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Diversity and inclusiveness are necessary components of resilient international teams

Igor Linkov^{1,2}✉, Benjamin Trump^{1,3} & Greg Kiker²

The current SARS-CoV-2 pandemic has impacted all forms of global international engagement, inclusive of long-standing and recently formed research teams. Most were formed to be efficient within budget, time, and personnel limits, without building an ability to recover from crises, i.e. inherent resilience. Diversity and Inclusiveness, a requirement for resilient ecological systems, has only been discussed in a normative sense for teams of humans, including research teams. Studying different diversity configurations of international research teams will allow resilience-based tools and metrics to inform improved team design, implementation, and recovery to adverse events.

¹ US Army Engineer Research and Development Center, Concord, MA, USA. ² Department of Agricultural and Biological Engineering, University of Florida, Gainesville, USA. ³ School of Public Health, University of Michigan, Ann Arbor, USA. ✉email: Igor.Linkov@usace.army.mil

Introduction

From the onset of the SARS-CoV-2 pandemic, international exchange has been significantly hampered by limitations on travel as well as associated public health lockdowns. International scientific collaboration is no exception, with many research organizations, universities, and companies forced to reconsider how global engagement and exchange is to be conducted. While impromptu transitions to video conferencing have allowed essential communications to continue as a stopgap measure for those with reliable internet services, the ability of video conferencing to maintain the momentum of international scientific collaboration is questionable, particularly for developing countries with limited access to high-speed internet. Further, as pandemic-related travel and collaboration restrictions continue, entire research business lines may significantly and permanently shift in a less conducive manner to global team-building.

Significant knowledge gaps remain for building resilient, adaptive, and innovative research teams into the post-COVID future. To complicate the matter, an inability to rectify these gaps may elongate or permanently disrupt the international exchange of scientific communication and development. How can international research teams persist and continue to deliver upon their research objectives when communication and travel lines are disrupted, necessary resources are lost, delayed, or unavailable, or leaders or team members are removed or incapacitated?

To answer this question, policymakers and leading stakeholders have borrowed from concepts of resilience to articulate how to realign international science post-COVID (Connelly et al., 2017; Hynes et al., 2020). Generally speaking, resilience of complex systems, including teams, can be defined as the capacity to prepare, respond to, recover from, and adapt to adverse events (NAS, 2012; Linkov and Trump, 2019; Ganin et al., 2016). Operationally, resilience is measured as the area under the curve of lost functionality in response to adverse events (Fig. 1)—more resilient teams recover quickly, with less consequences along with the capability to adapt so that research products continue to be produced in the same or even more insightful ways as compared to pre-disruption conventions. In practice though, there is significant disagreement on the interaction and potential synergies

of individual resilience traits, team-generated aspects, and institutionally maintained qualities (Arrow et al., 2000; Biggs et al., 2015; van Ness and Summers-Effler, 2016). A narrow, individually centered focus on resilience characteristics may miss critical system features while preoccupation with larger-scale organizational or societal aspects may miss an opportunity to enhance individual recovery and adaptation after the disruptive event (Fig. 1).

Two of the most understudied determinants of collective resilience include diversity and inclusiveness and related institutional characteristics, all of which interact in complex ways to influence team resilience. Though an increasing number of studies are centered on aspects of ethnic or gender diversity, diversity elements of cultural, cognitive, experiential, and others are rarely discussed or tested with integrational tools in the context of international engagement or collaboration (Fig. 1). This limitation extends to a lack of methods that parameterize both (i) how to foster efficiencies in the productivity behind diverse international teams, and (ii) understanding how such teams recover from and adapt to disruption that degrades or destroys mechanisms for collaboration, shifts incentives regarding goals to be achieved, or alters the extent of participation that one or more partners may offer to the team. Given such limitations, it is difficult to assess the impact of diversity and inclusiveness on team resilience programs and, accordingly, on organizational performance (making it difficult to objectively track performance towards institutional or economic objectives). Critical questions remain, such as:

- (i) How critical and interchangeable are individual qualities of resilience vs. team attributes vs. institutional characteristics?
- (ii) How much do qualities such as inclusion and diversity instill parsimonious levels of resilience at the team- and institutional-scales?
- (iii) How can the composition and implementation of international research teams integrate resilience science to prepare for, recover from, and adapt to (NAS, 2012) ongoing and future volatility, uncertainty, complexity, and ambiguity (Helbing, 2013), all of which are resident within complex, transdisciplinary challenges?

