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Teams in extreme environments: Alterations in team development and teamwork☆

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ABSTRACT

We rely upon teams to perform complex tasks in highly demanding environments, ranging from space exploration to response to earth-bound disasters. In this article, we first briefly review the rich historical legacy of research on teams in extreme settings. Second, we orient our discussion of team performance in extreme environments by focusing on the contextual environment—the high demand, high-stress environment in which these teams operate. We discuss the mechanisms through which extreme demands or stress may impact team behavior, and discuss specific team processes and emergent states that may be impacted by these conditions. Finally, we address challenges in conducting research on extreme teams, and describe implications for application and practice.

It is reasonable to imagine that people have always banded together in small groups under threatening or extreme conditions, not only because there is safety in numbers, but also because the power of the group can help attain desired outcomes. Whereas our prehistoric ancestors may have joined forces in a daily battle for survival, today we compose teams to meet the challenges of modern, high-demand task settings. This may include teams working in space, undersea, and in polar regions, but also teams operating in emergency rooms, in military contexts, and in disaster response, among other settings.

Teams are marshalled to tackle a myriad of tasks in a myriad of contexts. These contexts may range from relatively benign workday settings to the extreme contexts of spaceflight. However, we don't expect teams that perform in these extreme environments to function similarly to those in "normal" settings. That is, teams in extreme environments are under greater pressure stemming from the high-demand conditions under which they operate, and operate in a context in which there are heightened consequences for failure. Certainly, the potential exists that these factors will impact team functioning and performance.

In this article, we examine teamwork in extreme performance settings. We address three primary topics. First, we briefly review the rich historical legacy of research on teams in extreme settings. Second, we discuss the mechanisms through which high-stress task demands may impact behavior, and examine specific team processes and emergent states that may be impacted in extreme performance contexts. Third, we describe implications for further research and for application and practice.

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1. Teams in extreme environments

It is useful to first describe what we mean by the terms "team" and "extreme environments." We define a team as two or more persons who interact in pursuit of a common goal (see Salas, Cooke, & Rosen, 2008). For our purposes, we will use the terms "team" and "group" interchangeably and further note that teams of interest may typically range in size from a dyad (e.g., the early studies of isolated and confined groups by Haythorn and colleagues; Haythorn, Altman, & Myers, 1966) to ten (e.g., the Navy Sea Lab program; Helmreich, 1966) to twenty or more (e.g., groups wintering-over in the Antarctic; Stuster, 1996).

Further, we define the term *extreme environments* as settings in which there are significant task, social, or environmental demands that entail high levels of risk and increased consequences for poor performance. According to Harrison and Connors (1984), extreme (or exotic) environments may be marked by (a) hostile environmental demands, (b) danger and physical risk to self or others, (c) restricted living or working conditions, and (d) social demands that may include isolation from those outside the setting and close confinement with those inside. Bell, Fisher, Brown, and Mann (2016) define extreme environments as (a) task contexts that are atypical in terms of the level of demands (e.g., time pressure) or the type of demands (e.g., confinement, danger), and (b) contexts in which ineffective performance has severe consequences. It is worthwhile to note that our working definition subsumes a large number of diverse types of settings. For example, Stachowski, Kaplan, and Waller (2009) define *crisis situations* as low-probability, high-impact events characterized by time pressure and ambiguity and that have significant consequences for the team (see also Yu, Sengul, & Lester, 2008). Harrison and Connors (1984) describe *exotic environments* as those marked by severe environmental conditions, danger, isolation, and enforced interaction with others. Gardner (2012) describes *performance pressure* as an external force imposed on the team that includes shared outcome accountability, heightened scrutiny of the team's work, and significant consequences for the team's performance; whereas Salas, Driskell, and Hughes (1996) define *stress* as a process by which environmental demands evoke an appraisal process in which perceived demand exceeds resources, and that results in undesirable physiological, psychological, behavioral, or social outcomes. These are all related terms that have been used to describe different types of high-demand task settings.

Moreover, we note that the main commonality among these various terms is that they all refer to a highly demanding performance context. Current research on teams in extreme environments include the study of teams in long-duration spaceflight (Salas, Tannenbaum et al., 2015), mountaineering teams in high-altitude settings (Wickens, Keller, & Shaw, 2015), teams in military settings (Driskell, Burke, Driskell, Salas, & Neuberger, 2014), teams in nuclear plant control rooms (Stachowski et al., 2009), and other teams in various high-demand, high-stress environments (Ellis, 2006; Kamphuis, Gaillard, & Vogelaar, 2011; Pearsall, Ellis, & Stein, 2009). Finally, we note that the task, environmental, and social demands that teams face in extreme settings are matters of *degree*—that is, we view "extreme teams" as those operating under task conditions that may vary on a continuum of very high demand to moderate demand. Thus, our view is that teams operating under demanding conditions may include combat teams as well as project teams.

Landmark research on small groups in isolated and confined environments was initiated in the early 1960's. This research was spurred by a confluence of several historical factors. One factor was the advent of the space program. The Soviet Union launched the first satellite in space, Sputnik 1, in 1957, and the space race was on. In response, the U. S. National Aeronautics and Space Administration (NASA; originally the National Advisory Committee for Aeronautics) was established in 1958, leading to the first solo Mercury missions and eventually to the first space missions involving crews comprised of dyads (Gemini), triads (Apollo), and 5–7 members (Space Shuttle). This, in turn, stimulated research on group performance in space and space-like (analog) settings.

A second factor was the military's interest in submarine habitability and crew performance. In WWII, diesel submarines could stay submerged for a maximum of three days. In contrast, the first nuclear submarines, such as the Nautilus, commissioned in 1954, could stay submerged for months (or, theoretically, until food or consumables ran out). Accordingly, research was initiated to examine social and psychological problems of crew members under prolonged marine submergence (Weybrew, 1963). This work also included research on small groups in underwater habitats such as the Navy's Sea Lab program (Helmreich, 1966).

A third impetus during this time period was the initiation of the 1957 International Geophysical Year program, an international research effort to advance polar research, among other topics. In preparation for this research, the US sent a crew to establish a research base in the Antarctic. One member of the crew experienced a severe psychotic episode and was incapacitated for the duration of the mission (Rasmussen, 1973; Stuster, 1996). Concerned with the stresses inherent in this environment, program managers initiated research to further examine small groups in isolation and, especially, the dynamics of groups that winter-over in Antarctic stations.

These events spurred a large body of research in the 1960s and 1970s on group functioning and performance in extreme environments. This resulted in a rich legacy of research on team performance in high-demand settings such as submarines and other undersea environments (e.g., Beare, Bondi, Biersner, & Naitor, 1981; Radloff & Helmreich, 1968; Weybrew, 1961), the Arctic and Antarctic (e.g., Gunderson & Nelson, 1963; Nelson, 1965; Taylor & McCormick, 1985), military field settings (Berkun, Bialek, Kern, & Yagi, 1962; Driskell & Olmstead, 1989; Torrance, 1954), isolated and confined environments (Altman & Haythorn, 1967; Palinkas, 2003; Smith & Haythorn, 1972), space exploration (Harrison & Connors, 1984; Helmreich, 1983; Kanas, 1998), aviation (Foushee, 1984; Milanovich, Driskell, Stout, & Salas, 1998), and in various laboratory and field simulations (Alluisi, Chiles, Hall, & Hawkes, 1963; Taylor, Wheeler, & Altman, 1968).

