© *Academy of Management Journal*
2022, Vol. 65, No. 5, 1571–1592.
https://doi.org/10.5465/amj.2020.0369

THE HIGHS AND LOWS OF HIERARCHY IN MULTITEAM SYSTEMS

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Multiteam system research operates under the assumption that multiteam systems should be structured hierarchically, or consist of component teams nested under a formal, centralized leadership team that oversees and orchestrates system activities. Although multiteam system research has certainly provided evidence suggestive of the merits of more hierarchical (vs. egalitarian) structures, we take a more balanced view and argue that hierarchy both facilitates *and* impedes multiteam system success. Using an experimental study and a sample of 76 multiteam systems observed over three performance episodes, we provide evidence that structural hierarchy (a) facilitates multiteam system learning by mitigating cognitive depletion among members, but (b) undermines multiteam system learning via its deleterious effects on horizontal coordination. Critically, however, we find that the benefits of hierarchy (i.e., reduced cognitive depletion) wane over performance episodes. This investigation underscores the important role that different hierarchical arrangements play in multiteam system functioning. Although a majority of multiteam system researchers have utilized hierarchical structures—which indeed have their virtues—we illustrate that egalitarian structures have key advantages as well.

"Multiteam systems," defined as tightly coupled networks of interdependent teams (Mathieu, Marks, & Zaccaro, 2001), have been increasingly employed by organizations pursuing various goals (e.g., scientific installations, space exploration, national security) in numerous industries (e.g., health care, petroleum, airlines) over the last several decades (Shuffler & Carter, 2018; Shuffler, Jiménez-Rodríguez, & Kramer, 2015). In recognition of the growing use of multiteam systems by practitioners, the scientific literature on multiteam systems has also grown considerably over the last 20 years (Zaccaro, Dubrow, Torres, & Campbell, 2020). Although this growing body of research has certainly proven insightful, multiteam systems still frequently fail to accomplish their goals, due to the unique challenges associated with coordinating across team boundaries (Shuffler & Carter, 2018) and managing the system's complexity (Davison, Hollenbeck, Barnes, Sleesman, & Ilgen, 2012; Murase, Carter, DeChurch, & Marks, 2014; Porck, Matta, Hollenbeck, Oh, Lanaj, & Lee, 2019). Fortunately, scholars have recently identified various "linkage attributes"—mechanisms that connect component teams' efforts within the larger system (Zaccaro, Marks, & DeChurch, 2012)—that might be strategically utilized to facilitate cross-team coordination and mitigate multiteam system complexity.

One linkage attribute that is especially relevant in achieving these objectives is multiteam system "hierarchical arrangement," defined as the distribution of decision-making authority, resource control, and responsibility for system goal attainment among component teams (Zaccaro et al., 2012). Regrettably, empirical research on multiteam systems rarely considers the downstream consequences of different hierarchical arrangements (Shuffler et al., 2015) and has largely progressed under the assumption that multiteam systems should be arranged hierarchically, with component teams nested under a formal, centralized leadership team that oversees and orchestrates system activities (Zaccaro et al., 2020). For example, prior research has found that centralized planning and communication structures (i.e., planning and communication centralized within a formal leadership team) enhance multiteam system performance (Davison et al., 2012; Lanaj, Hollenbeck, Ilgen, Barnes, & Harmon, 2013), and therefore the takeaway is that multiteam systems should be structured hierarchically as a general rule. Similarly, a growing number of studies underscore the importance of a strong, central leadership team to multiteam system success (e.g., DeChurch & Marks, 2006; Murase et al., 2014; Waring, Moran, & Page, 2020). In fact, a majority of empirical multiteam system research conducted to date has utilized hierarchically structured systems (Luciano, Fenters, Park, Bartels, & Tannenbaum, 2021; Zaccaro et al., 2020), seemingly by default, thus implicitly rejecting the value of alternative, more egalitarian structures.

Although multiteam system research has certainly provided evidence suggestive of the merits of hierarchical structures, we argue that key advantages associated with egalitarian structures have been neglected due to the prevailing assumption that hierarchy is superior. Indeed, research on intra-team hierarchies (or hierarchies in standalone teams) has long recognized that the effects of hierarchy on group effectiveness are not simply "positive" or "negative," but, rather, that hierarchy can be both beneficial and detrimental to group success (Anderson & Brown, 2010; Greer, Van Bunderen, & Yu, 2017; Halevy, Chou, & Galinsky, 2011; Magee & Galinsky, 2008). Likewise, emerging research on "hierarchical flexing," or the deliberate oscillation between hierarchy and egalitarianism, suggests that there are unique strengths afforded by each arrangement within standalone teams (Greer, Abi-Esber, & Chu, 2020). Finally, recent qualitative research on emergency response multiteam systems revealed that deviations from traditional hierarchical leadership structures represent a "double-edged sword," in that they help multiteam systems manage the multiteam system–environment interface but also disrupt internal functioning (Luciano et al., 2021). Thus, there is evidence to suggest that hierarchy may not have strictly positive *or* negative effects on multiteam system operations. Instead, there are likely both merits and drawbacks to hierarchy in multiteam systems.

Accordingly, the purpose of this investigation is to provide a more balanced understanding of the effects of different hierarchical arrangements on multiteam system operations. To accomplish this objective, we examine the effects of hierarchy (vs. egalitarianism) on (a) "horizontal coordination" (the extent to which component teams "align and synchronize their activities"; de Vries, Hollenbeck, Davison, Walter, & van der Vegt, 2016: 1824), due to the premium placed on component team coordination in multiteam systems; and (b) "member cognitive depletion" (the extent to which members' mental energy has been exhausted; Porck et al., 2019), due to the uniquely taxing nature of the multiteam system environment. Importantly, horizontal coordination and cognitive depletion both have implications for multiteam system learning (the accumulation of task-relevant knowledge; Kozlowski & Bell, 2003), which subsequently impacts multiteam system performance, thus making horizontal coordination and cognitive depletion key success and failure factors, respectively, in multiteam systems. In an experimental study consisting of 76 multiteam systems ($n = 1,060$ individuals) observed over three performance episodes, we find that hierarchical arrangement indeed influences horizontal coordination, cognitive depletion, multiteam system learning, and multiteam system performance, and that some of these effects evolve over performance episodes.

This work offers several contributions to the literature by demonstrating *how*, *why*, and *when* different hierarchical arrangements affect multiteam system operations. First, we illustrate *how* hierarchy both facilitates *and* impedes multiteam system functioning, qualifying the assumption in the literature that the most effective multiteam systems are characterized by a strong, centralized leadership team (e.g., DeChurch & Marks, 2006; Murase et al., 2014). We find that, on average, egalitarian multiteam systems are characterized by higher levels of horizontal coordination than hierarchical multiteam systems, whereas hierarchical multiteam systems are characterized by lower levels of cognitive depletion among system members. Considering the downstream consequences of horizontal coordination and cognitive depletion for multiteam system learning and performance, our work provides a more balanced view of hierarchy in multiteam systems than what currently exists in the literature.

The second contribution of this work lies in our elucidation of *why* hierarchy affects horizontal coordination and cognitive depletion. Prior researchers have noted that component teams frequently fail to share information and resources across team boundaries due to the prioritization of their own objectives, identities, and operations (Davison & Hollenbeck, 2012; de Vries et al., 2016; Kanfer & Kerry, 2012), and found that system members often struggle with the cognitively depleting complexity associated with the multiteam system task environment (Shuffler & Carter, 2018). On the one hand, component teams in hierarchical systems share even less information and fewer resources across team boundaries than component teams in egalitarian systems, theoretically because hierarchy elicits competitive mindsets, power struggles, and conflict (Anderson & Brown, 2010; Fath & Kay, 2018; Greer, de Jong, Schouten, & Dannals, 2018; Hinsz & Betts, 2012; Van Bunderen, Greer, & van Knippenberg, 2018). On the other hand, multiteam system members in hierarchical systems are characterized by lower levels of cognitive depletion—at least initially—than members of egalitarian systems because hierarchy provides structure, a sense of stability, and order (Gruenfeld & Tiedens, 2010; Magee & Galinsky, 2008), as well as a formal leadership team tasked with resolving uncertainties and delegating responsibilities. Thus, there are clear trade-offs associated with hierarchy when it comes to these two mechanisms in multiteam system contexts.

The final contribution of this work is related to our longitudinal approach, which allows us to demonstrate *when* hierarchy impacts these two mechanisms. Research on multiteam systems frequently fails to take a temporal perspective (Shuffler et al., 2015), and the conclusions one derives from cross-sectional research can diverge considerably from the conclusions one derives from longitudinal research (Mitchell & James, 2001; Ployhart & Vandenberg, 2010). The findings presented herein demonstrate that taking a cross-sectional approach would indeed obfuscate the effects of hierarchy on multiteam systems as we illustrate that (a) the benefits of hierarchy for cognitive depletion may fade as early as after the first performance episode, while (b) the drawbacks of hierarchy for horizontal coordination persist.