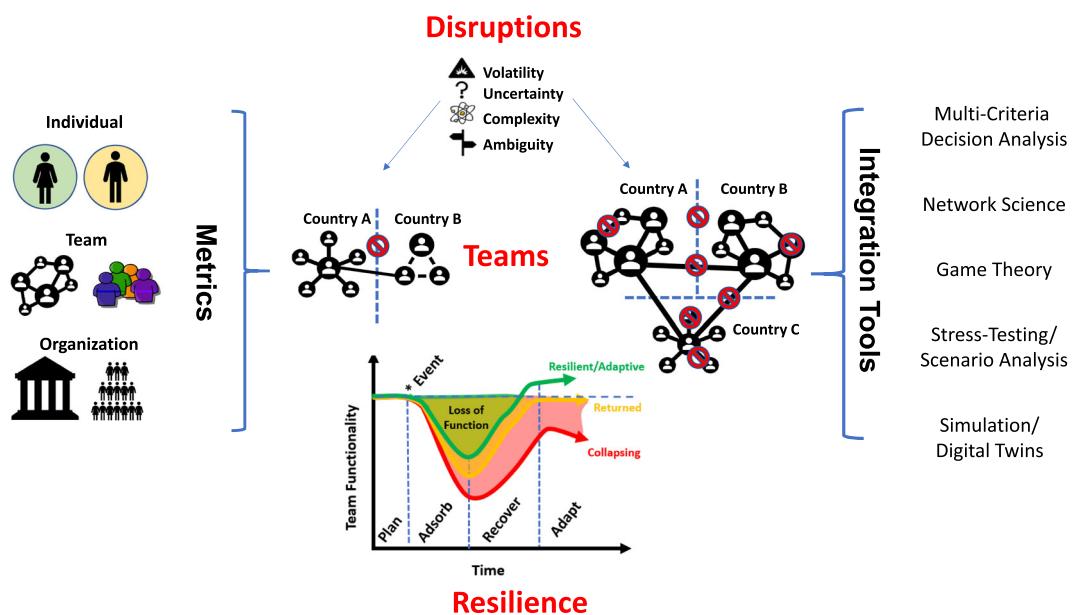


Fig. 1 Blueprint of our current dilemma. Both small and large international research teams lack resilience to diverse disruptions that incorporate volatility, uncertainty, complexity, and ambiguity (Helbing, 2013). While many disciplines have defined and applied local-scale metrics to individuals, teams and institutions, few integrative tools can translate these diverse lines of evidence into actions that create resilient international teams that can respond to different challenges over a project's functional timeline.

Team efficiency and resilience

Creating efficient (i.e. capable of meeting mission needs at lowest resource requirements) transdisciplinary research teams is a field with considerable, long-standing inquiry (Arrow et al., 2000; Shuffler et al., 2018). Within international research and development, teams are often constructed on an ad hoc, discipline-compelled basis to compete for funding opportunities (Morrison-Smith and Ruiz, 2020). Given the low success probabilities of most proposals, international teams are ephemeral, ever-changing, and socially complex. Even successful international research teams are built on the basis of success of past alliances, ease of communication and bureaucratic maneuvering, similarity of institutional culture, and the satisfaction of funding priorities (Dusdal and Powell, 2021). From an efficiency perspective, teams often include a group of potentially similar individuals with focused skillsets and backgrounds most appropriate for the execution of specific mission objectives. Such teams may not be inclusive and diverse beyond the superficial level required to be competitive by funding priorities.