This elevated level of research activity inevitably subsided, and in a wide-ranging review of research on groups in high-stress environments published in the mid-1980s, Harrison and Connors (1984) stated that "behavioral research on groups in exotic

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environments has almost ground to a halt" (p. 81). Noting that the requirement for research on groups in extreme settings was likely to become even more salient in the future, they called for a revitalization of research in this area.

Recent research evidence suggests that this call has been met. A current challenge that has spurred current research on teams in extreme environments is the concern with crew performance in long duration spaceflight and the requirements for human exploration of Mars (Salas, Tannenbaum et al., 2015). NASA's planned mission to Mars in the 2030's will involve a crew of 4 to 6 individuals on a 3-year journey in a small, confined habitat. Moreover, the crew is likely to be comprised of males and females as well as crewmembers of various nationalities. They will be undertaking a journey so far that our earth will fade out of view, and even communication with those on earth will be delayed up to 20 min each way. They will have limited personal space and are separated from family and friends. Finally, there is considerable inherent danger associated with such a demanding and hostile environment. It is worthwhile to note that whereas the transit from Earth to the International Space Station is an approximate 6-hour trip for current astronauts; the demands of long duration exploration missions are of a vastly different magnitude (Schmidt, Keeton, Slack, Leveton, & Shea, 2009).

Considerable research is underway within realistic analog environments to meet this challenge. NASA's Human Exploration Research Analog (HERA) and the underwater NASA Extreme Environment Mission Operations (NEEMO) habitat are both analog settings that allow researchers to examine the effects of high-demand conditions on crew performance and to evaluate countermeasures to overcome these effects (Vessey, Palinkas, & Leveton, 2013). Related research is underway to examine unobtrusive approaches to assess cognitive and emotional state of crew members (Driskell et al., 2014), to examine team resilience under pressure (Alliger, Cerasoli, Tannenbaum, & Vessey, 2015), to examine the effect of high demand conditions on the structure and stability of team roles (Burke, Driskell, Driskell, & Salas, 2016), and to examine the impact of long-duration spaceflight on interpersonal tension and cohesion (Kozlowski, DeShon, Biswas, & Chang, 2012).

2. Stress effects

We believe that one overarching construct that defines extreme task environments is that of *stress* or demand. The term *stress* comes from the Latin *stringere*, to draw tight (or to strain). Therefore, from the early Latin, we have a strong hint of what stress means – it taxes, it strains, and it restricts. Accordingly, we can define stress at a broad level as a high demand, high threat situation that disrupts performance (Driskell, Salas & Johnston, 2006). Similarly, team stress has been defined as the "relationship between the team and its environment, including other team members, that is appraised as taxing or exceeding their resources and/or endangering their well-being" (Weaver, Bowers, & Salas, 2001, p. 86).

Stressors are those task, environmental, and social factors that impinge on performance, such as threat, time pressure, task load, noise, crowding, performance pressure, and ambiguity (see Driskell & Salas, 1996). Thus, in a conceptual sense, we view *stress* in transactional terms as a process, *stressors* as the contextual demands salient in a specific task context, and *stress effects* as the resulting impact on individual and team functioning and performance (termed *strain* by some researchers). However, it is unclear precisely how stressors impact performance. That is, what are the primary means by which stressors affect individual and team performance? For example, Poulton (1978) has argued that the detrimental effects of noise on performance are primarily the result of distraction. Others have argued that the detrimental effects of noise on performance are primarily the result of increased task load. In fact, noise can have either effect: Noise that is relevant to the task (i.e., sound that has a bearing on the task) can place an increased task load on the operator, whereas noise that is irrelevant to the task (that carries no task-related information) can serve primarily as a distraction (Driskell & Salas, 1996).

Driskell, Driskell and Salas (2015) have proposed that there are a limited number of cognitive, emotional, and social mechanisms through which stress impacts performance. The "Big Five" stress mechanisms include the following:

2.1. Stress increases distraction and decreases attentional focus

Seminal research conducted by Combs and Taylor (1952) and Easterbrook (1959) first established the finding that as stress or arousal increases, the individual's breadth of attention narrows. That is, stress or arousal can produce tunnel vision. Eminent pragmatist and father of American psychology, William James, was likely the first to suggest this effect. In his book, Principles of Psychology, James (1890) proposed the belief that an individual's field of view varies from a broader perspective under normal conditions to a more narrow, restricted focus under stress. Thus, during complex task conditions, a restriction in attentional focus is likely to result in an inability to attend to all relevant task information, and consequently, performance may suffer. The narrowing of attention has been explained through the lens of perceptual tunneling (Easterbrook, 1959), a reduction in working memory capacity (Huey & Wickens, 1993), and increased performance rigidity (Staw, Sandelands, & Dutton, 1981).

2.2. Stress increases cognitive load and demand on capacity

Task load is defined as performing two or more tasks concurrently. This construct is related to a number of other terms, including multi-tasking, dual-task performance, and workload. Typically, the term workload refers to the individual's perception of the work demands imposed by a task environment, although the term has also been used to describe the demands of the task environment itself in terms of the volume and pace of the work to be performed (see Spector & Jex, 1998). Drawing from theories of information processing, stress can impact performance due to an increase in cognitive load and demand on individual and team cognitive capacity. The increase in cognitive load is a result of an increase in task load caused, for instance, by

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multitasking or dual-task performance and/or an increase in workload associated with task performance and the stress appraisal process. That is, high stress environments often require individuals and teams to perform multiple tasks simultaneously, switch back-and-forth between multiple tasks, and attend to novel or unfamiliar stimuli. Each of these characteristics of a high stress environment may serve to impair performance by increasing the demands on limited cognitive capacity (Oswald, Hambrick, & Jones, 2007). Moreover, individuals and teams undergo an appraisal process when under stress (Salas et al., 1996; Weaver et al., 2001, p. 86). This appraisal process itself also places a demand on limited cognitive capacity, thus potentially impairing performance.

2.3. Stress increases negative emotions and frustration

Negative affective reactions to stress may include subjective feelings of anger, annoyance, tension, and frustration. Research indicates that effective performance under stress requires that individuals maintain self- and emotional- control while remaining focused on the task at hand (Driskell, Johnston & Salas, 2001; Singer, Cauraugh, Murphey, Chen, & Lidor, 1991). Because stress can increase negative emotions, negative emotional states such as sadness, melancholy, anger, and frustration may become more prevalent and performance can suffer. Moreover, emotional stability has been suggested to be a significant factor in any task that requires cooperative behavior (Driskell, Hogan, & Salas, 1987; Mount, Barrick, & Stewart, 1998). Moreover, Pfaff and McNeese (2010) reported that one way in which time pressure diminishes team task performance is by generating negative affect among team members.

2.4. Stress increases fear and anxiety

Performance in high-demand situations may result in an increase in fear and anxiety, and increased physiological reactivity such as increased heart rate, sweating, or shaking. Anxiety may be viewed as a specific type of negative emotion, but one that incorporates several specific dimensions, including cognitive anxiety (negative expectations and concerns about oneself) and somatic anxiety (perceptions related to physiological arousal of unease or worry) (Mellalieu, Hanton, & Fletcher, 2006).

2.5. Stress increases social impairment

Social effects of stress may include a reduction in the tendency to assist others, increased interpersonal aggression, neglect of social or interpersonal cues, and less cooperative behavior among team members. The very presence of others can be arousal inducing (Mullen, Bryant, & Driskell, 1997). Research further indicates that, under stress, people tend to be less likely to help others, transfer information more poorly, and have greater difficulty coordinating with other team members (Driskell, Salas, & Johnston, 1999).