HIERARCHICAL ARRANGEMENTS IN MULTITEAM SYSTEMS

Now that teams constitute the "basic building blocks" of work organization (Mathieu, Hollenbeck, van Knippenberg, & Ilgen, 2017: 460), the study of task interdependencies between teams is pertinent when it comes to understanding contemporary organizational functioning. Accordingly, the study of multiteam systems—or systems of interdependent teams—has grown considerably over the past two decades (Zaccaro et al., 2020). Unfortunately, this research has found that multiteam systems frequently fail to accomplish their goals, due to the challenges associated with coordinating across team boundaries (Shuffler & Carter, 2018) and the demands associated with navigating the system's complexity (Murase et al., 2014; Porck et al., 2019). Perhaps ironically, the "premium" placed on cross-team coordination (Luciano, DeChurch, & Mathieu, 2018: 1068) and the complexity associated with the multiteam system task environment (Shuffler & Carter, 2018; Zaccaro et al., 2020) are what set multiteam systems apart from other organizational forms. In other words, the very characteristics that make multiteam systems unique are precisely the characteristics that tend to undermine their success.

Fortunately, researchers have identified a number of linkage attributes that can be strategically configured to facilitate cross-team coordination (i.e., horizontal coordination), manage system complexity, and, as a result, promote multiteam system success (Zaccaro et al., 2012). One linkage attribute that we theorize is especially relevant in achieving these objectives is the hierarchical arrangement among component teams. As noted, hierarchical arrangement reflects the distribution of decision-making authority, resource control, and responsibility for system goal attainment among component teams.

As a result, the multiteam system's hierarchical arrangement also dictates the distribution of power within the system (Shuffler et al., 2015; Zaccaro et al., 2012), such that component teams occupying higher positions in the hierarchy are afforded more power than are those that are lower in the hierarchy. Thus, going forward, "hierarchical multiteam systems" include those that are characterized by relatively unequal distributions of decision-making authority, resource control, responsibility for system goal attainment, and power among component teams. In contrast, "egalitarian multiteam systems" include those that are characterized by relatively equal distributions of decision-making authority, resource control, responsibility for system goal attainment, and power among component teams.

Although the dominant assumption in the multiteam system literature is that hierarchy is superior to egalitarianism, insights from intra-team hierarchy research suggest that hierarchy could just as easily harm as it could help multiteam systems. On the one hand, hierarchy may increase system effectiveness by providing predictability and order, thereby helping to manage the complexity inherent to multiteam systems (Zitek & Phillips, 2020; Zitek & Tiedens, 2012). On the other hand, hierarchy may decrease system effectiveness by deterring synchronization and alignment among component team activities (Cronin, Acheson, Hernández, & Sánchez, 2015; Greer et al., 2017). Thus, one body of research suggests that hierarchy might undermine multiteam system success whereas another suggests that hierarchy might enhance it.

In what follows, we elaborate on these dueling insights from intra-team hierarchy research to better understand how hierarchy might undermine horizontal coordination yet mitigate cognitive depletion in multiteam systems. We focus on these outcomes because, as noted, the need for cross-team coordination and the complexity inherent to the multiteam system environment sets these systems apart from other organizational forms, yet are areas where multiteam systems struggle. In these sections, we also link horizontal coordination and cognitive depletion to multiteam system learning (and, ultimately, performance), and we identify the system's performance episode as a moderator of our theorized relationships.

The Detriments of Hierarchy in Multiteam Systems: Reduced Horizontal Coordination

Although individuals embedded in almost any team-based structure must coordinate with one another to achieve collective goals (Luciano et al., 2018), the need for teams to coordinate "horizontally" across team boundaries is a defining feature of multiteam systems (Zaccaro et al., 2012). This is because the different tasks and goals of the component teams nested within multiteam systems are intimately linked (due to resource dependencies, goal hierarchies, and so forth; Kanfer & Kerry, 2012; Marks, DeChurch, Mathieu, Panzer, & Alonso, 2005; Zaccaro et al., 2012). As a result, the effectiveness of the broader system is contingent on successful horizontal coordination among the component teams that comprise it (Davison & Hollenbeck, 2012; Marks et al., 2005).

Unfortunately, component teams are predisposed to fail when it comes to sharing information and resources, due to the prioritization of their own proximal objectives, unique identities, and divergent skill sets (Davison & Hollenbeck, 2012; de Vries et al., 2016; Kanfer & Kerry, 2012). We argue that hierarchical differences among component teams will exaggerate these predispositions because hierarchy often induces (a) competitive mindsets (Anderson & Brown, 2010; Fath & Kay, 2018; Tost, Gino, & Larrick, 2012), (b) power struggles (Van Bunderen et al., 2018), (c) information withholding (Hinsz & Betts, 2012), and (d) interpersonal conflict (Greer et al., 2018). Hierarchy can also reduce members' willingness to contribute to their groups (Cronin et al., 2015; Greer et al., 2017), and research suggests that some of these effects are magnified when work is particularly interdependent (Anderson & Brown, 2010), as is necessarily the case in multiteam systems.

Given that hierarchy evokes competition, power struggles, and conflict, it should exaggerate component teams' tendencies to prioritize their own interests, proximal objectives, and identities over those of the larger system. That is, we anticipate that component teams in hierarchical multiteam systems will focus resources and information inward, whereas component teams in egalitarian systems will share resources and information more freely. Thus, we theorize that hierarchical multiteam systems will have lower levels of horizontal coordination (i.e., activity alignment and synchronization) among component teams than egalitarian systems.

Although this theorizing is at odds with functional perspectives on hierarchy, which argue that hierarchy is omnipresent due its ability to facilitate coordination through the creation of patterns of deference and clear channels of communication (Halevy et al., 2011; Magee & Galinsky, 2008), we argue that competition and conflict can undermine coordination. This is because coordination, competition, and conflict are likely interrelated, and thus affect one another (as team process models would imply; Ilgen, Hollenbeck, Johnson, & Jundt, 2005). That is, to the extent that teams within a multiteam system are engaged in conflict and competition with one another, their efforts at coordination are likely to be undermined. These arguments are corroborated by a recent meta-analysis, which found a negative relationship between hierarchy and coordination-enabling processes within teams (Greer et al., 2018). We believe this is the case in our context, such that the antagonistic interpersonal dynamics that often coincide with hierarchy (e.g., conflict, competition) impede horizontal coordination in multiteam systems.

Hypothesis 1. Hierarchical multiteam systems are characterized by lower levels of horizontal coordination than egalitarian multiteam systems.

The lower levels of horizontal coordination in hierarchical multiteam systems (relative to egalitarian multiteam systems) should, in turn, have a negative effect on multiteam system effectiveness, given the interdependent nature of these systems. Specifically, we argue that lower levels of horizontal coordination will interfere with "multiteam system learning," defined as the multiteam system's accumulation of task-relevant knowledge (Kozlowski & Bell, 2003; Lorinkova, Pearsall, & Sims, 2013). Multiteam system learning is an important and relevant outcome because multiteam systems are characterized by complex task environments (Shuffler & Carter, 2018), and learning has been identified as an important contributor to multiteam system task adaptation (Zaccaro et al., 2020). Additionally, learning in team-based contexts is a known precursor to heightened team performance (e.g., Ellis, Hollenbeck, Ilgen, Porter, West, & Moon, 2003; Lorinkova et al., 2013).

We argue that lower levels of horizontal coordination will impede multiteam system learning due to information loss, as the exchange of information is an inherent component of coordination (Marks, Mathieu, & Zaccaro, 2001). In contrast, higher levels of horizontal coordination will enhance learning through the prevention of inconsistencies, redundancies, and misalignments among component teams' activities (de Vries et al., 2016; Firth, Hollenbeck, Miles, Ilgen, & Barnes, 2015). That is, heightened levels of horizontal coordination ensure that component teams use their resources and energy efficiently, rather than squander them on wasteful activities and divergent strategies, thus facilitating learning.

Hypothesis 2. Horizontal coordination (a) relates positively to multiteam system learning and (b) mediates the negative indirect effect of hierarchy (vs. egalitarianism) on multiteam system learning.

The Benefits of Hierarchy in Multiteam Systems: Reduced Cognitive Depletion

Multiteam systems often create uncertainty and confusion for their members. Within multiteam systems, there is frequently ambiguity with regard to responsibilities, expectations, and objectives (Murase et al., 2014). Additionally, the specialized skill sets of team members, who may have strong within-team identities, histories, and cultures, can create a fairly complex work environment (Luciano et al., 2018). Indeed, complexity is so characteristic of multiteam systems that some researchers have contended that "the easiest way to categorize the task environments for [multiteam systems] is to simply label them as 'complex'" (Shuffler & Carter, 2018: 395; see also Zaccaro et al., 2020). The mental effort associated with navigating the uncertainty and complexity implicit in multiteam systems could result in cognitive depletion that threatens system functioning (Hagger, Wood, Stiff, & Chatzisarantis, 2010; Porck et al., 2019). With this in mind, we contend that members of hierarchical multiteam systems will have lower levels of cognitive depletion than will members of egalitarian multiteam systems.

By providing structure, stability, and order (Anderson & Brown, 2010; Gruenfeld & Tiedens, 2010; Magee & Galinsky, 2008), hierarchy can alleviate the cognitive depletion stemming from the uncertainty and complexity inherent to multiteam systems. Indeed, research broadly suggests that hierarchy helps meet humans' fundamental needs for certainty and organization (Friesen, Kay, Eibach, & Galinsky, 2014; Landau, Kay, & Whitson, 2015), and that it provides an external source of structure that offers individuals a sense that their environment is orderly and predictable (Friesen et al., 2014). The natural structure and order provided by hierarchy should help to ease the cognitive load that navigating the complex multiteam system environment places on team members.

