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The Science of Teams in the Military: Contributions From Over 60 Years of Research

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Teams are the foundational building blocks of the military, which uses a hierarchical structure built on and around teams to form larger units. Consequently, team effectiveness has been a substantial focus of research within the military for decades to ensure military teams have the human capabilities to complete their missions and address future challenges successfully. This research has contributed greatly to broader team theory and informed the development of evidence-based interventions. Team-focused research supported or executed by the military has yielded major insights into the nature of team performance, advanced the methods for measuring and improving team performance, and broken new ground in understanding the assembly of effective teams. Furthermore, military research has made major contributions to advancing methodological and statistical techniques for studying teams. We highlight the military contributions to the broader team literature and conclude with a discussion of critical areas of future research on teams and enduring challenges for both the military and team science as a whole.

Keywords: teams, military, team effectiveness, team training, team processes

Teams are the nucleus around which the majority of the U.S. military force is built to accomplish its mission. This structure allows military teams to accomplish tasks larger in scale and more complex than can readily be accomplished by individual members alone. Military teams are used for tasks ranging from tactical actions (e.g., clearing and securing buildings, operating aircraft) to strategic direction (e.g., monitoring and managing large military operations). The collective skills and actions that result when using small units or teams enable the military to quickly and more efficiently accomplish missions (Shuffler, Pavlas, & Salas, 2012). Further, the combination of unique perspectives and backgrounds of team members can enhance creativity and problem-solving. Nevertheless, due to the intricate nature of the military and its high-stakes missions, maximizing team performance has proven to be an ongoing challenge.

The importance of teams has led the military to study teams scientifically and serve as a primary funding source for team science for over 60 years (Salas, Cooke, & Gorman, 2010). Although the psychological understanding of individual attributes and performance demonstrated military value in World War I (WWI), it was not until World War II (WWII) that team dynamics and performance were noted as potentially important contributors to military effectiveness. Through the decades since then, historical events have continued to shape the nature of the research questions being investigated. The findings from military team research have had a widespread, pervasive impact on how the military organizes, trains, and assesses team performance.

The military investment in team research has not only contributed to the military mission but has also played a major role in significantly advancing the science of teams

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more broadly (Ilgen, 1999). As one example, the Navy's[1] Tactical Decision Making Under Stress (TADMUS) research program resulted in over 250 publications and has been credited with significantly advancing the understanding of team training and cognition while also stimulating military and nonmilitary research (Ilgen, 1999). Understanding historical perspectives can help simplify and explain the most significant details and the contextual influences that led to those advances.

However, extant reviews have not adequately captured the extent to which the military has contributed to team science and furthered understanding of teams beyond the military context. The last major review of military contributions to research on teams was conducted over 20 years ago and focused more narrowly on contributions in military contexts rather than how this research more broadly influenced the field (Salas, Bowers, & Cannon-Bowers, 1995). A number of significant advances and pivotal historical events have occurred since that time.

Thus, the purpose of this article is twofold: (a) to provide a historical perspective of team research supported by the military and (b) to synthesize and describe the contributions of military research to broader team science. We build on and extend prior reviews to summarize the significant contributions.[2] In particular, we enumerate the most critical contributions military research has offered to team science. Based on the review and synthesis of this research, we highlight gaps and future directions in the broader field of team science.

Although the military context is somewhat unique, a closer examination of the properties of military teams can illuminate points of generalizability. Military teams are embedded in a multilevel, hierarchical organizational structure that requires highly effective coordination across units.[3] Similar to executive and top management teams, military leadership (i.e., command) teams and functional teams (i.e., staff) at headquarters collect and synthesize information to direct and coordinate activities of lower level teams (e.g., rifle squads, aircrews). Hollenbeck, Beersma, and Schouten (2012) devised a team typology framework that differentiates between team types along the dimensions of skill differentiation, authority differentiation, and stability. Within this framework, most military teams are low in skill differentiation, high in authority differentiation, and moderate to high in stability over time. However, when assembled into systems of teams (e.g., in a command and staff organization), high skill differentiation between teams is common. Additionally, as in nonmilitary organizations, it is relatively common for team members in some teams and particularly within larger systems of teams to be geographically dispersed and rely on technology to communicate and coordinate. As a result, research conducted in and sponsored by the military can generalize to a broad range of teams that have similar characteristics.