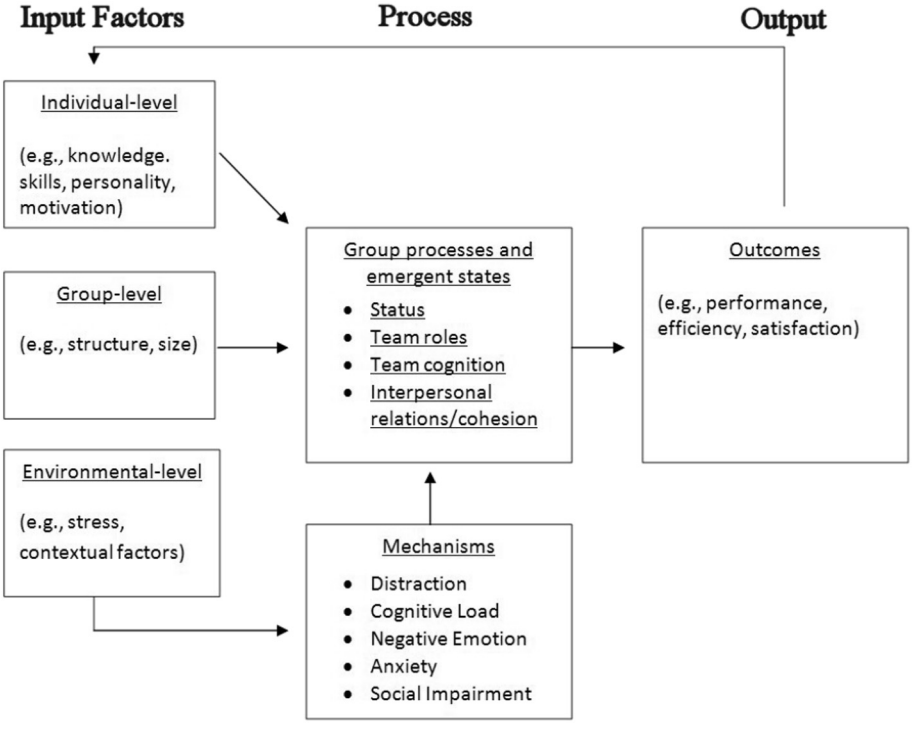

Fig. 1. An organizing framework for examining teams in extreme environments.

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In summary, stress can be distracting, it can impose an additional task load on the task performer, it increases negative emotional reactions of anger or frustration, it can increase subjective feelings of anxiety and worry, and it can disrupt coordination with others. Moreover, in examining group performance under extreme stress, we wish to broadly bear in mind how the combined effects of distraction, task load, negative emotion, anxiety and social impairment can impact group processes.

3. Team processes and emergent states

We believe that the contextual demands in extreme team environments and the impact of these demands on core psychological mechanisms can affect basic team processes and emergent states. For example, Tuckman's (1965) model of group development submits that groups move through five stages: forming (groups assemble and members become oriented with one another), storming (conflict arises among the group), norming (conflict is resolved through the development of group norms and roles), performing (team members perform as a unit to accomplish an objective), and adjourning (the group disassembles). It is likely that in high-demand task environments, the storming stage may be more salient, be sustained longer, and potentially create more interpersonal conflict than in normal task settings. Further, we may expect that team cohesion, an attitudinal emergent state, may be more difficult to establish and maintain in this type of environment. Moreover, given that extreme teams operate under conditions in which the consequences for poor performance are severe, the failure to understand these potential difficulties can exact a very high price.

In the following sections, we will discuss several aspect of team interaction that may be compromised in extreme settings. Our approach is summarized in Fig. 1, which serves as an organizing framework for examining teams in extreme environments. Fig. 1 is a recursive input-process-output (IPO) model (see McGrath, 1964 and more recent iterations of this basic model in Ilgen, Hollenbeck, Johnson, & Jundt, 2005). Input variables are described in three categories: individual-level factors, group-level factors, and environmental-level factors. Given our interest in teams in extreme environments, our primary focus in Fig. 1 is on the environmental or contextual factors (the lower left-hand box) that impinge on team interaction. We propose that high-demand or stress conditions operate through five primary psychological mechanisms to impact team performance outcomes, and they do this through their impact on team processes and emergent states. We will discuss four processes or emergent states that may be affected, including *status, team roles, team cognition*, and *interpersonal relations or cohesion*. Furthermore, as shown in the uppermost arrow in Fig. 1, detrimental effects on team outcome such as performance and satisfaction can in turn impact factors such as *team member motivation*, which will also be discussed as one potential problem in extreme team environments.

3.1. Status

Status differentials among team members are one of the most readily observed processes in groups. More communications are both initiated and received by high-status team members relative to low-status team members (Driskell, Olmstead, & Salas, 1993). The content of messages directed towards high-status members tends to be more positive than those directed downward in the status hierarchy (Berger & Webster, 2006). In addition, it is more likely that a high status person will be influential in group decisions because high status persons are more likely to have their ideas accepted and are more likely to reject influence from others (Berger, Rosenholtz, & Zelditch, 1980). In brief, some group members attain a superordinate position in terms of power and prestige; they talk more, have their ideas more readily accepted by others, and are viewed as more influential and competent. Thus, some group members enact a more proactive role and command more of the group's resources, whereas other group members are generally more compliant and react in a more subordinate manner (see Berger, Wagner, & Webster, 2014; Berger & Webster, 2006; Driskell & Mullen, 1990; Milanovich et al., 1998).

Research reveals that status gradients quickly emerge in initially unstructured task groups. In status-equal teams (in which team members are similar in terms of age, gender, rank, or position), a status hierarchy develops over time based on the contributions that team members make during team interaction. That is, those who provide evidence during interaction of greater competence are awarded higher status in the group. In status-unequal teams (in which, for example, one person may be assigned as team leader), a status structure develops very quickly at the onset of interaction, based on the observable status characteristics (e.g., position, race, gender) that differentiate team members (Berger & Webster, 2006).

The status process is viewed as a cooperative process within groups, in which status and influence is allocated based upon expectations for positive performance (the cooperative nature of status processes differentiate this construct from that of *power*, which may be coercive). In other words, it is in each group member's self-interest, in order to accomplish the task, to defer to others based on the other's expected task contributions. Therefore, deference is exchanged by some members of the group for the perceived superior task contributions of others. These perceptions or expectations of task competence are formed on the basis of group members' observable status characteristics, documented skills and competencies, and actual behavior in the task situation (see Walker, Doerer, & Webster, 2014).

Some researchers have claimed that a hierarchical status structure (with clear lines of authority and centralized communication) is potentially more advantageous for tasks that are highly structured, simple, and routine, whereas a relatively flat status hierarchy with more open and decentralized interaction is preferable for tasks that are ambiguous, uncertain, and complex (Ridgeway, 1983; Worchel & Shackelford, 1991). However, there are some suggestions that, under stress, a group's status structure may tend to become *more* centralized and hierarchical. For example, Foushee and Helmreich (1988) have noted that subordinate flight crew members are more hesitant to speak up to the captain under emergency conditions, sometimes deferring to the extent of not offering valuable task information. One explanation for this phenomenon is derived from the organizational

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literature, and holds that organizations respond to stress by a centralization of authority, whereby control and authority for decision-making is concentrated in higher levels of the organizational hierarchy such that decisions of high-status members in the organization may prevail more readily (Staw et al., 1981; Hermann, 1963).