Hierarchy also requires less mental effort than egalitarianism because the presence of a formal leadership team that is focused on resolving uncertainties regarding roles and decision-making eliminates many of the required negotiations between team members (located in different component teams) enacted during task execution in egalitarian structures. This is particularly beneficial when deliberative thinking is required on the part of component teams that are already facing cognitively demanding work (Van Berkel, Crandall, Eidelman, & Blanchar, 2015). Finally, hierarchy is more cognitively fluent than egalitarianism, meaning that hierarchical structures are easier to mentally process, understand, and remember than egalitarian structures (Winkielman, Schwarz, Fazendeiro, & Reber, 2003; Zitek & Tiedens, 2012).

In sum, we theorize that hierarchical multiteam systems, relative to egalitarian multiteam systems, will exhibit lower levels of cognitive depletion among members because hierarchy offers several cognitive benefits relevant to the multiteam system context. Hierarchy provides predictability and order, reduces uncertainty, and alleviates the mental burden associated with negotiations between team members who may not share the same identities or priorities.

Hypothesis 3. Hierarchical multiteam systems are characterized by lower levels of cognitive depletion among members than egalitarian multiteam systems.

The lower levels of cognitive depletion associated with hierarchy should, in turn, have a positive effect on multiteam system functioning by increasing the overall learning that occurs within the system. This is because heightened levels of cognitive depletion can make it difficult for team members to maintain effort, stay engaged, and execute tasks (Porck et al., 2019), process information (Schmeichel, Vohs, & Baumeister, 2003), and regulate activities (Hagger et al., 2010). Therefore, we hypothesize that hierarchical multiteam systems will have higher levels of multiteam system learning than will egalitarian multiteam systems, due to hierarchy's negative effect on cognitive depletion.

Hypothesis 4. Cognitive depletion (a) relates negatively to multiteam system learning and (b) mediates the positive indirect effect of hierarchy (vs. egalitarianism) on multiteam system learning.

The Benefits and Detriments of Hierarchy over Successive Performance Episodes

Multiteam systems, like any workgroup, develop over successive performance episodes (Ilgen et al., 2005; McGrath, Arrow, & Berdahl, 2000; Shuffler et al., 2015). That is, the state of the multiteam system may change from one performance episode to the next. As a result, the failure to examine the long-term effects of experimental interventions in multiteam systems may obscure the cumulative effects these interventions have (Mitchell & James, 2001), as evidenced by recent research that has taken a developmental approach to the study of component teams (Matusik, Hollenbeck, Matta, & Oh, 2019). Although we theorize that hierarchy will, on average, have negative effects on both horizontal coordination and cognitive depletion, we also argue that, as multiteam systems engage in successive performance episodes, (a) disparities in horizontal coordination attributable to hierarchical arrangement will increase, whereas (b) disparities in cognitive depletion attributable to hierarchical arrangement will decrease.

Horizontal coordination. Early in their lifecycles, systems of individuals (e.g., teams) develop self-reinforcing sets of routines (Edmondson, Bohmer, & Pisano, 2001; Gersick & Hackman, 1990), or repetitive patterns of interdependent action (Parmigiani & Howard-Grenville, 2011). Although systems may become entrained in their routines (Ancona & Chong, 1996), meaning that routines can persist at stable levels over performance episodes, routines can also, perhaps counterintuitively, lead to change (Feldman, 2000; Feldman & Pentland, 2003). This is because there is an internal dynamic to routines. After engagement in some routine behavior, actors often reflect on the outcomes associated with this latest iteration and determine whether the behavior returned a favorable result (Feldman, 2000). If said behavior returned a favorable result, this reinforces the behavior in subsequent performance episodes. In other words, patterns of interaction (i.e., patterns of teamwork; Kozlowski & Bell, 2003) deemed effective are likely to persist, and potentially increase in frequency, over performance episodes.

Assuming that egalitarian multiteam systems engage in higher levels of horizontal coordination than their hierarchical counterparts from their inception, the literature on routines suggests that the disparity between egalitarian and hierarchical multiteam systems—in terms of horizontal coordination—should increase with successive performance episodes. Egalitarian multiteam systems should see the connection between horizontal coordination and system success clearly and quickly, whereas this connection may be obscured for hierarchical multiteam systems, which engage in horizontal coordination at a lower frequency. Thus, we theorize that the difference in horizontal coordination between hierarchical and egalitarian multiteam systems will increase over performance episodes as egalitarian multiteam systems more quickly discover the benefits associated with this behavior and adjust their operating routines accordingly.

Hypothesis 5. Hierarchical arrangement interacts with performance episode, such that differences in horizontal coordination between hierarchical and egalitarian multiteam systems increase over episodes.

Cognitive depletion. We also argue that multiteam system members may no longer need to rely on hierarchy as a cognitive "crutch" that organizes and simplifies the system once they have had sufficient time to mentally process, and accumulate experience working within, the multiteam system environment. This is because individuals develop cognitive structures, such as "schemas" (knowledge structures representing a concept and its attributes; Fiske, 1995) and "mental models" (knowledge structures used to understand and describe a system's purpose, functions, and form [Rouse & Morris, 1986]), as they interact with their environments. Naturally, the formation of these structures is facilitated by experience (Fiske & Dyer, 1985; Fiske & Taylor, 1991; Richter, Bays, Jeyarathnaraja, & Simons, 2019). In other words, repeated exposure to the concept or system upon which the schema or mental model is based should encourage the formation of these cognitive structures. In our context, repeated exposure to the multiteam system (i.e., engagement in successive performance episodes) should facilitate the formation of members' cognitive structures regarding the system, providing them with a general understanding of it. As a result, they may no longer need to lean on the structure and fluency offered by hierarchy as the system matures—it should seem less complex and ambiguous with repeated exposure.

Relatedly, responsibilities, expectations, and objectives among team members should become clearer as individuals continue to work together because team member interaction also facilitates the development of *team* cognitive structures (e.g., team mental models, transactive memory; Lorinkova et al., 2013; Pearsall, Ellis, & Bell, 2010). These team cognitive structures reduce uncertainties regarding responsibilities and expectations that would otherwise need to be negotiated between team members during task execution. That is, activities will be executed more automatically once team cognitive structures are formed (Firth et al., 2015; Murase at al., 2014). As a result, a formal leadership team tasked with resolving uncertainties may no longer be necessary as members' roles and the system's operations become less ambiguous and more entrained. Given that both the perceived complexity and uncertainty associated with multiteam systems diminish over performance episodes, we theorize that differences in cognitive depletion between hierarchical and egalitarian multiteam systems will decrease over performance episodes.

Hypothesis 6. Hierarchical arrangement interacts with performance episode, such that differences in cognitive depletion between hierarchical and egalitarian multiteam systems decrease over episodes.

Multiteam System Learning and Multiteam System Performance

Finally, we anticipate that multiteam system learning relates positively to system performance. The positive link between learning and performance has been evidenced in both the literatures on standalone teams (e.g., Edmondson, 1999; Ellis et al., 2003; Lorinkova et al., 2013) and multiteam systems (Zaccaro et al., 2020). Moreover, multiteam system learning should prove highly beneficial to multiteam systems given the uniquely complex nature of their task environments (Shuffler & Carter, 2018; Zaccaro et al., 2020). Thus, we hypothesize that multiteam system learning relates positively to multiteam system performance and will serve as a second-stage mediator of the positive and negative indirect effects of hierarchy on performance.

Hypothesis 7. Multiteam system learning (a) relates positively to multiteam system performance, (b) mediates the negative indirect effect of hierarchy on multiteam system performance (via horizontal coordination), and (c) mediates the positive indirect effect of hierarchy on multiteam system performance (via cognitive depletion).

METHOD

The data examined herein were collected as part of a broader program of research focused on the study of multiteam systems as they operate over time, and thus there exists another study that utilizes a portion of the data presented below (Matusik et al., 2019). In detail, Matusik and colleagues (2019) examined how the transition from standalone teams to component teams nested within multiteam systems affected a variety of team processes and emergent states. Although there is no variable overlap between Matusik et al. (2019) and the present study, Matusik et al. (2019) did utilize data collected from 345 of the 1,060 participants who took part in this study. Also worth noting is that Matusik et al. (2019) examined their phenomena at the team level, whereas we aggregated and examined our phenomena at the multiteam system level. Future researchers, and especially meta-analysts, should keep this overlap in mind when reviewing and summarizing the multiteam system literature.

Participants and Procedure

To fulfill requirements for two sequential, entry-level business courses, 1,060 students enrolled in a U.S. university took part in the present study. Participants averaged 18.06 years of age, 56.8% identified as male, and 68.2% identified as Caucasian. We randomly assigned participants to 228 four- or five-person teams at the start of the semester, for an average of 4.65 students per team. We later assigned these 228 teams to one of 76 12- to 15-person multiteam systems (we provide more information on multiteam system assignment below).