Historical Context of Team Research in the Military

Military contributions to team research have largely been driven by challenges the U.S. military has faced and the strategies used to address them. The earliest engagement of applied psychological research occurred in 1917 when the United States became an active participant in WWI; psychologists worked with the military to develop personnel testing for selection and classification (Bingham, 1919). During WWII, despite being outnumbered and inferior in equipment, the German Army demonstrated "extraordinary tenacity," leading researchers to seek the source of this phenomenon (Shils & Janowitz, 1948, p. 281). This analysis concluded that soldiers persisted in war through a sense of loyalty and cohesion among their unit members (Shils & Janowitz, 1948). Building on this research and that of Kurt Lewin and Leon Festinger (Goethals, 2003), a more sys-

[1] To reduce confusion for readers, we refer only to the military service of the defense research labs that sponsored or conducted the research discussed here. Thus, *Navy* most often refers to the Office of Naval Research, Naval Training Systems Center, or the divisions of the Naval Air Warfare Center; *Army* refers to the Army Research Institute or Army Research Laboratory and their respective predecessor organizations; *Air Force* refers to the Air Force Research Laboratory or Air Force Office of Scientific Research.

[2] We openly acknowledge that significant advances in team science have happened in other domains and been sponsored by other nations. In this context of this special issue we mainly limit our focus to highlighting the U.S. military as one of the significant contributors to this scientific domain.

[3] Some military research has focused on the hierarchical level of a unit (e.g., platoon, company), which encompasses multiple teams (e.g., rifle teams, squads, tank crews). When referencing research on these undifferentiated groups of teams, we use the word *unit* in place of *team.*

Nikki Blacksmith

tematic exploration of teams commenced, and in the post-war era, the military began sponsoring research on the underpinnings of team effectiveness by investigating unit cohesion and team performance (Havron et al., 1954).

The end of the Vietnam War marked another shift for the military, with several fundamental changes to the national defense strategy. The military shifted from reliance on the draft and mandatory service to reliance on an all-volunteer, professional force (Rostker, 2006). The shift to an all-volunteer force was coupled with a strategic initiative to transition to a smaller, leaner, and more highly skilled force. For the military to reduce in size without losing overall capabilities, it needed to maximize the effectiveness of teams and units (Dyer, Tremble, & Finley, 1980). Maximizing team effectiveness can help to offset personnel reductions because teams have the possibility of achieving more than the sum of its individual members (Hackman & Morris, 1975). Team members can combine efforts to undertake more complex tasks and monitor the performance of one another to help catch and correct performance errors as well as allow for shifting the workload as needed within the team to meet evolving performance demands. Simultaneously, the military changed its strategic approach to fighting in a way that placed a premium on coordinated action among units. This brought additional emphasis to team dynamics and expanded the focus to enhancing the synchronized effectiveness of multiple teams (i.e., direction and coordination of small units).

After this shift in the military force, a series of critical events exposed weaknesses in the existing approaches to team effectiveness and consequently continued to drive research. In 1988, an Iranian civilian airliner was accidentally shot down by the Navy over the Persian Gulf (Ilgen, 1999). This event largely absorbed and transformed the focus of team research in the military; the focus was placed on improving team information processing and decision-making in stressful situations (Ilgen, 1999). To address this issue, the Navy developed the TADMUS research program (Cannon-Bowers & Salas, 1998), which systematically investigated the training, performance, and dynamics of decision-making teams. Subsequent to the TADMUS program, the Navy continued to invest in research focused on improving team information processing and decision-making through decision aids, training, and redesign of information systems to account for team knowledge management principles (Letsky, Warner, Fiore, Rosen, & Salas, 2007).

Several critical incidents and failures during military training and operations (e.g., friendly fire accidents) in the 1990s highlighted a lack of interteam coordination as a particular problem area that hampered overall mission effectiveness (Mathieu, 2012). These incidents led to military-sponsored research that originated and developed the concept of multiteam systems (MTSs). Multiteam systems are two or more teams that work collectively and interdependently to accomplish hierarchical, collective goals (Mathieu, Marks, & Zaccaro, 2001). Military emphasis on the MTS concept further advanced team science by deepening the knowledge of how multiple, interdependent teams effectively interact and coordinate to enhance their performance.

The terrorist attacks on September 11, 2001, were a turning point for the U.S. military (U.S. Department of Defense [DOD], 2006). The military reacted with a sense of urgency to develop its capability to fight in unconventional, dynamic, and unpredictable environments. Military and civilian personnel from a variety of backgrounds are often required to work together cohesively to function effectively in these dynamic, ambiguous environments and accomplish larger national security objectives. In response, the military services sought new approaches to assemble and train teams and systems of teams effectively. Efforts ranged from highly focused tools for assembling military assistance teams (Donsbach et al., 2009) to significant investments in team training technologies (Chapman & Colegrove, 2013).