In a direct test of this proposition, Driskell and Salas (1991) examined pairs of Naval personnel of differing rank performing a decision making task under normal conditions and under high stress. The results revealed the expected main effect of status—high status group members were more influential in decision making and more likely to reject the task inputs of a lower status partner, and low status group members were less influential and more likely to accept the task inputs of a higher status partner. Second, they found that, under stress conditions, both higher status and lower status group members became more open or receptive to their partner's task inputs. In other words, under stress, lower status group members became even more deferential, but higher status group members became more open. In a more recent test of these hypotheses by Kamphuis et al. (2011), however, results were contradictory. Kamphius et al. concluded that in problem-solving teams under stress, leaders exerted more control over decision making; however this finding was based on team member perceptions of leader behavior rather than actual behavior.

Status relations within the group are also of substantial importance when considering how a team coordinates its task activities. The extent to which the group's status structure corresponds to the actual task-related abilities of the members is a key aspect of the group's ability to coordinate its different members efficiently. For example, task groups reach higher quality decisions in a shorter time if the most skilled people occupy the high-status positions. To the extent that status processes operate to place those who are more likely to have the correct answer in an advantaged position in the group, an appropriate status structure should support effective performance. Moreover, it is important that team members accept the prevailing status structure as fair. If team members perceive status differences as being unfair, or feel that the wrong (i.e., incompetent) people are in positions of influence, energies may shift from the task to arguing about those status differences, with the potential that team members may become alienated and withdraw from the group effort (Ridgeway, 1983). Finally, high-demand task environments are often characterized by considerable task variability, in which the team must adapt to different task contingencies and requirements. This demands flexibility in the team's status structure, such that one team member may take the lead for some tasks and another team member for other tasks.

What can we surmise from this very brief exposition? In ad hoc teams that are formed with little history or experience of working together, there is an initial period of instability as team members attempt to work out who should be more influential in solving the team's task. Over time, interaction becomes more patterned based on the quality of the contributions that team members make. In established teams that have a history of working together, the status structure emerges immediately based on prior history and interaction and tends to remain stable. However, it is subject to change if those in positions of authority fail to perform adequately.

Finally, research suggests that under stress, the status structure becomes a bit flatter, in that high status team members become more responsive to task inputs from other group members, which we view as a generally positive outcome. On the other hand, the status structure becomes more hierarchical from the perspective of low status team members, in that they become more reliant on the high status team members to make decisions. This may lead to increased cognitive or attentional load for high status team members.

3.1.1. Implications for research

One problem that has been identified in existing research is the flexibility and adaptability required in extreme task environments. Smith-Jentsch et al. (2015) note that teams must be able to switch or interchange positions of leader and follower in the team as requirements demand, which may result in status conflict. Bendersky and Hays (2012) differentiated between several different types of conflict in groups: (a) task conflict, or disagreements over opinions or ideas related to the task, (b) relationship conflict, or interpersonal disagreements, (c) process conflict, or disagreements over how to get work done, and (d) status conflict, or disagreements over one's relative status or prominence in the group. Although shifting leader and follower positions in the team may be beneficial so that those with specific expertise can “lead” on specific tasks, it may also result in ambiguity in “Who's in charge of what?” and resulting tension and animosity. Smith-Jentsch et al. (2015) suggest that training all team members to be leaders and followers may proactively prevent these problems, although further research is needed to test these proposals.

In mixed-gender, multi-national teams, the operation of status processes may lead to unexpected and undesired consequences. For example, status processes operate to organize interaction in groups such that higher-status team members are generally more active and influential and lower status team members are less active and less-influential. Yet, there are cultural differences in status. For example, Weisfeld (1993) has noted that Arab cultures draw more pronounced status distinctions based on race and gender than do Western countries. This may lead to status incongruencies in interactions with those from other cultures, reflecting the conflict between the behaviors a female team member may exhibit in a given task interaction and the behaviors that those in other cultures may expect her to exhibit. However, we know very little about the effects of culture and status on team task performance.

3.2. Team role performance

Roles are important in teams because they represent patterns of behavior that are interrelated with the activities of other team members in pursuit of the overall team goal. Stewart, Fulmer, and Barrick (2005) define a role as a set of behaviors that are repetitive activities characteristic of a person in a particular setting. Roles have also been defined as institutionalized sets of

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expectations, relationships, and behaviors that ensure stable and predictable social interactions (Stryker & Statham, 1985). However, roles are not simply static sets of expectations and behaviors, but instead they change and adapt in response to role demands. In fact, two overarching goals of research on roles within teams are to account for both role stability and role change.

Although Stewart et al. (2005) state that "A universally accepted taxonomy of team member roles does not exist" (p. 346), this is not necessarily the case. Whereas there is no one way of characterizing team roles that is used to the exclusion of others, there are a number of different types of role taxonomies. Some are simple—for example, Bales (see Bales, 1950; Bales & Slater, 1955) suggested a two-factor model distinguishing roles as primarily task-oriented or primarily socio-emotionally oriented. Others have elaborated more complex team role taxonomies, describing distinct roles such as leader, initiator, coordinator, and harmonizer (see Benne & Sheats, 1948; Burke et al., 2016; Driskell, Driskell, Burke, & Salas, 2017; Mathieu, Tannenbaum, Kukenberger, Donsbach, & Alliger, 2015; Mumford, Campion, & Morgeson, 2006).

A long-established literature on role change in disasters or emergency conditions exists that is relevant to role performance in extreme environments (see Dynes, 1986; Dynes & Quarantelli, 1968; McMichael, Beverly, Noon, Patterson, & Webb, 1999). This body of research has posed some important questions: Do traditional roles carry over into emergency situations? How do they change? Do some roles become more relevant and some less relevant? What types of role improvisions occur in high-demand situations? How are new roles integrated into the group? (see Dynes, 1986; Webb, 2004).

McMichael et al. (1999) argue that roles enable stable and predictable group interactions, yet under high-stress or crisis conditions, flexibility is required to meet individual needs and situational demands. They further note that, under such conditions, there is a period of "role moratorium" that constitutes a period of role simplification, such that the most task- or situationally-relevant roles become emphasized and less relevant roles become eliminated or suspended. In attempting to classify the types of role improvisations that occur, they identified several general types of role improvisations under high-demand. *Procedural changes* refer to alterations in the way a role is typically performed or deviations from standard procedures. *Status changes* refer to changes to the scope of a role incumbent's behavior, such a broadening or extending a role to fill perceived gaps. *Normative-order changes* reflect role alterations in which behaviors are enacted that would be viewed as a norm-violation in normal circumstances (e.g., suspending a valued activity). These types of improvisations are viewed as "necessary and functional alterations to the social structure undertaken to meet the demands of extreme situations" (p. 17). On the other hand, as Ellis and Pearsall (2011) note, this may result in confusion in team members' roles and responsibilities. Indeed, Harrison and Connors (1984) cite an instance reported by Leonov and Lebedev (1975) in which two members of a polar expedition team refused to help put out a fire because it "wasn't part of their job."

Given that, under stress, some roles may become more relevant and some discarded, this may lead to other problems. For example, Dynes (1986) notes that, in emergencies, you may have more people trying to assume relevant roles than there are relevant roles to fill. This may lead to greater role conflict and role ambiguity. Moreover, in an examination of crew performance at the Amundsen-Scott South Pole Station, Johnson, Boster, and Palinkas (2003) noted that *role collision* may occur in which two different individuals in a group attempt to perform roles which overlap in some respects. They observed that this was evident in the winter-over crews they studied when multiple members attempted to fill an instrumental leadership role.