Unforeseen disruptions and changing priorities can result in changing team missions and needs (Stoverink et al., 2020). A team composed of individuals with skillsets limited to one specific mission area can fail to adjust to changing needs or to address new opportunities (Arrow et al., 2000). Nevertheless, team heterogeneity can also result in competition and conflict leading to team disaggregation (Kapucu and Garayev, 2011). Recent studies have focused on understanding how individual members, teams, and organizations interact toward *resilient* outcomes (Duchek et al., 2020; Stoverink et al., 2020). Zemba et al. (2019) provided a holistic examination of the literature on military teams and community-level resilience which resulted in the identification of key variables and activities which influence team resilience. People express resilience in the face of adversity, yet certain characteristics, physical expressions, spatial patterns, or overall predispositions and/or training allow certain individuals or teams to be far more successful in recovery and adaptation in the aftermath of disruption than others (Wood et al., 2019). Though resilience is recognized as a critical research need to improve individual and team responses to a variety of stressors, experimental, and analytical methodologies for framing resilience as a function of system composition and mission within and across social hierarchies and team dynamics are largely absent.

Connecting diversity, inclusiveness, and resilience

Scholars have addressed various questions related to optimal team composition, leadership qualities, and individual requirements for high-stress, high-visibility positions in order to foster more effective teams in government, industry, and broader society (Duchek et al., 2020; Driskell et al., 1994). Diversity, in its most general sense, is defined as (i) variety or (ii) practice of including or involving people from a range of different social and ethnic backgrounds and of different genders, sexual orientations, etc. (Oxford Dictionary, 2021). McGrath et al. (1995) expanded this general description into more explicit categories of Knowledge, Skills and Abilities (KSA), Values, Beliefs and Attitudes (YBA) and Personality, Cognitive and Behavioral styles (PCBs) in addition to the usual demographic features of diversity (gender, age, religion, ethnicity). Team diversity is thus can be defined as differences between team members on certain attributes (Harrison and Klein, 2007), but in practice is usually assessed through differentiation of demographic attributes (Townsend and Scott, 2001) or between readily detectable task-related attributes (Millican and Martins, 1996). Similarly, inclusiveness is defined as (i) the quality of covering a range of subjects or areas, and (ii) the practice or policy of providing equal access to opportunities and

resources for people who might otherwise be excluded or marginalized, such as those having physical or mental disabilities or belonging to other minority groups (Oxford Dictionary, 2021). While diversity emerges from characteristics of individuals (cognitive diversity), inclusiveness stems from the ability of teams and organizations to utilize diverse individuals to achieve their specified mission (Ferdman et al., 2020).

Diversity and inclusiveness are discussed in the literature primarily as requirements driven by social norms and fairness rather than from a position of team optimization. Even though it is shown in general that team diversity can increase research output (Freeman and Huang, 2014), comparisons of more or less diverse and inclusive teams are made without a clear understanding of the mechanisms of the positive impacts of diversity and inclusiveness on organizations and teams. Moreover, most of this research analyzes domestic teams and their composite members as relatively static, or unchanging. In other words, this research neither accounts for team member shifts nor a considerable disruption where the fundamental international activities, dependencies, and resource requirements for that team are no longer available. Diversity and inclusiveness is thus added in a way to minimize its impact on system efficiency without consideration of resilience.

In contrast, in the study of ecological and environmental systems, diversity is linked to dynamic behavior and survivability that may not be necessarily efficient in terms of specific outcomes. Peterson et al. (1998) highlight that system resilience is emergent from diverse and oftentimes redundant elements operating on multiple, interlinked scales (Polis, 1998). The interaction of these components allows recovery and renewal from various disruptions. Thus, diversity in ecological systems (e.g., in food chains) allows for resilience and stability (Polis, 1998). Biggs et al. (2015) integrated diversity and other resilience-related principles into a wider institutional framework for socio-ecological systems and maintenance of ecosystem services under future challenges.

