which team members provide feedback and coaching to each other, assist each other in performing their tasks and complete tasks for members when overload is detected (Marks *et al.*, 2000). Shared mental models are defined as collective representations of task and team-related knowledge. Team-related knowledge structures contain information on aspects such as what the team should strive for, how the team should function and how team members should behave in certain situations. Task-related knowledge structures contain information such as task procedures or procedures related to the use of tools and equipment (Salas *et al.*, 2005). Mutual trust is "the shared perception that individuals in the team will perform particular actions important to its members and will recognize and protect the rights and interests of all the team members engaged in their joint endeavor" (Salas *et al.*, 2005; p. 568–569).

These four facets are a good representation of the two most important dimensions of teamwork (i.e. processes and emergent states) in a military setting. Mutual performance monitoring and backup behavior represent crucial teamwork processes for coordination and execution of the task whereas shared mental models and trust represent the climate in which such processes can be rightfully enacted. Without trust, team members may regard mutual performance monitoring as spying on each other and reduce information sharing. Without shared mental models, team members would have difficulties to anticipate and predict each other's needs and are therefore less likely to engage in backup behaviors (Salas *et al.*, 2005).

Effects of extreme environments on teamwork over time

Both threat rigidity theory (Staw *et al.*, 1981) and more recent adaptations of input-process-output models of teams in extreme environments (Driskell *et al.*, 2017) discuss the potential

negative effects of extreme environments on teamwork. When confronted with external threat, teams are more likely to narrow their attention to a local focus, to restrict their information processing and ignore relevant pieces of information from the environment (Staw *et al.*, 1981; Driskell *et al.*, 2017). This has been described as a "freeze," non-adaptive reaction with negative consequences on team processes and emergent states. In an experimental study with ad-hoc teams, Kamphuis *et al.* (2011) showed that physical threat leads to a decrease of team discussions, coordination and supporting behavior. When teams are faced with threat, they reduce their focus on the team and narrow their attentional capacity related to social cues (Kamphuis *et al.*, 2011). Although proponents of threat-rigidity theory acknowledge that a shared team history might influence the extent to which this "freezing" reaction emerges (e.g. previous successful episodes might enhance teamwork and reduce the "freezing" effect), no specific claims have been advanced. We build further on threat rigidity theory to empirically test two connected claims.

First, we advance the idea that when teams train to work in extreme environments they will be more likely to develop better levels of teamwork in comparison to teams that train to work in non-extreme environments. When envisioning future threats and its possible consequences for the mission and the team, team members will be more inclined to monitor each other to find out if the team functions well toward its goal. Moreover, they will be more inclined to help each other to make sure team tasks are completed in time and team members are supported when needed. Also, team members will be more inclined to invest in a shared understanding of their taskwork and teamwork and in trusting each other. Together, this will help them better cope psychologically with the anticipation of danger and will make them feel prepared for dealing with the upcoming threat. Given that groups naturally engage in teamwork development, irrespective of their tasks (Tuckman, 1965; Marks *et al.*, 2001), we expect that teams training to work in non-extreme environments will also develop certain levels of teamwork. However, given the lack of urgency imposed by the imminence of threat, we expect the level of teamwork for teams training for non-extreme environments to be less pronounced than in the case of teams training to operate in extreme environments. Thus, teams training for operations in non-extreme environments will set a lower standard for teamwork in comparison to teams training for operations in extreme circumstances:

H1. Teams training for a military mission in an extreme environment will develop higher levels of teamwork than teams training for a military mission in a non-extreme environment.

The second claim that we advance is connected to the evolution of teamwork, when military teams move from the training phase to the operation phase. We argue that teamwork developed during the training phase will be maintained also during the operation phase, irrespective of the environment (either extreme or not extreme). During the military missions taking place in the deployment phase, teams will no longer need to invest time in developing trust relations or a shared understanding of their team. They will enact what they already previously developed and routinized in terms of teamwork. For this reason, "the freeze" effect described by the threat rigidity theory will no longer be present as the teams will be able to focus on the solving of their tasks:

H2. During the deployment phase, teams will maintain the same level of teamwork as the one developed during the training phase such that teams operating in extreme environments will display higher levels of teamwork in comparison with teams operating in non-extreme environments.