Data collection for this experimental study represented a large-scale effort that employed a cohort research design (Cook & Campbell, 1979; Shadish, Cook, & Campbell, 2002) and spanned five years. Specifically, each year of data was collected from a distinct cohort that only participated in the study for that particular year. Each year, each cohort of participants attended laboratory sessions on five occasions. In their first session, the 228 standalone teams underwent hands-on and video training in the Leadership Development Exercise (LDX) simulation, the task used in all four subsequent sessions. LDX is a 10-round simulation that has been used in prior multiteam system research (e.g., Firth et al., 2015; Lanaj et al., 2013). LDX requires participants to utilize a variety of offensive, defensive, and intelligence-collecting assets to identify and destroy hidden enemy targets on a 16 × 16 game grid (see Lanaj et al., 2013, for a visualization of this grid). In addition to identifying and destroying enemy targets, participants must protect their own assets and "friendly base" from enemy attacks.

In their second session, the 228 teams completed the full LDX simulation as standalone teams. The purpose of this session was to (a) ensure that our future component teams were "real" teams (Hackman, 2004) with their own history prior to multiteam system assignment, and (b) assess standalone team ability for the sake of assigning teams to component team roles in their third session (more information on role assignment is provided below). In their remaining three sessions (which we label T1, T2, and T3), participants completed the LDX simulation in their assigned multiteam systems ($n = 76$), with each team fulfilling a specific function. In total, we had data on 224 multiteam system performance episodes, rather than 228 multiteam system performance episodes (76 multiteam systems × 3 performance episodes), due to technical and logistical issues.

Manipulation

Our hierarchical arrangement manipulation consisted of two conditions: a hierarchical condition ($n = 44$) and an egalitarian condition ($n = 32$).[1] Figure 1 provides visualizations of our hierarchical and egalitarian multiteam systems' structures. These visualizations resemble the organizational charts that we used as part of our manipulation, detailed below. In the hierarchical condition, there were clear differences between teams in terms of hierarchical rank. In the egalitarian condition, there were no between-team differences in hierarchical rank. We manipulated hierarchy with visual organizational charts, verbal instructions in lab sessions, and design elements of the task related to decision-making. We elaborate on each of these below.

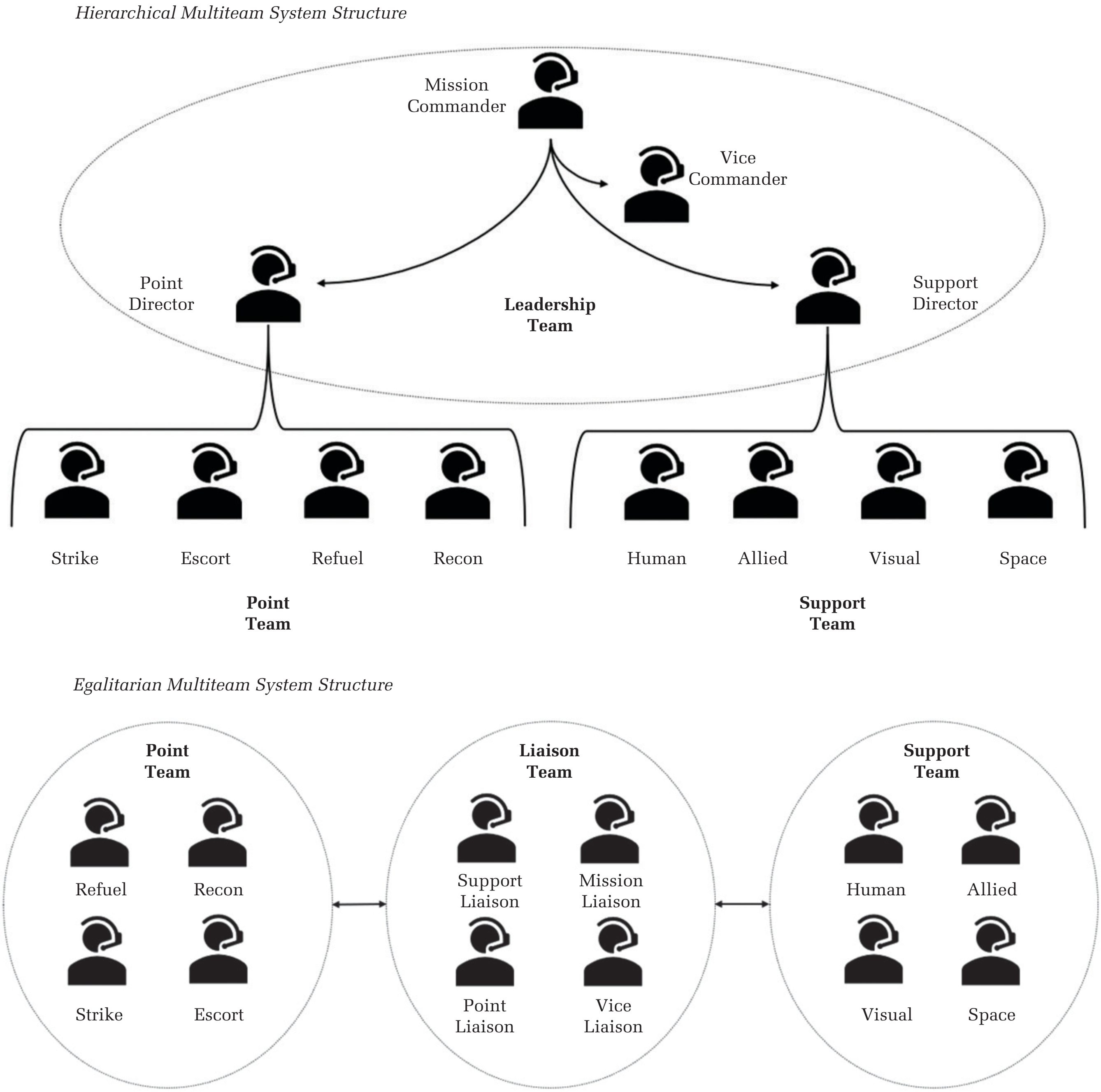
Hierarchical condition. In this condition, we assigned the three teams nested within each multiteam system to one of three component team roles: the *point* team role, the *support* team role, or the *leadership* team role. The leadership team wielded formal hierarchical and decision-making authority. We chose to designate this team the "leadership" team, rather than use an alternative label, as teams charged with integration (i.e., activity alignment, information dissemination, and mutual adjustment) in multiteam systems vary along a continuum from *leadership* teams to *liaison* teams (de Vries et al., 2016). Thus, we used terminology already established in the multiteam system literature. We used each team's relative performance as a standalone team to determine role assignments, with the highest-performing team in a given multiteam system assigned the role of the leadership team, the second highest-performing team assigned the role of the support team, and the lowest-performing team assigned the role of the point team. Once assigned, teams remained in the same multiteam system and component team role throughout the remainder of the study (T1–T3; i.e., all sessions as a multiteam system).

During course lectures following ability assessments of standalone teams, but before participants completed LDX as a multiteam system (i.e., before session T1, the first multiteam system performance episode), researchers informed teams that they would be assigned their component team roles as a function of their team's ability. Researchers also provided and explained an organizational chart during these lectures that depicted the hierarchical arrangement of the multiteam system, with leadership team members positioned at the top of the triangular hierarchy and point and support team members positioned at the bottom (i.e., underneath leadership team members; see Figure 1). We made our assignment procedures known because differences in competency between individuals shape implicit hierarchical rankings, with more competent individuals often conferred higher rank than less competent individuals (Magee & Galinsky, 2008). That is, we wanted to ensure that the hierarchical arrangement we implemented was consistent with how competency shapes implicit hierarchical judgements.

At T1, T2, and T3, we reinforced the hierarchical manipulation with verbal instructions. For example, we explained that members of the leadership team had "ultimate responsibility for each team member's

[1] The unequal cell sizes (44 hierarchical and 32 egalitarian multiteam systems) are attributable to our cohort research design. We could not control the number of individuals who enrolled in the program in a given year. We tested our theoretical model using an analytical approach that accommodates unequal cluster sizes, noted below.

FIGURE 1
A Visualization of Multiteam System Hierarchical Arrangement



individual actions," consistent with Zaccaro et al.'s (2012: 14) seminal conceptualization of multiteam system hierarchical arrangement, which reflects the "ordering of teams according to levels of responsibility." As another example, we explained that members of the leadership team had "final say over all operations and intelligence missions carried out during the entire game," and thus were highly influential as they wielded decision-making authority. Once again, this is consistent with Zaccaro et al.'s (2012: 14) conceptualization of power distribution, which is shaped by hierarchical arrangement and reflects component teams' relative influence within the multiteam system.

After researchers provided instructions, but before the simulation commenced, participants completed a comprehension check in which they selected their particular role from within an organizational chart. In the hierarchical condition, these charts were pyramid shaped, with members of the leadership team positioned higher in the chart than those in the support or point teams (see Figure 1). The simulation was programmed so that all participants had to pass this comprehension check before it would launch.

Finally, we programmed the LDX simulation so that individuals in leadership roles had final control over the placement of any defensive, offensive, and intelligence-collecting assets on the game grid. Specifically, each round of the 10-round simulation consisted of five distinct phases: the "staff planning" phase, the "director planning" phase, the "commander planning" phase, the "execution" phase, and the "critique and analyze" phase. In the first phase, which was three minutes long, the point and support teams sent out their respective assets onto the game grid. In the second and third phases, which were two minutes and one minute long (respectively), members of the leadership team could physically add, move, or remove the assets placed on the grid by the point and support teams, while the point and support teams were physically unable to move any assets. Thus, the leadership team was given a high level of decision-making authority and structural power, or "actual control over valued resources" (Tost & Johnson, 2019: 26), as they had ultimate say over all point and support team operations within each round. In the fourth phase (the "execution" phase), multiteam systems discovered and/or destroyed enemy targets. Finally, in the fifth phase team members noted the targets they had discovered and/or destroyed and determined next steps. This five-phase cycle then repeated in each subsequent round.