Technological advances also contributed in reshaping the military and its strategic goals in the 21st century (DOD, 2006). These advances have created new arenas for competition (e.g., cyberspace), placed reliance on information superiority as a strategic advantage, and introduced robots and artificial intelligence–enabled software systems into the team milieu. These new arenas spurred investment in understanding the computational and modeling requirements for building useful digital teammates (e.g., Ball et al., 2010) and strengthening cross-domain and interagency teams.

Meredith Coats

Military Contributions

We highlight five major areas of team science in which the military has made and continues to make significant contributions. The first three areas—team performance, team processes, and team leadership—have improved the understanding of team effectiveness and offered scientific insights as to how in practice the effectiveness of military teams might be improved. The last two areas—team staffing and team training—are specific approaches to enhancing team effectiveness that have been and continue to be of primary interest to the military. Although we review the body of military research on teams within these five specific domains, many of these critical contributions cut across the five domains. After reviewing these five areas, we identify several of the more significant cross-cutting contributions of military research to team science.

Team Effectiveness and Performance

Perhaps one of the military's more meaningful contributions to team science was the advancement of the conceptualization and measurement of performance as distinct from team processes. Cumulatively, the early exploratory efforts to understand and measure team performance and effectiveness provided a basis for comprehensive models of team effectiveness in use today. McGrath's (1964) team effectiveness research, funded by both the Army and Air Force, led to outlining of the input−process−output (IPO) framework, which has served as the dominant framework for studying teams in organizational settings. The IPO model explains that team inputs affect team processes that in turn lead to performance outcomes. Hackman and Morris (1975) later expanded on McGrath's work during their research for the Navy. Separately, Fiedler's (1954, 1971) Navy-funded research demonstrated that inputs such as team member attitudes and characteristics, climate, and leadership style are important factors to include in team effectiveness models (Fiedler, 1971). Other Navy researchers corroborated these findings by demonstrating that group composition influenced effectiveness (e.g., Tuckman, 1967).

Using the IPO model as a foundational structure, Salas, Dickinson, Converse, and Tannenbaum (1992) created the team effectiveness model, which addresses a broader range of performance behaviors and describes performance as a dynamic, cyclical process. This approach illustrates team effectiveness as a dynamic interaction between inputs and team member behaviors and interactions that occur as teams perform. The most current team effectiveness model, the input−mediator−outcome−input model (Ilgen, Hollenbeck, Johnson, & Jundt, 2005), further built on McGrath's (1964) IPO concept by distinguishing between the mediating states and processes of teamwork and more clearly emphasizing the cyclical aspect of team performance.

Throughout the 1980s and 1990s, the lack of sound measurement approaches to assess team performance was impeding scientific advancement (Dwyer, Oser, Salas, & Fowlkes, 1999; Dyer, 1984). Consequently, concerted efforts were made to study performance in an exploratory, descriptive manner to identify the specific behaviors constituting team performance. Through observations of Navy teams, clear distinctions were made between taskwork (i.e., the skills needed to accomplish tasks) and teamwork (i.e., interrelated thoughts, feelings, and behaviors of members) aspects of performance (Morgan, Salas, & Glickman, 1993; Oser, McCallum, Salas, & Morgan, 1989). Fleishman and colleagues (Fleishman & Zaccaro, 1992; Nieva, Fleishman, & Rieck, 1985) also built a taxonomy of team behaviors that helped to clarify team performance functions further.

The decades of research defining team performance paved the way for the development of innovative, psychometrically sound measures (MacMillan, Entin, Morley, & Bennett, 2013). Structured assessment methods such as observation ratings, behaviorally anchored rating scales, and behavioral checklists were introduced to Naval team performance measurement through the study of team evolution and maturation (Morgan et al., 1993). To assess performance in the complex, dynamic environments of military teams, the Navy developed the targeted acceptable responses to generated events and tasks (TARGETs) methodology (Fowlkes, Lane, Salas, Franz, & Oser, 1994), which utilized event-based measurement to objectively assess team processes in context-specific environments (Dwyer et al., 1999). By focusing observation and assessment of team interactions as they encountered specific events designed to elicit teamwork behavior, the difficult task of measuring team performance in complex and rapidly changing environments was improved. However, assessing team performance in the field was still not always practical and required observers who were difficult to attain.