Mediating role of teamwork

Teams operating in extreme environments are confronted with events that may endanger team members' lives (e.g. bomb attacks) and may jeopardize their task accomplishment. It has been previously emphasized that team performance in extreme environments receives different connotations given that the situation is assessed as a high-demand one (Driskell *et al.*, 2017). When teams are confronted with such events, they need to be able to timely enact the adequate responses to perform well. Teams operating in non-extreme environments, although not confronted with life-threatening events, also need certain levels of teamwork to adequately complete their tasks. We expect teamwork (both at the training phase and while being deployed) to positively mediate the relation between extreme environments and team performance. When team members have a good common understanding of what needs to be done, when they trust and help each other, they will be more likely to perform well. Previous empirical studies showed that a safe climate reduces threat and anxiety and overall threat rigidity effects (Austin, 1997; Friedman and Lipshitz, 1992; Schein, 1969). In line with this reasoning we posit that teamwork developed during the training phase and teamwork developed during the deployment phase will mediate the negative relation between extreme environments and team performance while being deployed:

H3. Teamwork (both at the training phase and while being deployed) will positively mediate the relation between extreme environments and team performance while being deployed.

Methods

Context of the study

This study was conducted among military teams of the Royal Netherlands Army that were prepared for (T1) and deployed to Afghanistan or Bosnia-Herzegovina (T2) in 2006 or 2007. The training phase included intensive preparation in The Netherlands or Germany. This phase lasted several months and included activities such as training team-level skills and drills necessary for the tasks to be completed during deployment. During the training phase, the teams knew that they were going to be deployed either to an extreme environment context or to a regular, non-threatening context (i.e. in Bosnia that had calmed after the peak of hostilities in 1995). The composition of the teams remained the same in both phases, with some exceptions. Also teams in extreme as well as non-extreme environment received the same training.

Military teams were deployed to Afghanistan (extreme environment for most teams) or Bosnia-Herzegovina (regular, non-war environment for all teams). The troops in Afghanistan aimed to contribute to a safe, stable and democratic nation-state. The teams provided security for the population, trained the police and the Afghan army and combated forces that opposed the legal government. Moreover, the troops contributed to the development of the country by executing several reconstruction projects, such as building schools or repairing the infrastructure. The teams in Afghanistan varied in the tasks they had to perform. A large part of the teams in this study conducted (long range) patrols, escorted provincial reconstruction teams, manned strongholds and outposts and were engaged in combat operations. Most teams in Afghanistan operated under dangerous circumstances, as testified by a number of casualties that occurred during the mission. Besides combat actions, the main threats against the teams were bomb attacks with improvised explosive devices and suicide attacks. Several attacks wounded or killed soldiers and civilians. For the teams in Afghanistan, the deployment lasted four months.

The troops in Bosnia-Herzegovina mainly assisted the government in combating (organized) crime, providing for border control against smuggling and disarming the population. In addition, they monitored the democratic and economic development of the country, and assisted the government with these developments. The teams that participated in this study in Bosnia-Herzegovina operated under relatively safe circumstances. Most teams conducted "policing activities" such as searching houses for illegal weapons, and preventing illegal logging in forests. Other teams provided for logistical support. There were no casualties during this mission period. For the teams in Bosnia-Herzegovina, the deployment lasted six months.

Procedure

Data regarding teamwork and team performance were collected at two time-points. Time 1 data were collected at the end of an extensive training period two to four months before the start of the deployment. Time 2 data were collected two months after the start of the deployment for the troops in Afghanistan and, three months after the start of the deployment for the troops in Bosnia-Herzegovina. Team performance at T2 was used as the dependent variable for our study while team performance at T1 was used as a control variable for two of our models. To avoid common method bias, we used multiple sources for our data collection (Podsakoff *et al.*, 2003). First, we asked the team members to provide information about teamwork. Second, we asked the commanders of the immediate command level above the team (mostly the platoon commanders and their deputies) to provide information on the performance of the teams under their command. Most operations in Afghanistan and Bosnia-Herzegovina were conducted with platoons, without other hierarchical levels present. So, the platoon commander and their deputy were the only parties external to the team to have a reliable, first-hand view on team performance.