Egalitarian condition. In this condition, we also assigned the three teams nested within each multiteam system to one of three component team roles: the *point* team role, the *support* team role, or the *liaison* team role. We used the term "liaison" to avoid signaling formal hierarchical authority. We also chose this particular term because, as noted, teams charged with integration in multiteam systems vary along a continuum from *leadership* teams to *liaison* teams (de Vries et al., 2016). Thus, we again used terminology already established in the multiteam system literature. Notably, the only component team role that differed in this condition was the "liaison" team, which replaced the "leadership" team. Role assignments were once again determined by team ability, with the highest-performing team in a given multiteam system assigned the role of the liaison team, the second highest-performing team assigned the role of the support team, and the lowest-performing team assigned the role of the point team. Just like in the hierarchical condition, teams in the egalitarian condition remained in the same multiteam system and component team role throughout the remainder of the study.

Although we assigned teams to their component team roles due to their performance as standalone teams, thus ensuring consistent assignment procedures between our two conditions, we did not make this information public to ensure that participants did not perceive explicit or implicit hierarchical differences between teams (Magee & Galinsky, 2008). Additionally, researchers provided an organizational chart depicting multiteam system hierarchical arrangement during course lectures that displayed the point, support, and liaison teams at the same hierarchical level (see Figure 1). Thus, the organizational chart was completely "flat," such that no members of one team were of higher rank than members of any other team in the system.

At T1, T2, and T3, we reinforced our egalitarian condition with verbal instructions. For example, we explained that the members of the liaison team were not "solely responsible" for the team's actions or success, and that they were not of any "higher rank than any other" individual. Instead, we stated that the multiteam system's success was the responsibility of the system as a whole. As another example, we explained that members of the liaison team did not "have final say over all operations and intelligence missions," and thus were no more influential than any other individual or component team in the multiteam system. After researchers provided instructions, but before the simulation commenced, participants completed a comprehension check in which they selected their role from within an organizational chart. In the egalitarian condition, these charts were rectangular, with no members of any team deliberately positioned higher than others (see Figure 1). As in the hierarchical condition, we programmed the simulation so that all participants had to pass this check before it would launch.

Finally, we programmed the LDX simulation so that individuals in liaison roles did not have direct control over the various defensive, offensive, and intelligence-collecting assets on the game grid. Although the liaison team could make recommendations to the point and support teams regarding asset allocation, tactics, and strategy (as their primary function was integration), they were not structurally empowered to make or change asset allocation decisions. Similar to the leadership team in the hierarchical condition, they represented a third party that served as an information hub and communication conduit for the multiteam system. In this condition, each round of the 10-round simulation consisted of only three phases, rather than five: the "staff planning" phase, the "execution" phase, and the "critique and analyze" phase. The first phase operated as it did in the hierarchical condition—point and support team members sent out their respective assets onto the game grid. However, this phase differed in the egalitarian condition in that it was now six minutes long, which we did to ensure that multiteam systems in both the hierarchical and egalitarian conditions had the same total amount of time to place assets on the grid before execution. Like before, team members discovered and/or destroyed enemy targets in the execution phase and recorded the targets they had discovered and/or destroyed (as well as determined next steps) in the final phase.

Measures

Horizontal coordination. Consistent with prior research (Davison et al., 2012), we operationalized horizontal coordination as the total number of "integrated missions" the multiteam system engaged in over the entire 10-round simulation. We captured this variable in each of the three performance episodes. Also consistent with prior research (Davison et al., 2012), we construed horizontal coordination as a multiteam system-level variable because (a) multiteam system operations and objectives are inherently interdependent and (b) integrated missions involved all assets collectively held by the multiteam system. An integrated mission occurs when point team assets (offensive and defensive assets) are sent to a location on the game grid that also contains a support team asset (an intelligence-collecting asset).

Although integrated missions involve the collocation of assets held by the support and point teams, and therefore ostensibly represent coordination between just these two teams, it is important to reemphasize the integration function fulfilled by the leadership or liaison team. Leadership/liaison teams have a broader understanding of the task environment, the system's overall strategy, and the system's collective capabilities than the other component teams (Davison et al., 2012). As a result, they are intimately involved in integrated missions, acting as information and communication conduits between teams. In fact, our laboratory was structured so that the leadership/liaison team was physically positioned between the point and support teams. Thus, the number of integrated missions a multiteam system engaged in captures the extent to which *all* component teams "aligned and synchronized" their activities with each other (de Vries et al., 2016: 1824), the definition previously provided for horizontal coordination.

The strategic purpose in sending a point team asset and a support team asset to the same location is to determine where the support team's intelligence-collecting assets are most accurate. Whereas point team assets reveal targets at 100% certainty no matter where the targets are located on the grid, each of the support team's four types of intelligence-collecting assets (which have their own unique labels) were 95% accurate on just half of the 16 $\times$ 16 grid: the "south" (rows 1–8), "north" (rows 9–16), or "central" sections (rows 5–12), or on "the borders" (rows 1–4 and 13–16). Therefore, if a point team asset reveals an enemy target in a given square on the game grid, and a support team asset sent to the same square reveals the same target, this signals that the support team asset is likely accurate in that area. In the hands-on training and in each subsequent lab session, researchers explained the strategic benefits of integrated missions and emphasized that the highest-performing multiteam systems were those that coordinated across team boundaries to determine where intelligence-collecting support team assets were most accurate. Because there were twice as many support team assets as there were point team assets, early identification of where the support team assets were accurate was critical for success.

Cognitive depletion. We measured cognitive depletion after researchers provided in-lab instructions, but prior to the 10-round simulation (consistent with the temporal order of these variables in our model), in each of the three performance episodes. We measured depletion using five items (α = .88) from Johnson, Lanaj, and Barnes (2014). Team members responded to each item on a 5-point, Likert-type scale (1 = *very slightly or not at all*, 5 = *very much*). An example item includes "Right now, my mental energy is running low." We used the individual as the referent because we construed cognitive depletion as an intrapsychic phenomenon. That is, *team members* become cognitively depleted, not component teams or multiteam systems. For, analytical purposes, however, we aggregated this variable up to the multiteam system level by averaging each multiteam system's members' responses and treating it as an additive construct (Chan, 1998), consistent with prior multiteam system research (Porck et al., 2019). To justify aggregation, we calculated $ICC_{(1)}$ and $ICC_{(2)}$ using output generated from nested analyses of variance (ANOVAs) (as we had repeated measures within multiteam systems). $ICC_{(1)}$ was equal to .12 and $ICC_{(2)}$ was equal to .62, justifying aggregation (Bliese, 2000; James, 1982; James, Demaree, & Wolf, 1984).

Multiteam system learning. As noted above, the support team controlled four different types of assets, and each of these assets differed in terms of where they were most accurate. We operationalized multiteam system learning as the number of times multiteam systems sent these assets to zones of high accuracy within each performance episode, consistent with prior research (Lorinkova et al., 2013; though they referred to this variable as *team learning* as their unit of analysis was standalone teams). Importantly, these high-accuracy zones were entirely unknown at the beginning of the simulation and changed from one performance episode to the next (i.e., an asset's high-accuracy zone in T1 was not necessarily the same in T2 or T3). That is, participants had to relearn this part of their task every time they engaged in a new performance episode.

Again, because these high-accuracy zones were specific to the support team's intelligence-collecting assets, one might misconstrue this variable as *support team learning* rather than *multiteam system learning*. However, the identification of high-accuracy zones was a collective effort. Support team assets often providedfalse positives and false negatives in their low-accuracy zones (they were 95% accurate in their high-accuracy zones and only 5% accurate in their low-accuracy zones), and therefore it was nearly impossible for the support team to discover high-accuracy zones on their own (i.e., they needed to integrate their assets with point team assets, which were 100% accurate across all zones). Additionally, the leadership/liaison team's primary function was integration, acting as information and communication conduits between teams, and therefore these teams were essential in this discovery process. Finally, all component teams were invested in the discovery of high-accuracy zones because this facilitated the identification of enemy targets (which needed to be eliminated to accrue points). All teams within the multiteam system actively contributed to the discovery of these zones, and therefore we construe this as a multiteam system-level variable.

Multiteam system performance. Multiteam system performance was an objective function of points gained from destroying enemy targets minus points lost due to enemy attacks. Naturally, this was a multiteam system-level variable measured in each performance episode.