Furthermore, to the extent that roles that are most relevant to the immediate task situation are emphasized under extreme stress conditions, this may lead to an under-emphasis on fulfilling social or group maintenance role activities in the team. Interestingly, Johnson et al. (2003) note that unlike more instrumental or task roles in which the effects of role collision can be detrimental, multiple team members enacting social or group maintenance roles may ensure that group maintenance functions are fulfilled to counter the demands of the stress environment.

Finally, Summers, Humphrey, and Ferris (2012) note that disruptive events in teams stimulate change or transition, and refer to Gersick's (1988, 1989) notion that teams may experience dramatic restructuring in this period of instability. Summers et al. extended this viewpoint to examine change in strategically core roles (those roles that address more team problems, have greater exposure to the team tasks, and are more central to the team work flow) versus less strategically core roles (see also Humphrey, Morgeson, & Mannor, 2009). Results indicated that changes in strategic core roles were more disruptive to team coordination and performance.

In summary, research documents the value of a stable role structure in the division of labor and enhancing predictability in team interaction (Hackman & Morris, 1975; Stachowski et al., 2009; Worchel & Shackelford, 1991). On the other hand, in periods of high stress or high demand, in which a shifting or ambiguous task situation requires greater flexibility, a rigid role structure can constrain and confine team interaction (Stachowski et al., 2009). However, these adaptive role adjustments can also lead to less role clarity and greater role confusion.

3.2.1. Implications for research

Burke et al. (2016) have identified several key research questions related to role performance in extreme team environments. What are the key team member roles that are critical to effective team performance in extreme environments (relative to a normal task setting)? Are there certain "types" of people who fulfill specific roles more readily, such that they experience greater psychological adaptation, less conflict, and more effective performance within that role? For example, is there an optimum fit between team member personality and role requirements (Stewart et al., 2005)? How do roles change or shift in response to internal or external demands, and what contextual features of the environment trigger these shifts? How do team role requirements change over time or over the course of a task?

Because of the dynamic nature of performance in extreme task settings, Smith-Jentsch et al. (2015) have emphasized the importance of maintaining shared role expectations among team members, such that there is agreement regarding who is

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responsible for specific tasks and how they should be performed. Training designed to assist team members to identify discrepancies in role expectations and to negotiate a shared understanding may be valuable. Cross-training, which allows team members to gain familiarity with other team members' tasks and role responsibilities, may also be a useful training approach to maintain shared role knowledge and expectations (Cannon-Bowers, Salas, Blickensderfer, & Bowers, 1998; Marks, Sabella, Burke, & Zaccaro, 2002).

Team conflict may stem from misunderstandings or disagreements about role responsibilities (especially role activities that are less desirable, such as clean-up duty). In a meta-analysis of intragroup conflict, De Wit, Greer, and Jehn (2012) found stable negative relationships between process (i.e, role) conflict and group outcomes such as cohesion, commitment, and performance. Training on conflict management may be a useful approach to counter these effects, and Marks, Mathieu, and Zaccaro (2001) describe both preemptive conflict management approaches (to address conflict before it occurs) and reactive approaches (to resolve conflicts) to minimize conflict.

3.3. Team cognition

Team cognition – described as the emergent combination of team members' cognitive states (e.g., knowledge, understanding, awareness) regarding issues of the team and its task – is a driving force of team performance (Salas & Fiore, 2004). For example, cognitive emergent states (e.g., shared mental models) have been argued to be a primary mechanism which allows teams to coordinate their actions in an adaptive manner (Entin & Serfaty, 1999; Rico, Sanchez-Manazares, Gil, & Gibson, 2008). Team cognition, by its very definition, is dynamic and evolving in nature. For example, transactive memory, a cognitive emergent state, is a property of a group that describes the group as a single information processing system responsible for encoding, storing, and retrieving information (Hollingshead, 1998; Wegner, 1987). At a broad level, transactive memory includes a combination of team member knowledge and awareness of who has what knowledge (Austin, 2003). As one would expect, this knowledge develops across a team's lifespan and may become more fine-tuned and comprehensive across time (Lewis & Herndon, 2011). That is, teammates may develop a better understanding of who has what knowledge, in addition to developing a larger knowledge repository. However, as is the case with most fine-tuned machines, there are obstacles that can disrupt or derail the development of team cognition.

As noted throughout this paper, teams performing in extreme environments are exposed to a myriad of stressors that can serve to negatively impact team performance. In respect to team cognition, stress has been shown to disrupt the development of team cognition in several ways. First, stress research has demonstrated that acute stress leads to a loss in team perspective (Driskell et al., 1999). That is, stress has been shown to result in a shift to an individual-focus to the detriment of the team. As Pfaff and McNeese (2010) have noted, “high levels of stress and negative moods both appear to narrow attention to a local focus (that is, not seeing the big picture), [and] diminish attentiveness to team processes” (p. 329). As a consequence, team members may tend to communicate less under stress. Subsequently, team cognition can be adversely impacted because communication among team members is an integral factor in the development of cognitive emergent states (e.g., shared mental models, transactive memory systems, and shared situational awareness). Using transactive memory as an example, we would expect its development (e.g., as a knowledge repository) to progress more slowly under extreme conditions.

Ellis (2006) has demonstrated that stress can directly impact transactive memory, as well as shared mental models. Related to transactive memory, shared mental models are “knowledge structures held by members of a team that enable them to form accurate explanations and expectations for the task, and, in turn, to coordinate their actions and adapt their behavior to demands of the task and other team members”(Cannon-Bowers, Salas, & Converse, 1993, p. 229). Research on shared mental models identifies two primary dimensions: taskwork mental models and teamwork mental models. Teamwork mental models is the primary focus of most team research and describes the shared understanding of team interaction processes and knowledge about team members, (e.g., preferences, team member roles; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). Adopting an information-processing theoretical perspective, Ellis (2006) examined the mediational role of team cognition on stress and performance. This research substantiated the finding that stress negatively impacts team performance and further demonstrated that this effect was moderated by transactive memory and teamwork mental models. That is, stress disrupted team interaction mental models and transactive memory, and this disruption accounted for the observed decrement in team performance. In a more recent study, Ellis and Pearsall (2011) examined the effects of stress on teamwork mental models, information allocation, and tension. Their results indicated that an increase in job demands reduced mental model accuracy and information allocation and increased tension among team members. Moreover, they found that when job demands were high, teams that received a cross-training intervention evidenced higher mental model accuracy, more information allocation, and less tension than teams that were not cross-trained.

Recent research has examined the effects of team role stress on team learning and performance (Savelsbergh, Gevers, van der Heijden, & Poell, 2012). Team learning has been described as the group-level “acquisition of knowledge, skills, and performance capabilities of an interdependent set of individuals through interaction and experience” (Kozlowski & Ilgen, 2006, p. 86) and has been conceptualized as a process related to team cognitive emergent states such as transactive memory and shared mental models (Edmondson, 1999). Savelsbergh et al. (2012) define team role stress as a “composite construct consisting of team role ambiguity, team role conflict, and team role overload” (p. 5). Team role stress is a type of stressor that was hypothesized to negatively effect team performance by inhibiting team learning behaviors. The mediational role of team learning behaviors was demonstrated in this study. That is, the researchers found that team role stress indirectly impacted performance by inhibiting team learning behaviors.

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It is clear that team cognition is an important factor effecting team performance. More fine-tuned, comprehensive, and high-quality team cognitive structures lead to better team performance. In extreme environments, characterized by stressful conditions, team cognition may progress more slowly for the reason that research has demonstrated the adverse effects of stress on team cognition (e.g., transactive memory, teamwork mental models, team learning).