At both measurement moments, the units to which the teams belonged were dispersed, with teams training at several training locations (T1) or operating at outposts (T2). Also, at T1 and to a lesser degree at T2, team members were not always available. At T1, a number of soldiers were absent because of the individual training courses they were following in various training centers. At T2, not all team members were able to answer the questionnaires as they could be absent because of sickness or leave for a special occasion or a temporarily re-assignment. These situations account for the different response rates and numbers of teams in the study. Moreover, these situations made the coordination and execution of data collection difficult. Specific personnel belonging to the military units to which the teams belonged were asked to hand out the questionnaires. The questionnaires were collected at times that were most convenient for each unit within a timeframe of about two weeks at both T1 and T2. Because of this procedure, it is not exactly clear how many soldiers were asked to participate in the study.

Sample

At T1, 1,498 respondents participated, and at T2, there were 1,360 respondents. After eliminating the teams with one respondent only and the ones missing identification numbers, the final sample consisted of 301 teams that provided teamwork data at T1 and 258 teams that provided teamwork data at T2. The average team size (of respondents) was 5.8 at T1 (standard deviation [SD] = 4.8) and 3.8 at T2 (SD = 2.4). Performance ratings were available for 86 teams at T1 and 109 teams at T2. When matching the data from T1 and T2 for all variables, the sample size equaled 60 teams that provided information on teamwork and for which performance ratings from platoon commanders were available. To maximize the power of the data gathered, we used all data we had to test various hypotheses. This resulted in different sample sizes for the testing of various hypotheses. Information about the sample sizes can be found in the results tables (Table 3).

Measures

Teamwork was measured with a self-rating scale containing 27 items that was administered to the respondents of this study. Teamwork facets included mutual performance monitoring, backup behavior, shared mental models and trust. The scale was developed by a small team of (military) teamwork experts in line with the definitions of these teamwork facets as provided by Salas *et al.* (2005) and other studies that adapted scales for specific settings (Schaubroeck *et al.*, 2012). See Table 1 for the items and response options. The overall teamwork scale indicates good reliability; Cronbach's alpha at T1 is 0.95 and 0.96 at T2.

Teamwork dimension	Items	Factor loadings T1	Factor loadings T2
Mutual performance monitoring*	We check whether everyone executes his tasks well	0.76	0.87
	We ask for explanation when tasks are not performed well or on time	0.59	0.73
	We monitor the progress of each other's tasks	0.90	0.91
	We give each other directions so that the execution of the task can be improved or adjusted	0.73	0.79
Backup behavior*	We help each other when we notice someone having problems executing his tasks	0.68	0.75
	We help each other when we notice someone having too much workload when executing his tasks	0.81	0.82
	We complete each other's work when necessary	0.92	0.90
	We give each other directions to help someone else when necessary	0.78	0.72
	We take over each other's tasks when necessary	0.86	0.83
Shared mental models**	How our team will perform its tasks	0.76	0.88
	Why we perform our team tasks	0.73	0.80
	What tasks I have to perform when and how	0.83	0.86
	What tasks my team members have to perform when and how	0.89	0.89
	When I have to adjust my tasks to the tasks of my team members	0.87	0.85
	When I have to help my team members with their tasks	0.79	0.79
	When I may expect help from my team members while performing my tasks	0.66	0.62
	How my team members will react in certain situations	0.46	0.52
	What other team members are doing	0.63	0.55
Mutual trust*	We can depend on every team member to execute his tasks with full effort	0.69	0.64
	We can trust each other's skills and knowledge	0.72	0.68
	We accept each other's remarks about our performance	0.83	0.98
	We admit mistakes we make	0.74	0.86
	We accept mistakes other team members make	0.74	0.82
	We appreciate and respect each other	0.79	0.82
	We are open to each other and share information	0.76	0.68
	We can depend on team members not to take unnecessary risks	0.67	0.63
	We are loyal toward each other	0.75	0.74

Notes: The response options for the items were: 1 = never; 2 = sometimes; 3 = regularly; 4 = often; and 5 = always; *All items were preceded by the phrase: "During the execution of the team tasks." ** All items were preceded by the phrase: "During the execution of the team tasks I know exactly." Cronbach's alpha: T1 = 0.95 and T2 = 0.96