Because the assessment of teams in naturalistic settings has proven to be difficult and complex, military researchers have created synthetic worlds and computational simulations to measure team performance without the labor intensity and obtrusiveness associated with observations (Chapman & Colegrove, 2013; Kozlowski, Chao, Grand, Braun, & Kuljanin, 2016). Through these efforts, the Navy and Air Force supported the development of several approaches to measure team situational awareness (e.g., Gorman, Cooke, & Winner, 2006) as well as communication-based measures of interactive team cognition (Cooke, Gorman, Myers, & Duran, 2013). The Army also developed measurement methods that minimized requirements for observers. Studies of communication behaviors using unobtrusive measurement techniques that gather trace data (i.e., concrete remnants of human behavior) of Army team interactions from e-mail, chat, and face-to-face interaction (from wearable sensors) have resulted in a better understanding of how organizations operate as large MTSs (Orvis, Brown, McCormack, & DeCostanza, 2016) and advanced the understanding of unobtrusive measurement. Most recently, the Army has begun exploring advanced unobtrusive approaches that may be adapted to measure performance through a combination of wearable sensors, machine learning, advanced algorithms, and social network theory (e.g., Orvis et al., 2016). Through this research Orvis et al. (2016) demonstrated the utility and validity of these unobtrusive measures for assessment and feedback in training.

Key contributions. Team performance both within the military and in other sectors is now understood to be an episodic, multilevel (i.e., individuals, team, MTS), and cyclical process arising from team members' working together toward shared task-focused and team-focused goals (Mathieu et al., 2001; Salas et al., 2010). Over the decades, the military continues to improve the understanding of team performance through the development of sophisticated measurement tools. Lessons from early research demonstrated that methods should avoid interfering with performance and use multiple metrics to capture the dynamism and episodic nature of performance to measure it adequately. For instance, trace data has emerged as an effective measurement tool and can be gathered through wearable devices and software systems.

Team Processes and Emergent States

Team processes are functions performed by team members to coordinate and combine individual activity and accomplish team goals; they are the means through which teams perform (Hackman & Morris, 1975). McGrath (1964) advanced the understanding of team processes by characterizing communication, cooperative planning, and coordination behaviors as critical processes. Building from McGrath's work, a number of taxonomic efforts synthesized research to describe and characterize team processes (e.g., Brannick, Prince, Prince, & Salas, 1995; Fleishman & Zaccaro, 1992). At the behest of the Air Force, Marks, Mathieu, and Zaccaro (2001) organized a temporal framework in which team behavior can be understood as recurring episodes of inputs, processes, and outputs (see Salas, Sims, & Burke, 2005, for an alternate conceptualization). In doing so, they clearly articulated the differences among those processes relevant to action (i.e., within episode) and transition (i.e., between episode) behaviors, as well as interpersonal or social processes that span multiple episodes.

Team processes have been distinguished from emergent states. Emergent states are dynamic properties of a team and have been broadly categorized into motivational (e.g., collective efficacy), affective (e.g., cohesion), and cognitive (e.g., shared mental models) states (Marks et al., 2001). Early Army-sponsored research established that team cohesion enhanced trust and coordination within the team (Havron et al., 1954). Cohesion has also been linked to a variety of outcomes, including lower rates of stress and illness and higher satisfaction and retention (Griffith, 2002). Currently, the Army is reexamining cohesion as a multilevel, temporally dynamic phenomenon (DiRosa, Estrada, & DeCostanza, 2015).

Military research has also greatly contributed to the understanding of team cognition (Letsky et al., 2007). Building from mental model theory (Rouse & Morris, 1986), the Navy's TADMUS program demonstrated that shared mental models (i.e., organized knowledge structures held by team members) were a key enabler of coordinated performance (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). This examination subsequently grew into a broad domain of inquiry on many other forms of shared cognition, such as team situational awareness, transactive memory, and consensus (DeChurch & Mesmer-Magnus, 2010; Orvis, Ruark, Pierce, & Goodwin, 2009). In parallel, the Navy and Air Force sponsored research that defined *team cognition* as an interactive activity undertaken by teams, rather than an emergent state (Cooke et al., 2013). In this view, patterns of team communication and activity reveal the essential processes of cognition. To date, researchers have not resolved the differences between these perspectives on team cognition, and both have empirical support.

Team processes and emergent states are dynamic, making them relatively difficult phenomena to accurately measure in real-world teams. To study these phenomena, the military has made progress through the use of high-fidelity synthetic worlds (i.e., simulations) that elicit the psychological characteristics of the phenomenon of interest (Fiore et al., 2010; Kozlowski et al., 2016). For example, several simulations of military task environments have been developed to examine team cognition, goal pursuit, macrocognition, and learning

(Kozlowski et al., 2016). These tools use sophisticated analytic techniques such as computational process models and computational simulation to develop insights into team processes and states.