Control variables. First, we controlled for the total number of support team assets multiteam systems deployed across the entire 10-round simulation in each performance episode.[2] We wanted to ensure that the number of times support team assets were sent to their high-accuracy zones (our operationalization of multiteam system learning) was not simply a function of multiteam systems placing a large number of support team assets randomly on the game grid. Second, we controlled for the total number of times two different support team assets were sent to the same location on the game grid in each performance episode. We controlled for this because the high-accuracy zones of the different support assets overlapped to varying extents, and therefore another potential strategy multiteam systems might have

[2] We took steps to ensure that our measure of horizontal coordination was distinct from general effort, and to ensure that the relationship between hierarchical arrangement and multiteam system learning, via horizontal coordination, was not confounded by effort. Specifically, we examined both (a) the number of support team assets sent and (b) the number of point team assets sent as control variables in the prediction of multiteam system learning. We ultimately found that the former related to multiteam system learning ($p < .01$) whereas the latter did not ($p = .55$). Given the known issues associated with retaining statistically unrelated controls (Becker, 2005; Spector & Brannick, 2011), we did not retain the non-significant control variable in our focal analyses. Also worth noting is that we did not confound effort with our two conditions. A series of ANOVAs revealed that our two conditions did not differ in terms of the number of point team assets sent in performance episode one ($p = .12$), two ($p = .86$), or three ($p = .91$), or the number of support team assets sent in performance episode one ($p = .59$), two ($p = .54$), or three ($p = .77$). Finally, a series of ANOVAs revealed that there were no significant differences between performance episodes in terms of the number of support team assets ($p = .93$) or point team assets ($p = .90$) deployed during the simulation. Even when we broke this into different conditions (hierarchical vs. egalitarian), ANOVA results suggested that there were no differences between performance episodes in terms of support (hierarchical: $p = .92$; egalitarian: $p = .82$) or point (hierarchical: $p = .69$; egalitarian: $p = .79$) team assets sent. Likewise, when we ran a 2 (condition) $\times$ 3 (performance episode) ANOVA, there was no effect on either the number of support ($p = .91$) or point ($p = .60$) team assets sent. Therefore, we do not believe participants, in either condition, disengaged from the task over time.

attempted to determine high-accuracy zones involved placing two different support team assets in the same location. For example, had the multiteam system determined which of its support assets was accurate in the "southern" part of the game grid (rows 1–8), it could have then strategically overlapped these assets with *different* support team assets to determine which were accurate in the "central" region of the game grid (rows 5–12) or on "the borders" of the game grid (rows 1–4 and 13–16).

Yet, this strategy typically backfires. By overlapping their assets, multiteam systems not only underutilize their resources but may also mistakenly believe they have discovered a high-accuracy zone for one support asset and then use that asset to guide the placement of other support assets (a "blind leading the blind" scenario). As noted above, it is nearly impossible for the support team to discover high-accuracy zones on their own as their assets often provide false positives and false negatives in their low-accuracy zones. Given that we wanted to explicitly capture multiteam system learning as a function of coordination between component teams and member cognitive depletion, we partialled out the variance explained by this faulty strategy.

Analytical Approach

Due to the nested nature of our data (three performance episodes nested within each multiteam system), we conducted multilevel path analysis with full information maximum likelihood estimation in Mplus 7 (Muthén & Muthén, 2012). We chose this method not only due to the multilevel nature of our data, but also because it accommodates for unbalanced cluster sizes (Preacher, 2011; Preacher, Zyphur, & Zhang, 2010). The Level 1 variables included the repeated observations of horizontal coordination, cognitive depletion, multiteam system learning, multiteam system performance, our control variables, and performance episode number. Our moderator—performance episode number—took on a value of 2, 3, or 4 (corresponding to multiteam system performance episodes T1, T2, and T3) because participants' first time as a multiteam system represented their second performance episode overall (recall that they previously performed once as standalone teams).

The only Level 2 variable was our independent variable—hierarchical arrangement—which took on a value of "0" (egalitarian) or "1" (hierarchical), and was stable across all performance episodes. In other words, all variables aside from hierarchical arrangement were measured within each performance episode, and therefore were nested within multiteam systems. See Figure 2 for a visual representation of our model. We tested our hypotheses regarding mediation and serial mediation using Monte Carlo simulations with 20,000 replications (Selig & Preacher, 2008).

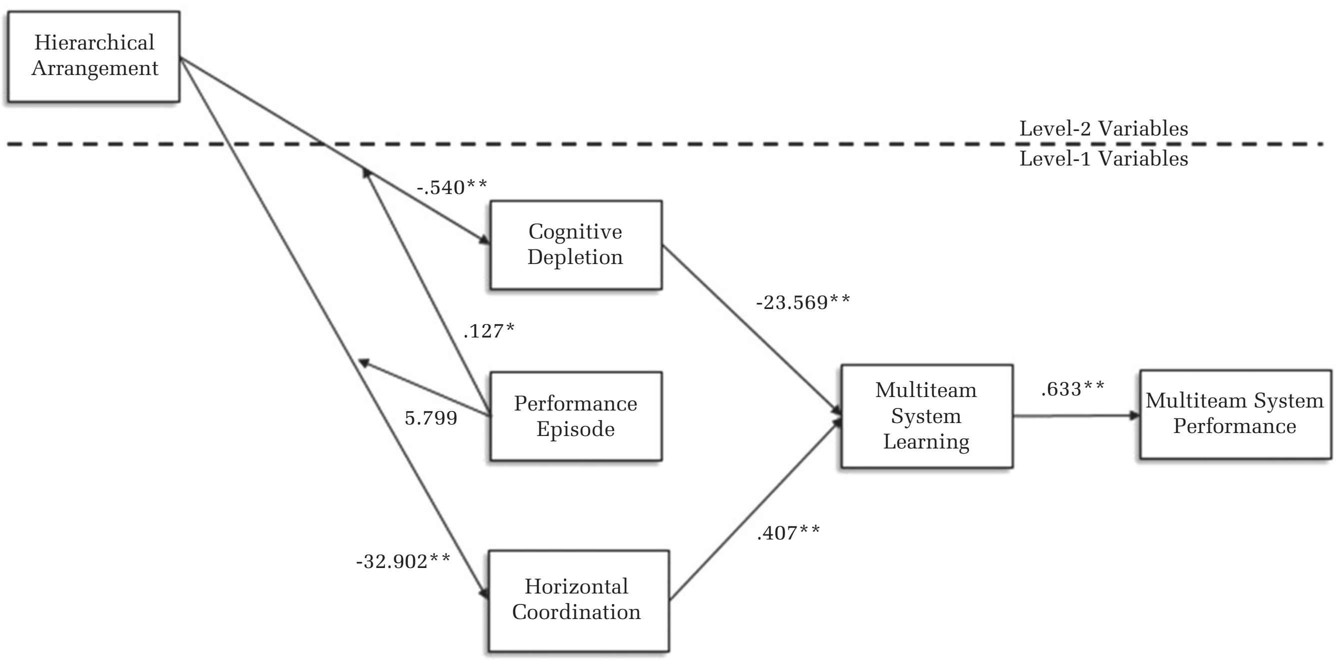
We tested the moderating role of performance episode by (a) modeling the interaction between hierarchical arrangement and performance episode in our multilevel path analysis, (b) conducting pairwise comparisons between the hierarchical and egalitarian conditions within each performance episode, (c) calculating the index of moderated mediation (Hayes, 2015), and (d) performing Monte Carlo simulations with 20,000 replications on this index. The index of moderated mediation indicates whether the indirect effect is conditional on the value of the moderator, such that it equates to the difference between two conditional indirect effects (Hayes, 2015). For testing pairwise comparisons across our performance episodes, we used Stata version 13.1 and accounted for nesting by setting the panel by multiteam system identification number and session, which informs the software that the order of performance episodes is relevant.

RESULTS

Table 1 provides the descriptive statistics of and correlations among all variables.[3] Both of our control variables were related to our measure of multiteam system learning in the anticipated directions. The total number of support team assets deployed by multiteam systems across the entire 10-round simulation was positively related to multiteam system

[3] The negative correlation between performance episode and multiteam system performance was an artifact of the three different simulation experiences—specifically, steps taken to keep the simulation engaging. In each episode, target sets appeared in different locations (and target sets, in general, differed in the third episode), and support team assets had different high-accuracy zones. We made these changes so participants would not rely on memory to execute the task. Between the first and second performance episodes, the target sets were similar but were in opposite locations on the game grid. In the third episode, targets were in different locations *and* differed. For example, we removed all of the stationary (i.e., non-moving) highest-value targets and replaced them with mobile targets, which moved to a new location on the grid each round (aside from rounds 4, 7, and 10), making them more difficult to eliminate. This made it more difficult for multiteam systems to accumulate points in the third performance episode.