Table 1. Teamwork facets and factor loadings

We conducted a factor analysis to check if the items pertain to one overall teamwork factor. Principles axes extraction with oblique rotation was used because we assumed that the measured variables were a linear function of one latent variable (teamwork). Results were similar for both teamwork T1 and T2. Here, we report the results for teamwork at T1; more details about the factor loadings for T1 and T2 can be found in Table 1. In the initial extraction, four factors emerged with eigenvalues higher than 1. However, in line with our conceptualization, the scree plot suggested one general factor explaining the majority of variance. The first factor accounted for 47.6% of the total variance (the other factors explained 9%, 6.5% and 4.4% of the variance). This provides sufficient evidence to use teamwork as an overall construct.

Team performance was measured with a nine-item scale. The questions were developed by a team of (military) teamwork experts in line with previously developed team performance scales (Rousseau and Aubé, 2010). The Cronbach's alpha at T1 is 0.90 and at T2 is 0.91, indicating good reliability. We ran an exploratory factor analysis to check for the unidimensionality of the construct. One factor emerged accounting for 57.3% of the total variance at T1 and 59.1% of the total variance at T2. Factor loadings and items can be found in Table 2.

Table 2.
Factor analysis for team performance

	Items	Factor loadings T1	Factor loadings T2
Team performance	The team performs its tasks effectively	0.74	0.78
	When performing its tasks, the team uses the available means optimally (weapons, communication assets, vehicles, etc.)	0.77	0.80
	When performing its tasks, the team makes optimal use of the circumstances (time, weather, terrain, etc.)	0.75	0.81
	The team shows that it masters the essential skills and drills for task performance	0.74	0.79
	The team is persistent and remains resilient when performing its tasks	0.68	0.77
	The team is disciplined when performing its tasks	0.72	0.75
	The team members optimally use each other's knowledge and skills when performing team tasks	0.78	0.70
	The team members cooperate effectively when performing their tasks	0.80	0.67
	All in all, this team performs well	0.81	0.85

Notes: The response options for the items were: 1 = never; 2 = sometimes; 3 = regularly; 4 = often; and 5 = always. Cronbach's alpha: T1 = 0.90 and T2 = 0.91

Table 3.
Descriptive statistics and correlations

Variables	*N*	Mean	SD	1	2	3	4
1. Teamwork T1	301	3.81	0.46				
2. Teamwork T2	258	3.85	0.48	0.29**			
3. Extreme environment	205	0.68	0.46	0.18**	0.29**		
4. Performance T1	86	4.03	0.51	0.20	0.19	0.14	
5. Performance T2	109	3.93	0.49	0.22**	0.20	−0.17	0.63**

Notes: T1 = time 1; T2 = time 2; $^{**}p < 0.01$

Extreme environment was coded in a dichotomous way (0 = not extreme; 1 = extreme). Commanders of the units to which the teams belonged provided information regarding the teams operating in extreme environments. In general, teams deployed to Afghanistan were assessed as operating in extreme environments if they operated oftentimes outside the forward operating base. This means these teams had to perform their tasks in dangerous and demanding circumstances. The teams were confronted with serious threats to military personnel, such as the risk and the actual occurrence of (suicide) attacks, or attacks by improvised explosive devices, leading to military personnel getting wounded and killed. This is a very salient aspect of extreme environments in military missions (Van den Berg, 2009). Teams that were deployed to Afghanistan, but performed their tasks in the forward operating base (so they were mostly able to work and live under protective circumstances), and teams that were deployed to Bosnia-Herzegovina were assessed to perform their tasks in (relatively) safe environments (i.e. not extreme).

Aggregation to team level constructs

Given that teamwork is a team-level variable and data were gathered from individual team members, an inter-rater agreement index that justifies aggregation is required. We computed an $r_{wG(J)}$ index for teamwork ratings in line with the recommendation given by LeBreton and Senter (2008) and James *et al.* (1984). The values for the $r_{wG(J)}$ index are higher than 0.80 for both T1 and T2. In line with Bliese (2000), we also computed interclass correlation coefficient (ICC) (1) and ICC (2). The average ICC (1) for all items was 0.1 while for ICC (2) was 0.35.Overall these scores suggest that there is agreement among the members within each team and aggregation of scores at a team level is justified (LeBreton and Senter, 2008; James, 1982).