Key contributions. Three key military contributions have advanced the scientific understanding of team processes. First, an integration of findings from numerous studies culminated in the widely accepted framework of action, transition, and interpersonal processes (Marks et al., 2001). Second, shared cognition was identified as a key aspect of effective performance in teams and MTSs. Third, motivational and affective states such as cohesion provide a means for teams to cope with and overcome adversity and challenges.

Team Leadership

The DOD has long understood that leadership is an integral factor in team effectiveness and, along with private sector organizations, has supported leadership research for decades (e.g., Stogdill, 1950; Zaccaro, Heinen, & Shuffler, 2009). The Navy sponsored the Ohio State Studies, which found that leadership was an essential aspect of directing and managing teams (Stogdill, 1950). Also with Navy sponsorship, Fiedler (1971) explored leadership as an interaction between followers and leaders. These early theories of leadership were representative of the zeitgeist in conceptualizing a leader as distinct from the team (Zaccaro et al., 2009). Beginning with Stogdill (1950) and Fiedler (1971) and continuing across several decades of leadership theory (e.g., Bass, 1990), leadership was largely conceptualized as a set of behaviors enacted by a designated individual; team leaders set the direction of the team, managed team operations, and developed the team's leadership capacity (Kozlowski, Gully, Salas, & Cannon-Bowers, 1996; Zaccaro et al., 2009).

A related approach treated leadership not as an attribute or behavior of an individual but as a function of the team that may be jointly fulfilled by team members as required by the context or situation (Zaccaro et al., 2009). The Army emphasized the interpersonal and functional aspects (Orvis et al., 2009; Zaccaro et al., 2009), whereas the Navy and Air Force placed emphasis on the decision-making aspects of leadership (Davison, Hollenbeck, Barnes, Sleesman, & Ilgen, 2012). These investments highlighted the role of leaders and shared cognitive processes in complex, collaborative problem-solving and coordinated action (Fiore & Schooler, 2004). More recently, theories of collective (e.g., Friedrich, Vessey, Schuelke, Ruark, & Mumford, 2011), distributed (Burke, Fiore, & Salas, 2003), or shared (DeChurch & Mathieu, 2009) forms of leadership have conceptualized leadership such that multiple members may take on and share the leadership role in various ways.

Recent theory has framed leadership as a multilevel phenomenon (Friedrich et al., 2011). A group of Army-sponsored researchers has examined leadership phenomena within and between teams in an MTS framework (DeChurch & Marks, 2006; DeChurch & Mathieu, 2009). Leadership in this context consists of guiding and directing multiple teams as a collective to achieve superordinate goals and effectiveness (DeChurch & Marks, 2006). Interteam coordination and leadership are critical to achieve superordinate goals when teams within an MTS are performing nonroutine, dynamic tasks that are highly interdependent (DeChurch & Marks, 2006; Mathieu, 2012; Mathieu et al., 2001). One of the more intriguing developments from this body of research is the idea of confluent and countervailing forces. That is, some leadership functions reinforce each other (i.e., confluent), whereas others negate each other (i.e., countervailing) across levels (Asencio & DeChurch, 2017). As a byproduct of the MTS research, the Army has explored teams and MTSs using a social networks perspective including leadership, leader emergence, influence across team boundaries, and leader effectiveness.

Key contributions. Military research has made several significant contributions to the understanding of team leadership. First, leadership is crucial for effective team performance; it provides the direction necessary to maximize the synergy among members (Zaccaro et al., 2009). Team leadership is often more than an individual role; it can be shared and distributed across members within the team (Friedrich et al., 2011; Shuffler et al., 2012). Finally, although leaders are critical enablers for the performance of their own team, within MTSs they must also facilitate interteam coordination, interaction, and process−performance relations.

Team Staffing and Composition

Team members have unique knowledge, skills, abilities, and other characteristics (KSAOs) that affect individual performance in teams and holistic team performance (Fiedler, 1954). Early research focused on cognitive ability and personality factors as predictors of team performance (McGrath, 1957). For example, a study of Navy teams provided initial evidence that composition factors (i.e., combination of individual variables) contributed to performance on the combat information center tasks (Tuckman, 1967).