3.3.1. Implications for research

We emphasize again that team performance in extreme environments is a dynamic process. In response to novel, unanticipated, or demanding events, teams may have to switch from one type of work structure to another, switch between tasks, switch between sub-teams, or switch from an interdependent task to an independent individual task and back again (Landon, Vessey, & Barrett, 2016). Entrainment in a single type of strategy or procedure can be detrimental and, instead, adaptability and flexibility are required. However, changes in tasks, in task procedures, and task expectations can lead to decrements in shared cognition, breakdowns in coordination, and less accuracy in information exchange within the team (Smith-Jentsch et al., 2015).

According to Salas, Sims, and Burke (2005), adaptability is viewed as the capacity to adjust strategies and activities in response changing conditions, and the requirement for adaptability is driven by the complexity within which many teams operate. Zaccaro, Gilbert, Thor, and Mumford (1992) similarly defined behavioral flexibility as "the ability and willingness to respond in significantly different ways to correspondingly different situational requirements" (p. 322). Further research is needed to examine the efficacy of adaptability training to both allow team members to identify breakdowns in coordination and shared cognition as well as to support the maintenance of shared mental models, transactive memory systems, and shared situational awareness in rapidly changing environments.

3.4. Interpersonal relations and cohesiveness

Socioemotional or interpersonal friction is one of the most noted problems in extreme team environments. Admiral Byrd's description of crew relations in an Antarctic base is most telling:

> *The time comes that one has nothing left to reveal to the other; when even his unformed thoughts can be anticipated, his pet ideas become a meaningless drool, and the way he blows out a pressure lamp or drops his boots on the floor or eats his food becomes a rasping annoyance…You are hemmed in on every side by…the crowding pressures of your associates* (Byrd, 1938, p. 16–17)

Stuster (1996) has noted that even trivial issues can be exaggerated by people working in extreme environments over time and lead to group impairment. He stated that "Minor annoyances, differences of opinion, or perceived transgressions that would be inconsequential under normal conditions can be magnified by isolated and confined personnel into issues of monumental importance. Evidence of this phenomenon was found in nearly all of the expeditions that I have reviewed" (p. 308). Kanas and Manzey (2008) concur that "interpersonal irritants and problems that can be ignored for short durations become magnified and difficult to deal with during longer periods of time" (p. 89). Smith (1969) concluded that "pronounced irritability, hostility, and personality conflicts are reported throughout the literature" (p. 377).

Both empirical research and anecdotal evidence back this claim. Ellis and Pearsall (2011) found that high task demands led to increased tension among members of problem-solving teams. Pfaff and McNeese (2010) observed that teams performing under increased stress (time pressure) reported greater negative affect and anxiety. In a review of the psychological and social problems that may be associated with future space missions, Connors, Harrison, and Akins (1985) cited social tensions such as touchiness, social irritability, and interpersonal friction (see also Haythorn et al., 1966; Taylor et al., 1968). In discussing potential difficulties in long-duration space missions, Orasanu, Fischer, Tada, and Kraft (2004) conclude that interpersonal tensions are one of the most problematic issues.

Further research suggests that, although high stress may lead to increased negative emotion, team members often attempt to suppress the overt expression of hostility (Connors et al., 1985; Smith, 1969). This may serve to contain conflict, but may lead to social withdrawal and greater territorial behavior and concern with privacy, termed "cocooning" (Altman & Haythorn, 1967). Furthermore, researchers have noted that such suppressed emotions can lead to displaced anger or scapegoating against outsiders (Connors et al., 1985). Collins (1985) cited one instance in which cosmonauts aboard the Salyut space station were so frustrated with ground personnel that they terminated communications for a two day period.

Research has also documented the effects of stress on social behavior. Mathews and Canon (1975) found that under high noise stress, individuals were less likely to help or assist others; whereas Sherrod and Downs (1974) found that under similar conditions, subjects were less likely to help the experimenter by volunteering to perform a requested task. Cohen (1978, 1980) noted that the narrowing of attention that occurs under stress may include a restriction of social cues as well, and that stress may lead to a neglect of social or interpersonal cues and decreased sensitivity to others. Supporting this claim, Driskell et al. (1999) found that team members were less likely to maintain a broad team perspective under stress and were more likely to shift to a more individualistic self-focus.

Within teams, issues of interpersonal integration and attachment are viewed in terms of *cohesion*. In fact, cohesion is viewed as one of the most fundamental aspects of teams (Salas, Estrada, & Vessey, 2015). Recent conceptualizations of cohesiveness have adopted a multi-dimensional approach to defining cohesiveness (see Driskell, Driskell, et al., 2015). Feldman (1968) was one of the first to support the notion that there are at least three major separate, identifiable dimensions of cohesiveness, which he

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termed *interpersonal integration,* which reflects affective relations or attraction to other team members; *functional integration*, which reflects coordinated behavior and commitment to the task or goals of the team; and *normative integration*, which reflects group pride, loyalty, or normative consensus. Other researchers have adopted this tri-partite conceptualization (see Beal, Cohen, Burke, & McLendon, 2003; Driskell, Salas, Driskell, Burke, Neuberger, 2015; Mullen & Copper, 1994). With some qualifications (e.g., groupthink), greater cohesion supports effective group functioning. Research has shown that cohesive groups tend to interact more (Back, 1951), agree more readily (Lott & Lott, 1965), report greater satisfaction with the group (Curtis & Miller, 1986), and at least under some circumstances, outperform less cohesive groups (Mullen & Copper, 1994).

The prevailing view is that stress can degrade team cohesion (Driskell, Driskell, & Salas, 2015). That is, it can impact each of the three primary components of cohesion: (a) it may lead to increased interpersonal tension and greater negative affect; (b) greater interpersonal friction may result in lower commitment to the group task, and (c) stress may weaken normative bonds and loyalty to the group. However, the picture that emerges is not that simple. Gardner (2012) has noted that performance pressure can act as a double-edged sword, compelling a team to greater performance or crippling team functioning. Thus, group cohesion can increase during a crisis or decrease during a crisis. Lanzetta (1955) proposed a partial answer to this question, noting that the locus or origin of the stress is important. That is, external threats (that originate outside of the team) can lead to greater in-group cohesion; whereas internal threats (internal conflict or interpersonal friction) can lead to lower group cohesion (see Choi, Sung, & Kim, 2010). Moreover, team cohesion is not static but instead "emerges over time, cycles, and fluctuates" (Salas, Tannenbaum, et al., 2015, p. 202). Thus, cohesion is likely to vary over the duration of a team's life cycle.

3.4.1. Implications for research

Interpersonal friction can result in increased conflict and difficulties in establishing and maintaining collective orientation, cohesion, and trust within the team. Mutual trust has been defined as "the shared belief that team members will perform their roles and protect the interests of their teammates" (Salas et al., 2005, p. 561). Ashleigh and Stanton (2001) note that interpersonal trust is developed from mutually satisfying interactions, and further note that the interdependency present within a team necessitates that some element of trust is present. When trust is compromised, effective trust repairs are required, such as apologies by one party (see Wildman, Fiore, Burke, Salas, & Garven, 2011) and forgiveness by the other (Molden & Finkel, 2010). Although promising research has examined complications in developing swift trust in dynamic action teams (Wildman et al., 2011), very little empirical research has addressed these issues in task teams.