Analyses

To test *H1* and *H2*, we ran two independent samples *t*-test for teamwork at T1 and T2, respectively. In addition, we ran a generalized linear model (GLM) repeated measures analysis with teamwork as a within factor and extreme environment as a between factor. To test *H3*, we ran two mediation models (see Models 1 and 3 in Table 4) while using the nonparametric resampling procedure of bootstrapping developed by Hayes (2012). This method has been proved powerful and valid for testing intervening variable effects (Hayes, 2009; MacKinnon *et al.*, 2004; Williams and MacKinnon, 2008). In Models 2 and 4, we ran the same two mediation models but this time we controlled for previous levels of performance and teamwork.

Results

Descriptive statistics and correlations of the team level measures are displayed in Table 3. Teamwork at T1 is positively correlated with teamwork at T2 ($r = 0.29$, $p < 0.01$), extreme environment variable correlates positively with both teamwork at T1 ($r = 0.18$, $p < 0.01$) and teamwork at T2 ($r = 0.29$, $p < 0.01$) and team performance at T2 correlates with both teamwork at T1 ($r = 0.22$, $p < 0.01$) and team performance at T1 ($r = 0.63$, $p < 0.01$). The results of our test of *H1* indicate that teams knowing to work in extreme environments displayed higher levels of teamwork at T1 (M = 3.91, SD = 0.32) as opposed to teams anticipating to work in non-extreme environments (M = 3.77, SD = 0.41), with $t = 2.35$, $p = 0.03$ and $d = 0.38$. To test *H2*, we first ran an independent sample *t*-test to check whether teamwork differences remain stable at T2. Our results indicate that teams working in extreme environments (M = 3.92, SD = 0.37) at T2 displayed higher levels of teamwork as opposed to teams working in non-extreme environment (M = 3.66, SD = 0.45), with $t = 4.35$,

p = 0.000 and d = 0.63. We also checked the robustness of our results with an additional GLM repeated measures analysis, with teamwork as a within factor (T1 and T2) and extreme environment as a between factor. The within subjects effect of teamwork was not significant with Wilks' λ = 0.99, F(1,164) = 0.64 and p = 0.42. Also there was no significant effect for the interaction between teamwork and extreme environment, with Wilks' λ = 0.99, F(1,164) = 0.66 and p = 0.41. This indicates that teams did not change the level of their teamwork from T1 to T2, irrespective of the environment in which they operated (extreme vs non-extreme). The between effect was significant with F(1, 164) = 12.42 and p = 0.001. This indicates that teamwork differed between extreme and non-extreme environment context such that teams in extreme environment displayed higher levels of teamwork. This is illustrated also in Figure 1.

The results of our mediation analysis (see Models 1 and 3 in Table 4) indicate that extreme environment has a negative effect on team performance T2 (*coeff* = −0.47,