Clearly, an important avenue of research includes the quantitative investigation of how inclusiveness and diversity of team members' skills and networks influence overall team and organizational resilience, especially in situations of teams working internationally for highly complex and evolving goals. The question of what metrics and integrative tools can help to generate cost-effective, adaptive improvements to team resilience over time in order to facilitate the sustainable generation of research outputs needs to be answered. In teams, inclusiveness and diversity have been recommended as effective metrics for resilience, although with some lingering uncertainty over exact definitions and measures (Duchek et al., 2020). Harrison and Klein (2007) de-construct intra-team diversity by defining metrics covering *separation*, *variety*, and *disparity*, all of which are operative and even dynamic within international teams. In this sense, inclusion and diversity metrics may be critical resilience elements that can be analyzed within existing teams and can be stress-tested within hypothetical teams by integrational tools such as decision analysis (Linkov et al., 2020), network theory or simulation (Fig. 1). Increasing team inclusion and diversity can have both potential benefits and costs. Inclusion and diversity can be an advantage to generate innovative solutions, but with the potential cost of increased discipline-based confusion over terminology and research methods as well as additional salary support costs.

Resilience analytics for diverse and inclusive teams

The emerging field of resilience analytics can be helpful to design international research teams to be resilient and inclusive and allow them to persist and even improve in the aftermath of an

emergency or crisis separating them from those that are prone to paralysis or collapse. Resilience analytics emphasizes the capacity of systems and networks to recover from chronic or acute perturbations and subsequently improve over time (Linkov and Trump, 2019). The logic and mathematical approaches of resilience analytics include metrics-based and model-based approaches (Linkov et al., 2018; Kott and Linkov, 2019). In the context of research teams (Fig. 1) diversity and inclusiveness metrics at the individual-, team- and institutional-levels need to be posed, tested and operationalized to understand the dynamics and characteristics of how groups and the individuals within them perform in the presence of disruptions ranging from minor roadblocks to nearly insurmountable losses in function or capability. Metrics can be visualized in dashboards, combined in indices, or integrated in utility scale using decision-analytical tools. Ultimately, decision makers are presented with a few individual metrics or their integrated value to decide on the course of actions to improve team resilience. A detailed review of these tools goes beyond the scope of this commentary, but metrics-based approaches, especially decision-analytics, allows for explicit visualization of diversity and inclusion as components of resilience and evaluation of reduction of these properties on the overall team performance.

Diversity and Inclusion can be explicitly modeled using network science, game-theoretical or other quantitative methods where interconnectedness of team and their research output is explicitly modeled utilizing group network topology, communication and interaction structure as well as impacts of diversity and inclusion expressed as specific modifiers or new rules in system models. Simulation-based approaches allow both trade-offs and connections to be explored in a transparent and scientific manner that accounts for important variables such as cost, benefit (capacity to improve resilience), resource requirements, and other considerations within each resilience phase (Prepare, Absorb, Respond, Adapt). Studying different configurations of international research teams will allow resilience-based tools and metrics to inform improved team design, implementation, and recovery from adverse events.

The emerging science of resilience alongside core concepts of decision science, cognitive psychology, network science, and other fields can generate a synthesized understanding of what team resilience is, as well as how it may be fostered through inclusiveness and diversity. Though the interdisciplinary and uncertain nature of this research is an early exploration into a broad and challenging research topic, improvements in the space may yield transformative scientific theories and knowledge regarding how teams should be crafted, trained, and maintained over time in a variety of applications (academia, military, business, athletics, etc.). The SARS-CoV-2 pandemic demonstrates that, because considerable and systemic disruption may occur at any time and with little warning, successful and high-functioning teams must be implicitly aligned with principles of resilience to ensure their ability to persist and thrive in any environment that their duties may require them to operate within.

Data availability

All data are included in the article.

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All authors contributed equally in manuscript preparation and writing.

Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval was not deemed necessary, as this is an opinion piece, in which no individual-level data were applied. All research was performed in accordance with relevant guidelines/regulations and all co-authors have approved the content and submission of the article.

Informed consent

This was not relevant, as the article does not contain any studies with human participants performed by any of the authors.

Additional information

Correspondence and requests for materials should be addressed to Igor Linkov.

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