FIGURE 2
Results



Notes: Unstandardized path estimates presented. *Hierarchical arrangement*: 1 = hierarchical, 0 = egalitarian. Control variables omitted for ease of presentation. Number of support team assets sent had a positive effect on *Multiteam system learning* ($B = 0.587$, $p < .001$), but no effect of *Multiteam system performance* ($B = -0.209$, $p = .148$). Number of times support team assets overlapped had a negative effect on *Multiteam system learning* ($B = -0.146$, $p < .001$), but no effect of *Multiteam system performance* ($B = 0.079$, $p = .193$). *Hierarchical arrangement* did not have a direct effect on *Multiteam system learning* ($B = 6.680$, $p = .479$) or *Multiteam system performance* ($B = 6.367$, $p = .633$) after accounting for indirect effects.
* $p < .05$
** $p < .01$

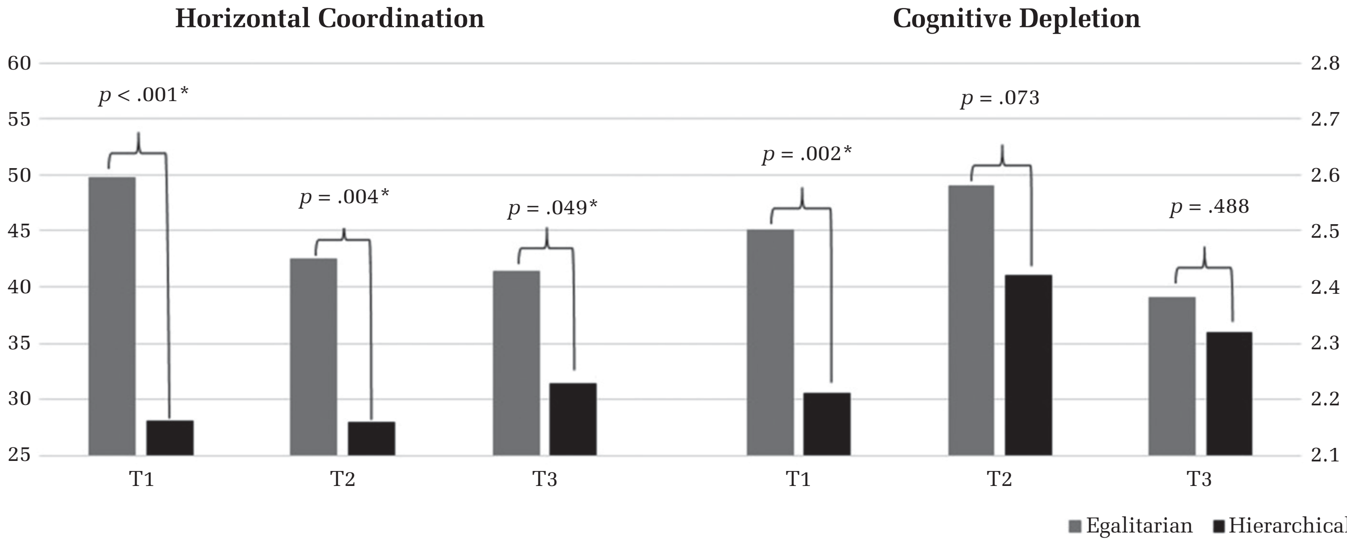
learning ($B = 0.59$, $SE = 0.07$, $p < .01$), while the total number of times two different support team assets were sent to the same location on the game grid was negatively related to multiteam system learning ($B = -0.15$, $SE = 0.04$, $p < .01$). Thus, we retained both of our control variables, as both were predictive of multiteam system learning (Spector & Brannick, 2011).

TABLE 1
Descriptive Statistics of and Correlations among Focal Variables

Variable	Mean	*SD*	1	2	3	4	5	6	7	8
1 Hierarchical arrangement	—	—	—	−.34*	−.21*	.06	.00	−.06	−.14*	.08
2 Horizontal coordination	35.72	23.03		—	.05	.16*	−.02	.09	.35*	−.10
3 Cognitive depletion	2.39	0.42		.12	—	−.10	.01	.06	−.06	.14*
4 Multiteam system learning	202.50	42.58		.18*	−.20*	—	−.07	.41*	−.14*	.27*
5 Performance episode	—	—		−.04	.01	−.08	—	.00	.01	−.35*
6 Number of support team assets sent	315.99	25.10		.21*	−.02	.46*	.00	—	.02	.13
7 Number of times support assets overlapped	38.62	58.03		.36*	.04	.12	.00	.17	—	−.05
8 Multiteam system performance	78.67	66.49		−.10	.17	.27*	−.35*	.12	.05	—

Notes: $n = 76$ multiteam systems. Mean and standard deviation across all performance episodes. *Hierarchical arrangement*: 1 = hierarchical, 0 = egalitarian. *Performance episode*: 2 = T1, 3 = T2, 4 = T3. Within-multiteam system correlations are presented below the diagonal, while between-multiteam system correlations are presented above the diagonal. Because *Hierarchical arrangement* is a between-multiteam system variable, we have excluded correlations from below the diagonal.
* $p < .05$

FIGURE 3
Pairwise Comparisons across Performance Episodes



Note: The leftmost *y*-axis represents values for horizontal coordination, while the rightmost *y*-axis represents values for cognitive depletion.
* $p < .05$

Tests of Hypotheses

Figure 2 provides the unstandardized path estimates resulting from our multilevel path analysis. The effects of our control variables and the effects of hierarchical arrangement on multiteam system learning and performance are omitted for ease of presentation but are noted below Figure 2. In support of Hypothesis 1, horizontal coordination was significantly lower in hierarchical multiteam systems than in egalitarian multiteam systems ($B = -32.90$, $SE = 9.29$, $p < .01$). Supporting Hypotheses 2a and 2b, horizontal coordination had a positive effect on multiteam system learning ($B = 0.41$, $SE = 0.15$, $p < .01$) and mediated the negative indirect effect of hierarchy (vs. egalitarianism) on multiteam system learning as the 95% Monte Carlo confidence interval for this indirect effect was negative and excluded zero (IE = −13.39, 95% CI [−25.34, −3.27]).

In support of Hypothesis 3, cognitive depletion was significantly lower in hierarchical multiteam systems than in egalitarian multiteam systems ($B = -.54$, $SE = 0.15$, $p < .01$). Supporting Hypotheses 4a and 4b, cognitive depletion had a negative effect on multiteam system learning ($B = -23.57$, $SE = 7.63$, $p < .01$) and mediated the positive indirect effect of hierarchy (vs. egalitarianism) on multiteam system learning (IE = 12.73, 95% CI [4.53, 21.25]).

In Hypothesis 5, we predicted that differences in horizontal coordination between hierarchical and egalitarian multiteam systems would increase with successive performance episodes. The interaction term in our multilevel path analysis was not significant ($B = 5.80$, $SE = 3.03$, $p = .06$) and the pattern of results did not support Hypothesis 5 (see Figure 3). Although horizontal coordination was significantly lower in hierarchical multiteam systems ($M = 28.07$, $SD = 14.59$) than in egalitarian multiteam systems ($M = 49.78$, $SD = 28.59$) at T1 (difference = 21.71, $p < .01$), T2 (hierarchical: $M = 27.93$, $SD = 13.29$; egalitarian: $M = 42.84$, $SD = 26.65$; difference = 14.91, $p < .01$), and T3 (hierarchical: $M = 31.48$, $SD = 16.64$; egalitarian: $M = 41.77$, $SD = 30.82$; difference = 10.30, $p < .05$), the difference between conditions did not *increase* over performance episodes. Finally, the index of moderated mediation was not significant, as the 95% Monte Carlo confidence interval for this estimate included zero (*index* = 2.36, 95% CI [−0.03, 7.08]), indicating that the indirect effect of hierarchy on learning (via coordination) was not conditional on performance episode.

In Hypothesis 6, we predicted that differences in cognitive depletion between hierarchical and egalitarian multiteam systems would decrease with successive performance episodes. Both the interaction term in our multilevel path analysis ($B = 0.13$, $SE = 0.05$, $p < .05$) and the corresponding pattern of results provided support for Hypothesis 6 (see Figure 3). Cognitive depletion was significantly lower in hierarchical multiteam systems ($M = 2.21$,

$SD = 0.29$) than it was in egalitarian multiteam systems ($M = 2.50$, $SD = 0.33$) at T1 (difference = 0.29, $p < .01$). However, this difference was smaller and not significant at T2 (hierarchical: $M = 2.42$, $SD = 0.47$; egalitarian: $M = 2.58$, $SD = 0.47$; difference = 0.17, $p = .07$) and T3 (hierarchical: $M = 2.32$, $SD = 0.39$; egalitarian: $M = 2.38$, $SD = 0.44$; difference = 0.06, $p = .49$). Additionally, the index of moderated mediation was significant, as the 95% Monte Carlo confidence interval around this estimate excluded zero (*index* = −2.99, 95% CI [−6.36, −0.58]), indicating that the indirect effect of hierarchy on multiteam system learning (via cognitive depletion) was conditional on performance episode.

Finally, in Hypothesis 7, we argued that multiteam system learning acted as a second-stage mediator, mediating the negative (via horizontal coordination) and positive (via cognitive depletion) indirect effects of hierarchy on multiteam system performance. Although multiteam system learning was positively and significantly related to multiteam system performance ($B = 0.63$, $SE = 0.16$, $p < .01$), supporting Hypothesis 7a, results indicated that multiteam system learning did not serve as a second-stage mediator for the negative indirect effect of hierarchy on multiteam system performance (via hierarchy's negative effect on horizontal coordination), as the 95% Monte Carlo confidence interval for this effect included zero (IE = −8.48, 95% CI [−17.78, 0.29]). Thus, Hypothesis 7b was not supported. However, results indicated that multiteam system learning did serve as a second-stage mediator for the positive indirect effect of hierarchy on multiteam system performance (via hierarchy's negative effect on cognitive depletion), as the 95% Monte Carlo confidence interval for this effect excluded zero (IE = 8.06, 95% CI [0.92, 16.73]). Thus, Hypothesis 7c was supported.[4]

DISCUSSION

Rather than argue that hierarchy is either "good" or "bad" for multiteam systems, we instead argued and demonstrated that hierarchy has simultaneous positive and negative effects. On the one hand, we found that hierarchical multiteam systems were, on average, characterized by lower levels of horizontal coordination than were egalitarian systems. On the other hand, we also found that hierarchical multiteam systems were, on average, characterized by lower levels of cognitive depletion than were egalitarian systems. Moreover, our results suggest that the benefits hierarchy has for cognitive depletion wane over performance episodes, whereas the detriments hierarchy has for horizontal coordination persist. Together, these findings have several theoretical and practical implications, and spur several questions for future research.