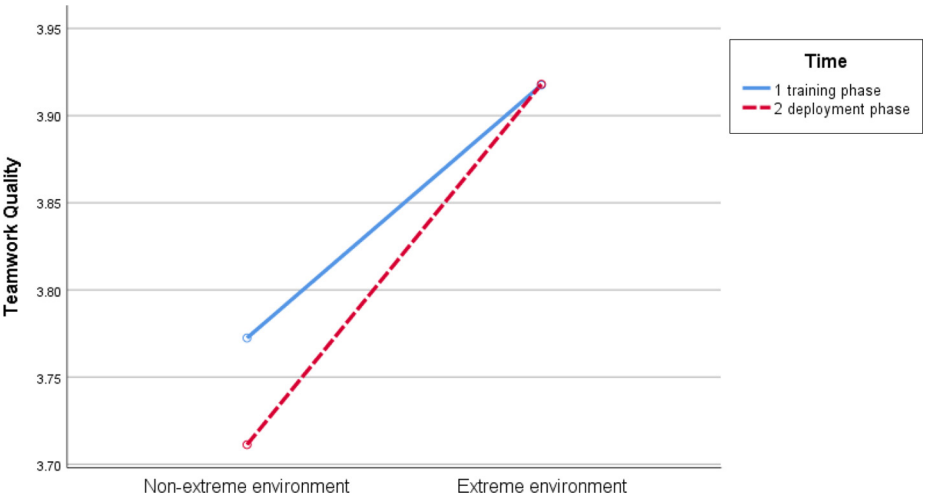

Figure 1.
Teamwork development from training to deployment phase

	Model 1		Model 2		Model 3		Model 4	
	Teamwork T2	Team Perf T2	Teamwork T2	Team Perf T2	Teamwork T1	Team Perf T2	Teamwork T1	Team Perf T2
Control								
Teamwork T1			0.34**	0.41*				
Team Perf T1				0.53**				0.53**
Teamwork T2								0.19
Independent variable								
Extreme environment	0.24*	−0.35*	0.005	−0.58**	0.24*	−0.47**	0.23*	−0.58**
Mediator								
Teamwork T2		0.50**		0.19				
Teamwork T1						0.46**		0.41*
Indirect effect	0.12 CI [0.02; 0.31]		0.009 CI [−0.01; 0.10]		0.11 CI [0.004; 0.32]		0.009 CI [0.003; 0.25]	

Table 4.
Mediation analysis with team performance T2 as an outcome

Notes: For Model 1, N = 84; for Model 3, N = 82; for Models 2 and 4, N = 60; Team perf = team performance; T1 = time 1; T2 = time 2; *p < 0.05; **p < 0.01

$p < 0.001$ for teamwork T1 as a mediator and *coeff* = −0.35, $p < 0.001$ for teamwork T2 as a mediator). Teamwork T1 (*coeff* = 0.46, $p < 0.001$) as well as teamwork T2 (*coeff* = 0.50, $p < 0.001$) have a positive direct effect on team performance T2 and at the same time mediate the relation between extreme environment and team performance T2 [*coeff* = 0.11 CI (0.004; 0.32) for teamwork T1 and 0.12 CI (0.02; 0.31) for teamwork T2]. In Models 2 and 4, we ran the same two mediation models but this time we controlled for previous levels of performance (T1) and teamwork. We wanted to explore the extent to which both teamwork at T1 and teamwork at T2 are equally relevant in predicting team performance at T2. At the same time, we wanted to explore if teamwork has a predictive power beyond and above the predictive power of team performance displayed at T1. Our results indicate that in the case of teamwork T1 as a mediator, when controlling for previous performance (performance T1) and teamwork T2, the results remain unchanged. Extreme environment continues to have a negative effect on team performance (*coeff* = −0.58, $p < 0.001$). Teamwork T1 continues to have a positive effect on performance T2 (*coeff* = 0.41, $p < 0.05$) and to mediate the relation between extreme environment and performance T2 [*coeff* = 0.09, CI (0.003; 0.25)]. In the case of teamwork T2 as a mediator however, the results change. When controlling for the effects of teamwork T1 and performance T1, the effect of teamwork T2 on team performance T2 disappears (*coeff* = 0.19, $p > 0.05$) while the effect of teamwork T1 as a control variable is significant and positive (*coeff* = 0.41, $p < 0.05$). The effect of extreme environment on teamwork T2 is also no longer significant (*coeff* = 0.005, $p > 0.05$), while the effect of extreme environment on team performance T2 remains significant (*coeff* = −0.58, $p < 0.001$). The indirect effect also disappears, *coeff* = 0.009 CI (−0.01; 0.10). This means that the mediation effect of teamwork T2 on team performance is qualified by the effect of teamwork T1, indicating the relevance of previously developed teamwork episodes for later performance.