Beginning in the mid-1980s, researchers began to more closely focus on understanding how individuals with varying characteristics work together (Driskell, Salas, & Hogan, 1987; Tziner & Eden, 1985). Tziner and Eden (1985) found that performance of high-ability military tank crews exceeded levels predicted by the linear composite of individual team members' cognitive ability, providing empirical evidence of the synergy that can be achieved through effective composition. Driskell and colleagues (1987) contributed to this understanding by demonstrating that the nature of the relationship between individual personality characteristics and team effectiveness varied across task types. Recent findings have indicated that the set of requisite member capabilities to maximize effectiveness changes as teams evolve and mature over time (Mathieu, Tannenbaum, Donsbach, & Alliger, 2014).

As the new century began, evidence accrued to support the hypothesis that team-level variables explained variance in team performance (Cooke et al., 2003; Halfhill, Nielsen, Sundstrom, & Weilbaecher, 2005). These team-level variables include team size, interdependence, and communication structure as well as group-level ability and personality (Shuffler et al., 2012). A number of ways to operationalize team composition, such as group averages, variance, and other mathematical formulations, emerged (e.g., Cooke et al., 2013; Halfhill et al., 2005). Still, findings have been difficult to synthesize, making it challenging to draw holistic conclusions regarding when and why different composition and compilation models are effective. With Army sponsorship, Mathieu et al. (2014) developed a conceptual framework of composition and compilation models for team staffing decisions to increase consistency, coherence, and explanatory power.

Military research efforts from across the services developed tools that could help assign specific individuals to a given team. Army-sponsored research developed the team optimal profiling system, which used modeled individual attributes in relation to team-level performance demands to help leaders make team staffing decisions (Donsbach et al., 2009). In a parallel effort, Air Force–sponsored researchers designed the TeamBuilder software system, which also helps commanders to rapidly assemble a team based on resume data by modeling individual KSAOs in relation to role performance and team performance (Orvis, Duchon, McCormack, & Colonna-Romano, 2010). While theory in this area has continued to advance (cf. Mathieu et al., 2014), these efforts remain state of the art in team composition.

Key contributions. Military research has led to several important conclusions on team staffing and composition. First, although team performance reflects the combination of individual capabilities necessary to perform, appropriate composition approaches most often represent the pattern or distribution of characteristics rather than simply a linear composite of individual KSAOs (Driskell et al., 1987; Mathieu et al., 2014). Second, the conceptual approach to team staffing must consider not only the combination of member attributes but also the type of staffing decision (e.g., member replacement, building a new team, staffing multiple teams) and organizational or other constraints placed on the staffing decision (Donsbach et al., 2009). Last, teams are not static entities; effective team composition requires that leaders pay attention to membership changes and task changes and understand the history of both the team and the current and prospective members.

Team Training

As mentioned previously, changes in national defense strategy in the late 1970s led to a significant focus on team training across services (Dyer et al., 1980). Army researchers reviewed the numerous studies on teams and identified several gaps in understanding how to improve team performance (Dyer, 1984). Navy research on training began by defining generalizable teamwork competencies (e.g., Cannon-Bowers et al., 1995; Morgan et al., 1993; Nieva et al., 1985) to determine what kind of teamwork skills should be trained (Cannon-Bowers & Salas, 1998).

Building from team training research and concepts from the aviation community (e.g., crew resource management [CRM] training), Navy research demonstrated that performance of aviation teams improved after training on team competencies (Salas, Burke, Bowers, & Wilson, 2001). Utilizing many of the concepts from CRM training, the Navy's TADMUS program produced a variety of training strategies and prototype training programs that have been shown to improve team coordination, adaptation, and performance (Salas et al., 2008; Serfaty, Entin, & Johnston, 1998). To address the need to train aircrews to coordinate in complex environments effectively, the Navy developed TARGETs methodology that results in an event-based, behavioral checklist for event-based training (Dwyer et al., 1999). Event-based training is a scenario-based training that uses a sequence of focal events to train specific team behaviors. Navy researchers demonstrated the effectiveness of TARGETs' checklist for event-based training for a variety of types of military teams, ranging from aviation crews (Fowlkes et al., 1994) to close air support teams, which support ground combat units with aviation-based firepower to fight against hostile targets (Dwyer et al., 1999).