Unpleasant interpersonal relations may also lessen the collective orientation of team members. Collective orientation has been defined as a team member's predisposition to work in a collective or interdependent manner in team settings (Driskell, Salas, & Hughes, 2010), and these researchers found that collective performance predicted team performance on decision making, negotiation, and assembly tasks. Furthermore, Driskell et al. (1999) found that stress led to a reduction in collective orientation of team members. Smith-Jentsch et al. (2015) have suggested that a loss of collective orientation may also result in a failure to perform supporting or back-up behavior in teams, and note that maintaining collective orientation in high-demand teams is an unmet training need. Further research opportunities include the examination of emotion regulation skills and conflict management to counter negative interpersonal relations (Marks et al., 2001).

One further relatively unexamined concern is the impact of close relationships in task teams. Operating under high-stress conditions for an extended period of time may have the effect of drawing some team members closer together, both interpersonally or romantically. On one hand, a close dyadic relationship can lead to an exclusive sub-grouping within the larger team, which may disrupt team dynamics (Landon et al., 2016). Furthermore, close or intense dyadic bonds may deteriorate, which may lead to negative emotion and heightened tension within the team. Further research is needed to examine the impact of close relationships on performance and well-being in teams in extreme environments.

3.5. Team member motivation

In general, members of extreme teams are highly competent and highly motivated. For example, Wickens et al. (2015) note that novices rarely attempt to climb the highest high-altitude peaks, and members of many extreme teams such as Special Forces teams or spacecrew are both highly selected and highly motivated. Nevertheless, sustaining motivation in extreme task environments is a significant concern (Morgeson, 2015). Extreme environments are often characterized by high task variability; that is, there are periods of very high task load as well as very low task load. In reference to long duration spaceflight, on the mission to Mars expedition, there is a significant task event at launch, a significant event reaching Mars, and certainly important work to be done along the way—but for the other approximately 1000 days, the same task that you perform with the same set of people this week is the same that you may do the next week, and the next, and the next. In other words, there are likely to be periods of very high task activity and periods of repetition and monotony that may result in a loss of motivation.

Moreover, there are conditions in which team members in extreme environments may be over-driven or over-motivated to achieve team goals to the extent that they ignore important safety information (Wickens et al., 2015, refer to this as the "summit or die" attitude among some mountaineering team members), as well as conditions in which team members are under-driven or under-motivated to the extent that they minimize effort or even withdraw from the task.

To date, concerns with low workload, monotony, and boredom has been most evident in Antarctic expeditions and winter-overs and in undersea habitats, and is expected to be a significant problem in future long-duration spaceflight. Smith (1969) has also noted that interpersonal friction and conflict can lead to withdrawal, apathy and decreased cohesion. Frederick Cook, medical officer of the Belgian Antarctic Expedition of 1898–1999, vividly captured the monotony that overcame the crew:

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> *Day after day, week after week, and month after month we rise at the same hour, eat the same things, talk on the same subjects, make a pretense of doing the same work, and look out on the same icy wilderness…We are under the spell of the black Antarctic night, and like the world which it darkens, we are cold, cheerless, and inactive* (Cook, 1980, p. 301; quoted in Stuster, 1996, p. 85).

Astronaut Gene Cernan even noted that: "Funny thing happened on the way to the Moon—not much. Should have brought some crossword puzzles" (Cernan & Davis, 1999, p. 310).

Fisher (1993) has defined boredom as an "unpleasant, transient affective state in which the individual feels a pervasive lack of interest in and difficulty concentrating on the current activity" (p. 396). Davis, Shackleton, and Parasuraman (1983) defined boredom as an individual's emotional response to an environment that is monotonous, repetitive, or under-stimulating. Moreover, they noted that the association of boredom with underload distinguishes boredom from fatigue, which results from sustained overload. van Hooff and van Hooft (2014) distinguish boredom from other negative affective states in that boredom makes people feel unchallenged and that activities are meaningless. Driskell, Driskell, and Salas (2014) note that boredom or ennui can stem from individual factors (e.g., extraverts tend to need more stimulation than introverts), social factors (e.g., the quantity, quality, and variety of social relationships can impact boredom), and task factors (e.g., tasks that are simple, monotonous, unchallenging, or repetitive can lead to boredom). Referring to the framework shown in Fig. 1, any disruptions in role behavior or interpersonal relations or other taskwork or teamwork dysfunctions can "cycle back" into lower team member motivation.

Driskell and Salas (2017) examined potential motivational loss in extreme team environments. Given that teams in extreme environments operate under highly-demanding conditions often for extended periods of time, a primary question is "what keeps them going?" In this review, the authors focused on two factors that sustain motivation in extreme team environments. The first is not letting the other team members down. Team members form social bonds such that not only do they know that the team "has their back," but that they are in turn responsible for the teams' success. These strong primary-group bonds are essential to sustaining motivation in high-demand team settings (Hüffmeier & Hertel, 2011; Wessely, 2006).

The second primary factor that serves to sustain motivation in high-demand environments is that team members have a strong drive to achieve and to do meaningful work. Rosso, Dekas, and Wrzesniewski (2010) define meaningful work as work that is experienced as significant and as holding positive meaning for the individual. Britt, Jennings, Goguen, and Sytine (2016) argue that engagement in meaningful work may decrease the demands associated with boredom and monotony, as well as buffer team members from the negative consequences associated with other stressors. They noted several ways that team members may perceive greater meaningfulness in their work, including by having increased autonomy in work scheduling, opportunities for personal growth, and by providing mechanisms (including social media) to share their work with others.

3.5.1. Implications for research

Barrick, Mount, and Li (2013) have described four fundamental or higher-order motivational goals that drive purposeful work behavior: We strive for affiliation, for recognition and status, to achieve and demonstrate competence, and we desire personal growth and meaning in work and life. The contextual demands that we have discussed in extreme team environments include restrictions imposed by too much work, too little work, meaningless work, interpersonal friction, and other stressors that may jeopardize achieving these motivational goals. For example, interpersonal friction may reduce affiliation with other team members. Team training approaches should be examined as one type of intervention to sustain cohesion in teams (Driskell, Salas, et al., 2015). Also, approaches to enhance feelings of competence, autonomy, and meaningfulness in work and to examine opportunities for positive growth in high-demand task environments may support team member motivation (Britt et al., 2016; Rosso et al., 2010). Britt et al. further note that people may vary in the primary work orientations that they hold, (referencing craftsmanship, kinship, and serving orientations; see Pratt, Pradies, & Lepisto, 2013), and research is needed to examine whether interventions can be successfully targeted to specific team members based on these individual differences.

4. Further research

Although we have noted some of the research needs relevant to the preceding topics, there are many more research areas that are relevant and under-researched. In fact, what we don't know regarding teams in extreme environments far exceeds what we do know. One reason for this is that conducting applied research on teams in extreme environments is difficult. Driskell, King, and Driskell (2014) describe *applied experimental research* as research that applies or extends theory to an identified real-world problem with a practical outcome in mind. Thus, this type of research focuses on real-world contexts. Driskell et al. note that whereas basic research emphasizes testing of theory for the purpose of understanding fundamental processes, applied research involves applying theory to real-world contexts. Conducting research in real-world contexts—for example, studying crews in space or space-like settings, elite military teams, or team at Antarctic stations –poses a number of challenges. One major problem is access. It is often difficult to gain access to real teams in real settings for research purposes, and if access is secured, there are typically a number of restrictions. First, most teams in the real world have a primary goal or purpose other than being the subject of research, so the researcher often has limited leeway to interfere with the teams' primary activities and purpose (limiting the types of manipulations that can be introduced). The researcher is often given limited access on a "not-to-interfere" basis. Second, whereas a researcher in a laboratory setting has considerable control over the types and number of research personnel that can be obtained for a given study, in real-world settings, teams that are available for study are typically already composed and the number of participants available are often very small. Small sample sizes pose problem for analysis, although solutions to these problems have been proposed (Bell et al., 2016). Finally, in contrast to the laboratory researcher who seeks to obtain greater control of

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extraneous variables in the experimental laboratory, applied research is defined by these contextual variables—the task, social, and environmental factors in which the team is enveloped. Salas, Cooke, et al. (2008) claim that rigorously studying teams in context or "in the wild" can lead to higher-quality context-specific guidance to organizations. This brief exposition is not meant to dissuade potential researchers, but to simply note that conducting research on teams in extreme settings can be a challenging endeavor, and more applied research is needed.