Discussions

The purpose of our study was to explore the extent to which teamwork (developed either during the training phase or during deployment phase) is influenced by the nature of the team's environment (extreme vs non-extreme) and the extent to which teamwork is one of the explaining mechanisms for team performance. In line with *H1* and *H2*, our results indicate that when teams consider working in extreme environments, they develop higher levels of teamwork as compared to teams expecting to work in non-extreme environments. Furthermore, these differences remain stable also during the deployment phase, such that teams operating in extreme environments will continue to have higher levels of teamwork as compared to teams operating in non-extreme environments. Teamwork reflects a climate of the team where team members trust, help, monitor and coordinate with each other in an effective manner. Development of such a climate can be seen as an adaptation mechanism through which teams attempt to better cope with the idea of confronting dangerous situations in the future. Given that teams have been specifically trained for the situations they would encounter during the training phase, they are able to maintain their level of teamwork also during the deployment phase. With these findings, we contribute to the threat-rigidity theory (Staw *et al.*, 1981) by showing that teams operating in extreme environments do not always experience the "freezing" reaction, described as a decrease in the quality of interpersonal interactions in the presence of threat. In our study, we found evidence that when teams develop their teamwork prior to the extreme environment missions they are more likely to maintain it also during these missions. Thus, having a shared history matters for the maintenance of teamwork.

In *H3*, we advanced the idea that teamwork developed during the training phase, as well as teamwork developed during the deployment phase will mediate the relation between extreme environments and team performance at T2. Our results indicate that extreme environments hamper team performance. This effect has been shown in theoretical treatises and experimental work before. In this study, the effect is replicated in real-life circumstances. However, this negative effect is attenuated by the quality of interpersonal interactions developed within teams. Our results show that teamwork developed early in a team's life (during the training phase in this case) can have long-lasting effects for team performance (during the deployment phase). This effect remains robust even when we control for previous team performance episodes and teamwork displayed during the deployment phase. Not the same can be concluded about the mediation effect of teamwork T2 and thus *H3* is only partially supported. When controlling for previous teamwork and performance episodes, the mediation effect of teamwork T2 disappears. Teams are dynamic systems, where time plays an important role (Marks *et al.*, 2001). McGrath *et al.* (1993) found for example that performance losses generated by virtual interaction disappear after three or four weeks of interaction. If one would measure the impact of virtual interaction on performance after five weeks, he/she would wrongly conclude that there is no effect. Similarly, our study shows that if one would only measure teamwork at T2, he/she would wrongly conclude that this teamwork episode is crucial for performance in extreme environments. This would be a wrong conclusion because the effect disappears if one controls for previous teamwork and performance episodes. Longitudinal research designs are inevitable to determine the dynamics in teamwork and performance. Overall, with this finding we contribute to a better understanding of team performance in extreme environments.

Overall our findings have implications for practice. Managers and trainers working with teams operating in extreme environments should be aware of the crucial role teamwork plays for performance. Early stimulation of teamwork quality is highly important and thus managers and trainers should consider developing specific trainings and teambuilding activities at the very early phases of team development.

Strengths, limitations and directions for future research

One notable strength of our study is the combination between the setting in which this study was conducted and the design used. In this regard, our study has important methodological contributions. Studies in military operational conditions are hard to find, even though there are famous exceptions such as Schaubroeck *et al.* (2012). Collecting data at two different time points, while using multiple sources, further increases the complexities associated with such data collection. As a result, we could not incorporate a very large number of teams with teamwork and team performance ratings at both measurement moments which is a limitation of this study. We embraced this approach, however, because of the limits associated with cross-sectional designs, such as type 1 and 2 errors (Harrison *et al.*, 2003). Although studying teams "in the wild" has a high ecological validity, it comes also with drawbacks. Given that the teams were not randomly assigned to the two conditions (extreme vs non-extreme environment), other intervening variables might explain also the differences found especially for *H1* and *H2*. Future studies could try to replicate these results in a controlled experimental setting. Also, we were only able to collect data at two different timepoints. It would be interesting to explore how teamwork evolves also across a longer period of time. Team research in general lacks empirical evidence concerning the dynamics of team processes and emergent states over time.

Conclusion

All in all our study shows that teams knowing to be working in the future in extreme environments develop higher levels of teamwork in comparison with teams that expect to work in regular environments and at the same time they are able to maintain these levels of teamwork also in later phases. Initial teamwork is the main mechanism through which the negative direct effects of extreme environments on team performance are diminished. These findings have implications for practice. Managers, commanders, instructors and trainers working with teams that prepare themselves to operate in extreme environments should facilitate the development of such teamwork at very early stages of team development. Teamwork may provide teams with the necessary abilities to successfully adapt to threatening situations in the foreseeable future.

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