Branching away from the aviation-based team training, naval researchers also explored a variety of other training methods and approaches for developing teams. Team Dimensional Training (TDT), one of the more effective training programs devised under TADMUS, is a method of training that uses guided self-correction to teach teams to diagnose their performance problems or challenges, exchange feedback among members, and develop solutions (Smith-Jentsch, Zeisig, Acton, & McPherson, 1998). Other efforts explored key questions around when and how to train teams to maximize effectiveness. Navy and Army research found that training intact teams on teamwork and taskwork skills showed the most positive impact on team performance (Salas et al., 2008). Training methods that help build awareness of each other's roles and performance requirements (e.g., cross-training) support the development of shared cognition and subsequent performance (Marks, Zaccaro, & Mathieu, 2000). Army and Navy researchers also explored a variety of training methods to improve team adaptability (e.g., Orvis et al., 2009; Serfaty et al., 1998).

Although all of the services pursued team training research, each service focused on different training topics or approaches. Whereas the Navy efforts were focused primarily on teamwork behavior, the Air Force approached team training with an emphasis on taskwork and developing training technologies (Chapman & Colegrove, 2013; MacMillan et al., 2013). Army research focused more on developing team adaptability, training team leaders, and most recently automating the assessment of team dynamics for training (Orvis et al., 2009, 2016; Shuffler et al., 2012).

Another substantial improvement in team training was the development of synthetic task environments and simulation-based training (Shuffler et al., 2012). As computer systems and network technologies advanced in the 1980s, DOD laboratories invested heavily in developing a distributed, simulation-based training platform. This program, Simulator Networking (SIMNET)), allowed trainees to participate and interact with each other despite being in geographically dispersed locations (e.g., Bell, 1999; Miller & Thorpe, 1995). Army and Air Force researchers continued the SIMNET research on distributed team training, learning, and feedback approaches to make this training capability robust and useful for a wide variety of training needs. Advancing from the SIMNET capability, Air Force researchers noted that given the complexity of modern military operations along with practical limitations (e.g., sharing classified information, safety issues, evolving missions), high-fidelity, networked simulators were one of the more effective methods to train multiple aircrews for combat operations (Chapman & Colegrove, 2013). These synthetic battlespaces were supported by research demonstrating that simulation-based training effectively prepared service members for combat (Bell, 1999; Chapman & Colegrove, 2013; MacMillan et al., 2013). To date, military developments in distributed digital training platforms and the associated measurement and training methods are still at the forefront of training innovations (Chapman & Colegrove, 2013; Orvis et al., 2016).

Key contributions. Substantial contributions in team training include the identification of key areas for focusing team training to maximize training effectiveness and the development of effective team training methods. First, team training should be focused on both taskwork and teamwork skills. Second, effective methods (for both military and civilian organizations) include training intact teams, guided team self-correction, and team coordination training. Last, training technologies (e.g., communication analysis, distributed training) should be leveraged because they can provide new opportunities to improve the understanding of team training and manage training costs and enable teams to train together more often (Shuffler et al., 2012).

Critical Contributions Across 60 Years of Research

Having reviewed more than six decades of research across five areas of team science—performance, processes, leadership, composition and staffing, and training—a number of themes that represent more significant military research contributions to how one thinks about, conducts research on, and supports teams in organizations within and outside the military are evident.

1. *Teams can be more effective than the sum of individual team members.* Cohesive teams (i.e., strong bonds among members) perform better and stay together longer than do noncohesive teams. Teams can absorb more task demands, perform with fewer errors, and exceed performance based on linear composites of individual performance.

2. *Team cognitive processes play a significant role in team performance.* What teams think, how team members think together, and how synchronized team members are in their perceptions and beliefs all significantly contribute to a team's ability to perform well.

3. *Team processes and performance are cyclical, dynamic, and episodic.* The refined IPO framework is a robust conceptual approach for understanding teamwork and team effectiveness. Process models provide a structure for understanding and measuring teamwork behavior within and between performance episodes.

4. *Multiteam systems (MTSs) matter.* Many teams exist within a broader system of teams; understanding the interteam leadership, processes, and performance interdependencies is critical to understanding and influencing the performance of any one team. Further, the countervailing and confluent forces within the MTS relationships can create unexpected effects where constructs acting at different levels can reinforce or nullify each other.

5. *Contextually rich environments enable teams to learn more effectively.* Effective team training approaches allow teams to learn in the context of their assigned tasks. Guided team self-correction approaches (e.g., TDT) give teams the on-the-job tools to reflect on their own performance. Synthetic task environments give teams a robust environment to focus on learning to work effectively together while performing realistic tasks.