A second, overarching research topic that deserves further discussion is the training of generic teamwork skills. Teamwork skills are "the behavioral, cognitive, and attitude skills needed to communicate, interact, and coordinate tasks effectively with other team members" (Salas, Burke, & Cannon-Bowers, 2002, p. 240). Importantly, teamwork skills are not specific to a given task, but are team-generic competencies that are relevant across various types of team tasks. Although comprehensive descriptions of teamwork skills have been provided (Salas, Rosen, Burke, & Goodwin, 2009), a parsimonious list would include leadership, collective orientation, adaptability/flexibility, back-up or supporting behavior, communication, collaborative problem-solving, and emotional regulation (see also Ellis, Bell, Ployhart, Hollenbeck, & Ilgen, 2005; Smith-Jentsch et al., 2015). The importance of these teamwork skills is that training supports effective team performance regardless of task or context.

Another type of training intervention that has been shown to counter the negative effects of high-demand or high-stress conditions is stress exposure training (Driskell, Salas, Johnston, & Wollert, 2008). Specialized stress training can provide pre-exposure to the high-demand conditions that may be faced by the team in extreme settings and provide the specialized skills required to maintain effective performance under stress conditions. Research indicates that specialized stress training procedures can "steel" the team to the pressures of high-stress environments, and can lead to decreased negative reactivity under these conditions (Driskell, Salas, & Johnson, 2001, 2006).

Third, relatively little is known regarding the positive growth opportunities or "salutogenic" effects that may result from performing effectively under difficult conditions. For example, Ihle, Ritsher, and Kanas (2006) found that a sample of active astronauts and cosmonauts reported positive change from their experience in space, including a greater appreciation of earth and mankind. Harrison, Clearwater, and McKay (1989) observed that many of the crew members that winter-over in the Antarctic describe it as one of the best periods of their lives. Britt et al. (2016) suggest that growth from performing in extreme environments stems from the sense of achievement and satisfaction provided by being able to successfully accomplish difficult tasks in the face of extreme demands. Harrison and Connors (1984) note that many extreme environments offer the opportunity for reward, including the opportunity to excel, to be immersed in one's work, and be recognized for achievement. Others have noted that crisis situations can create contexts for constructive growth, creativity, and innovation (Turner & Virick, 2008). Future research should examine the potential for positive outcomes as well as the traditional emphasis on difficulties that are inherent in extreme task settings.

5. Implications for application

Although research on team performance in extreme environments is not extensive, there are some practical guidelines that can be provided for organizations. First, how we compose teams is important. Barrett, Holland, and Vessey (2015) conducted a comprehensive job analysis to determine the core set of competencies related to long duration spaceflight, although these likely are relevant to other extreme team environments. They identified 18 competencies, including teamwork, communication, adaptability, self-care, sociability, and other factors. Although many of these are trainable, those competencies that were rated as particularly important at hire or selection include sociability, adaptability, motivation, communication, and teamwork. In terms of personality, research suggests that traits that are important in high-demand team settings such as aviation or spaceflight include high instrumentality (achievement, motivation) and high expressivity (interpersonal orientation and affiliation) and low levels of competitiveness and verbal aggressiveness (Brcic, 2010; Musson, Sandal, & Helmreich, 2004). Driskell, Goodwin, Salas, and O'Shea (2006) concluded that "The higher-level traits of emotional stability, extraversion, openness, agreeableness, and conscientiousness have all been related to team effectiveness at a broad level" (p. 264). The organization should also carefully consider role requirements in composing work teams. Research suggests that effective teams require a proper balance of role activities across leadership, social, and task dimensions (Driskell et al., 2017). Too many leaders, too few leaders, or no-one performing social support/team maintenance functions can be detrimental to overall team performance.

In addition to composing teams that are optimally effective, training is a critical tool to support team performance. Team training provides the opportunity to build and maintain both taskwork and teamwork skills (Salas, DiazGranados, et al., 2008). Specialized stress training that focuses on contextual factors—the organizational, environmental, and task demands that are imposed upon the team—can counter the negative effects of extreme conditions on team performance (Driskell et al., 2008). Furthermore, training for conflict management (Behfar, Peterson, Mannix, & Trochim, 2008) can support positive interpersonal relations and trust in teams.

Workplace and job design provide significant points of leverage to support team performance in extreme environments. First, the work environment should provide designated spaces for social activities (i.e., shared spaces for training, socializing, and leisure activities) as well as the opportunity for separation and privacy. Social support should be considered in teams that are isolated from family and friends, such as providing private communication and video messaging to connect with significant others outside of the work team. When the task activities may be monotonous or repetitive, emphasis should be placed on providing meaningful work opportunities, such as enhancing autonomy and providing opportunities for personal and professional development (Britt et al., 2016). Finally, attention should be given to continuously (and ideally, unobtrusively) assessing team member workload and socioemotional state and adjusting task load and work schedules as needed (Driskell et al., 2014).

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6. Conclusions

In this article, we have discussed teams in extreme environments–teams operating in diverse settings such as space, submarines and undersea environments, polar settings, military settings, and other high stress environments. We have examined some of the salient factors that may potentially be degraded in extreme team environments. Finally, we have noted research opportunities for extending our understanding of team performance in extreme environments and implications for practical application of the knowledge that is currently available.

There are a couple of caveats that should be noted. It is difficult to draw any conclusions regarding the effects of extreme environments on team functioning without consideration of other important factors that may moderate these effects. For example, team diversity is important. Teams with greater heterogeneity in terms of the culture or gender of the crew members may experience greater interpersonal friction (Landon et al., 2016). Task duration is of course important—teams that perform for extended durations are likely to suffer from longer exposure to demanding conditions. Another important factor is the temporal context of the team. McGrath (1997) has noted that there are significant differences between ad hoc groups with no past or anticipated future and more dynamic groups that are intact and perform over a longer period of time. Teams that perform over time gain experience with the task and the team, but as mentioned earlier, this familiarity may lead to boredom. Moreover, over time, it is important to examine how teams that make dynamic adjustments to situational demands transition back to normal or established patterns of interaction (see Stachowski et al., 2009).

Smith (1969) noted almost 50 years ago that knowledge on teams operating in extreme environments is likely to be an increasingly salient topic in the future. Harrison and Connors (1984) observed nearly 30 years ago that concern with these types of environments will increase over time. Both were correct, and these statements are as true today. We marshal teams to solve complex and difficult problems. These contexts are challenging, but teams that operate in space, in polar settings, in disaster response or recovery, in trauma centers or even in high-demand business settings have the potential to make great contributions. The costs of poor performance are also clear—the decision by the crew of the USS Vincennes that led to the downing of a commercial airliner in 1988 is a stark and well-studied example (see Cannon-Bowers & Salas, 1998; Bell & Kozlowski, 2011). Sustaining effective team performance under extreme conditions remains a special challenge not only for team members themselves, but for researchers and practitioners alike.

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