Theoretical Contributions

The first contribution of this work is that it provides much-needed nuance to the literature by illustrating *how* hierarchy both helps and harms multiteam systems, which we accomplished via the integration of insights from research on hierarchy in standalone teams (or research on intra-team, opposed to inter-team, hierarchies). Unlike the standalone teams literature, which recognizes that hierarchy can be both functional and dysfunctional for teams (Anderson & Brown, 2010; Greer et al., 2018), the dominant assumption in the multiteam system literature is that multiteam systems should be structured hierarchically, or consist of component teams nested under a centralized leadership team that oversees system activities and wields formal decision-making authority. Although hierarchy indeed benefited multiteam systems by lowering cognitive depletion among system members (at least initially), it also impeded activity alignment and synchronization among component teams (i.e., horizontal coordination). As a result, we find that hierarchy can be both a boon for and a barrier to system effectiveness, thus qualifying the dominant assumption in the literature that hierarchy is superior to egalitarianism in multiteam system contexts (Luciano et al., 2021).

A second and related contribution is our elucidation of *why* hierarchy had the effects on horizontal coordination and cognitive depletion that we evidenced herein. As noted, multiteam systems frequently fail to accomplish their goals due to the challenges associated with coordinating across team boundaries (Shuffler & Carter, 2018) and navigating the system's complexity (Murase et al., 2014; Porck et al., 2019). While egalitarianism facilitates horizontal coordination by eschewing the competition, power struggles, and conflict that often coincide with hierarchy, hierarchy attenuates cognitive depletion by providing the system with a sense of order, predictability, and structure (again, at least initially). As illustrated, both of these mechanisms have implications for multiteam system learning, a precursor to multiteam system

[4] Supplemental analyses—specifically, the results we obtained without the use of control variables, as well as our data, variable list, and survey measure for cognitive depletion—can be found at https://osf.io/f3mhu.

performance, with the former promoting learning and the latter impeding it.

Finally, our longitudinal approach and the integration of time into our theorizing helped us to determine *when* hierarchy affected cognitive depletion and horizontal coordination. A vast majority of research focused on the study of groups is cross-sectional in design (Cronin, Weingart, & Todorova, 2011), despite the fact that researchers have advanced more than one hundred conceptual models regarding group dynamics and development (Collins, Gibson, Quigley, & Parker, 2016). Considering that a science can only progress by putting forth *and* testing theoretical propositions (Popper, 1959), the time has come for team and multiteam system researchers to start taking temporal processes more seriously in empirical work. Our results clearly demonstrate the importance of studying multiteam systems over successive performance episodes. In the first episode, hierarchy benefited multiteam system members by mitigating cognitive depletion. However, by the second episode, cognitive depletion was only slightly (and not significantly) lower in hierarchical multiteam systems, and, by the third episode, the difference was negligible (see Figure 3). Had researchers examined the effects of hierarchical arrangement in only a single performance episode, they would not have discovered that the effects of hierarchy wane for cognitive depletion yet persist for horizontal coordination. Consequently, they may have overestimated the long-term effects of hierarchy on cognitive depletion and/or underestimated the long-term effects of hierarchy on horizontal coordination (Mitchell & James, 2001). Although hierarchy initially appears to represent a "double-edged sword" in multiteam systems, such that it has both benefits and drawbacks, our research suggests that one of these "edges" dulls while the other remains sharp over performance episodes.

Practical Implications

Given that organizations are gravitating toward interdependent systems of teams (Shuffler & Carter, 2018; Shuffler et al., 2015) and more egalitarian work structures (Lawler & Finegold, 2000), our results have important implications for practice, particularly as it pertains to work design. The term "work design" reflects the deliberate organizing and planning of tasks and activities to achieve firm goals, and structural factors have previously been identified as a major contextual influence on successful task completion in this literature (Morgeson, Garza, & Campion, 2013). Depending upon the strategic priorities of the firm and the interdependence requirements of focal multiteam systems, managers might want to structure multiteam systems as more hierarchical in some instances, but more egalitarian in others.

In some cases, multiteam system task accomplishment may require a high level of process interdependence among component teams (e.g., patient care teams; Shuffler et al., 2015). For example, the component teams of labor and delivery multiteam systems in obstetrics are characterized by intensive and iterative workflow interdependencies that go back and forth across component teams (Luciano et al., 2018). In these multiteam systems, horizontal coordination is likely to be particularly important—the system may not be able to function unless all component teams devote their efforts to integrating their resources and contributing to the task at hand. Multiteam systems such as this may benefit from egalitarian structures even if egalitarian structures are, at least at first, more depleting for team members. However, not all multiteam systems are characterized by comprehensive process interdependence, and, surprisingly, the level of task interdependence is rarely if ever manipulated in empirical research on multiteam systems, despite this variability (Luciano et al., 2018; Shuffler et al., 2015).

For example, in their book *Teams of Teams*, McChrystal, Collins, Silverman, and Fussell (2015) described how the U.S. Army has organized operations around the concept of multiteam systems, and recounted many different examples of systems that vary in terms of the nature of component team interdependence. This includes multiteam systems that exhibit pooled interdependence (see the discussion of the European Launcher Development Organisation rocket development program on pages 149–151 of *Teams of Teams*), sequential interdependence (see the discussion of the Krasnovia hostage rescue on pages 115–117), reciprocal interdependence (see the discussion of the Al Qaeda target capture and interrogation process on pages 135–137), and comprehensive interdependence (see the discussion of the "Follow-On Targets" mission described on pages 184–187). The cognitive benefits associated with hierarchy might outweigh the functional benefits of egalitarianism when process interdependence requirements are lower (e.g., pooled or sequential interdependence), or when teams are temporally limited (e.g., ad hoc teams [Hollenbeck, Beersma, & Schouten, 2012]).

Limitations and Future Research

The first limitation of this study is that we only examined hierarchies characterized by inter-team differences in power. We did not examine *status* hierarchies. Much like power, "status," defined as the level of respect and admiration one receives from one's group, represents a foundational base of hierarchy in organizations (Magee & Galinsky, 2008). We examined hierarchical arrangements pertaining to power, given seminal theorizing that multiteam system hierarchical arrangement and the distribution of power among component teams are intimately linked (Zaccaro et al., 2012). Nevertheless, future research should investigate the effect of status hierarchies in multiteam systems, to see if the theorizing presented herein generalizes.

A second limitation of this investigation is that we conducted our research using undergraduate students and a laboratory setting, which may raise concerns regarding external validity. Fortunately, the correspondence between lab and field effect sizes is high (Anderson, Lindsay, & Bushman, 1999), particularly in organizational research (Mitchell, 2012), and laboratory research has many strengths over field research, including temporal precedence of the independent variable and the elimination of alternative causes (both of which are requisites for inferring causality; Cook & Campbell, 1979). Our use of a military-like simulation may also raise questions about external validity. This said, organizational researchers frequently utilize military paradigms to examine phenomena of interest to organizations (e.g., McClean, Martin, Emich, & Woodruff, 2018), and such research has contributed significantly to the broader teams literature (Goodwin, Blacksmith, & Coats, 2018).

Another limitation of this work is the timing of our measure of cognitive depletion. We measured cognitive depletion after researchers provided in-lab instructions, reviewed each participant's specific role within the multiteam system, and refreshed the manipulation, yet before participants executed the task. Thus, we ensured temporal precedence of cognitive depletion (in that it was measured before multiteam system learning and performance), but we did not capture participants' cognitive depletion during the task itself, which would have made it consistent with how we measured horizontal coordination. Although the in-lab instructions, role review, and manipulation refreshment were extensive—and thus participants were aware of, and had time to mull over, the system's structure prior to the simulation—we recognize that we did not capture cognitive depletion in real time like we did horizontal coordination.

A final limitation of our investigation is that we utilized a unique subset of multiteam systems that had relatively stable membership and performed relatively similar tasks across performance episodes. That is, our multiteam systems had less fluid structures (in terms of changes in membership) and environments than might be observed in multiteam systems in practice. Thus, our findings regarding horizontal coordination and cognitive depletion (and how the two evolve over performance episodes) should be interpreted with the understanding that our multiteam systems exhibited greater member stability than might be witnessed in "real-world" multiteam systems and executed a specific, relatively stable task (though the task did change slightly over performance episodes, as previously footnoted). Additionally, the space between performance episodes in our sample of multiteam systems, which was usually a few weeks, due to labor, scheduling, and facility constraints, may not be representative of all multiteam systems (e.g., multiteam systems that engage in back-to-back performance episodes).

CONCLUSION

Organizations in government, business, medicine, and the military frequently employ multiteam systems to accomplish complex tasks and reap the benefits of increased capacity. In designing these systems, a major decision concerns the hierarchical arrangement of the component teams. We demonstrated that hierarchy has both benefits and costs when it comes to multiteam system operations, and that it delivers these benefits and costs through distinct mechanisms. Additionally, we demonstrated that the benefits of hierarchy for cognitive depletion wane over performance episodes while the benefits of egalitarianism for horizontal coordination persist. Future practitioners and researchers alike should keep these findings in mind when composing and studying multiteam systems, ensuring that they structure between-team relationships in an optimal manner for the task or research question at hand.

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