Future Directions

As we have illustrated to this point, the military contribution to team science has evolved in conjunction with the challenges the military faces. In the future, the military will continue to face existing challenges with fighting instability caused by nonstate actors and terrorism, as well as facing new challenges in urban and cyber warfare. Although many of the challenges faced by the military are similar to those facing most organizations, there are unique aspects as well. Like the military, many organizations have an interest in building innovative, adaptive, and efficient teams; building strong partnerships and alliances; operating in a global environment; and maximizing the use of human capital. Many organizations are showing a growing interest in building robotic systems and artificially intelligent software agents capable of being integrated into teams as fully functioning team members, although the military has a more concerted focus in this area than do most. Additionally, the military faces significant challenges related to rapidly assembling teams into larger units, integrating widely disparate types of teams and optimizing team staffing decisions for thousands of teams simultaneously. These goals will continue to require additional team research. Here we highlight some critical research needs.

Enhance understanding of MTS. The DOD is placing great emphasis on ensuring that forces work collaboratively and as a collective to maximize efficiency. Further, the military will require teams to fluidly assemble into an MTS as conditions demand and subsequently disaggregate back to independent teams afterward. Because recent research on MTSs has revealed complex and unexpected interactions across hierarchical levels (Asencio & DeChurch, 2017), it is imperative to revisit many aspects of team science to clearly understand the implications of the nested, hierarchical structure used by the military for team creation, development, and effectiveness within the MTS construct. Moreover, because the military increasingly needs to work closely with other agencies in the government (e.g., Department of State) to accomplish national security goals, it will be increasingly important to understand other organizational forms of the MTS.

Increase understanding of team composition. Because the military continues to decrease in size, the need to maintain and enhance team performance for sustainable combat strength is underscored. Future research can assist in better understanding how members with varying characteristics interact to best determine how to assemble high-performance teams. Some of the key challenges include determining how best to operationalize and model dynamic composition and adapt the mathematics for improved approaches to the team composition problem (Mathieu et al., 2014). This includes understanding the combination and interactions between multiple variables, including teamwork and taskwork KSAOs, personality profiles, previous relationships between members, and the amount of heterogeneity within the team.

Enhance cognitive competencies of teams. Work in the military, as in other sectors, is becoming progressively more cognitive (Cooke et al., 2013). Further, to continue adapting to the ever-changing environment, organizations will need to develop personnel to have the cognitive capacities to learn quickly, analyze information, and come to accurate conclusions using partial or ambiguous information. Future research should build on and integrate research in team cognition (Cooke et al., 2013; Fiore, Ross, & Jentsch, 2012), learning, and decision-making to maximize the potential of the teams' collective cognitive capabilities.

Include environmental factors in studies. The understanding of teams in organizations has largely understated contextual factors. Environmental factors such as level of autonomy, technological affordances and constraints, physical space and environmental factors, and organizational culture, for example, may have a significant impact on team and MTS performance (Shuffler et al., 2012). To more fully understand team effectiveness in this evolving environment, research will need to examine how and when environmental and contextual factors impact team dynamics and effectiveness.

Build computational representations of teamwork. In the past, there has been some interest in building digital teammates for training purposes. In the future, military teams will incorporate autonomous systems (e.g., robots, drones) as well as artificially intelligent software agents. To enable these systems to function as team members, the systems will need to be able to understand the needs, intentions, and actions of human team members as well as how these systems can perform the myriad teamwork functions required of them.

Enduring Barriers and Challenges

There remain many common challenges across all areas of team research as well as application domains for the study of teams. Of these challenges, perhaps the most significant continues to be the issue of construct clarity and proliferation. The number of identified constructs and models has exploded in the last 20 years (Salas et al., 2007). This has led to substantial difficulties in synthesizing and advancing the science in coherent ways. Establishing clear construct conceptualizations, building on each other's work with partial replications, and collectively pursuing construct validity will enable the body of research to advance and have a greater impact on organizations and policy. Temporal factors and longitudinal designs remain a distinct challenge for team research. Collectively science needs to find ways to adopt methods and analytic approaches that will permit deep longitudinal designs to more fully explore temporal issues and team development. Finally, practical constraints continue to hinder the ability to study teams in natural, real-world settings and to capture performance adequately.

Conclusion

Inarguably the military has played a significant role in advancing research on team effectiveness over the last 60 years and more. For much of this time the military, along with the aviation community, has been a dominant force in shaping the direction of team science. However, there are many application domains (e.g., health care, space exploration) that also have a vested interest in this research and will make significant contributions to the future progress in team science. Together these different domains make up a robust and diverse organizational ecosystem for advancing team science as a whole. A central challenge and opportunity is for each domain to capitalize and build upon the findings derived from the others.

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