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Future of Team Research: On Teamness and Dimensions of Variability in Teams

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Abstract

Teams are essential for most modern work. But who or what is a team? With today's rapidly diverse team contexts and the diversity of research frameworks for studying them, there is no longer a definitive answer to this question. Thus, Cooke et al. introduced "teamness," a construct through which future research can describe teamwork as a function of the many dimensions of variability between and within teams. In this multidisciplinary panel moderated by the two lead authors, we discuss the current state and future directions of team cognitive science in light of teamness as a guiding construct, along with its implications for human factors practice.

Keywords

teaming, teamness, human-AI-robot teams, team cognition

Points of Consensus and Divergence in Team Cognitive Science

We use the phrase team cognitive science to describe a broader interdisciplinary perspective for understanding teams. This includes recent developments, such as modeling teams and team processes as dynamical systems (Gorman et al., 2017) and the inclusion of technology and machine elements as parts of the team (Fiore & Wiltshire, 2016). Our key concepts for discussion are built upon historical points of consensus in team cognitive science, which inform practical applications from team member selection and training protocols to the design of technological interventions to support teamwork. Specifically, we consider these points in light of the divergent trends in how they have recently been approached in the literature.

First, the bulk of the team science literature defines teams as groups of people working interdependently toward a common goal, first stated by Salas et al. (1992). However, many researchers now study non-humans as teammates in settings like robot- and animal-assisted urban search and rescue teams (O'Neill et al., 2022). This is not without controversy; some prominent works (e.g., Groom & Nass, 2007; Shneiderman, 2022, ch. 13) question the validity of this approach, considering doubts whether people can perceive a non-human counterpart as a "true" teammate like how they would another person.

Another common point of agreement is that teamwork is a function of how team members' individual activities, goals, and interactions with each other are coordinated throughout a team's lifespan (Gorman et al., 2010). As such, though people can accomplish many tasks independently, team goals entail accomplishing multiple tasks that can only be efficiently and effectively done through teamwork (Crawford & LePine, 2013). But what constitutes efficiency and effectiveness in teaming is also increasingly disparate across team task contexts. For instance, differences in role structures between a team of paramedics (significant overlap of skills) and a surgical team (high degrees of specialization) could lead to considerable differences in coordination strategies between the two teams.

Most team science frameworks also posit that teamwork involves team-level cognition, which is distinct from the sum of each individual member's cognitive potential (Kozlowski & Ilgen, 2006). However, it is unclear from the current body of literature how to best characterize team cognition. Some define it as an activity that takes place through

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interactions (e.g., Cooke et al., 2013), an outcome achieved through overlaps between team members' mental models (e.g., DeChurch & Mesmer-Magnus, 2010), or an emergent property of team collaborations (e.g., Kozlowski & Chao, 2012). A common feature of these disputes is that they center on the applicability and operationalization of constructs like team cognition across an array of team task contexts.

It is also widely acknowledged that team cognitive science faces considerable generalizability issues concerning the context-dependence of team characteristics (such as size, composition, and team member interdependence; Cooke et al., 2024). For instance, differences in skill distribution could result in unique coordination dynamics between team types. Continuing with our prior example, a team of paramedics (with a significant overlap of skills) may allocate and coordinate individual tasks more flexibly than a surgical team (high degrees of specialization). Furthermore, team characteristics and teaming contexts are also intertwined; teams working on complex tasks that require subject matter expertise are also more likely to require interdependent teaming strategies (Swaab et al., 2014). An example is how surgical team members tend to be highly specialized but limited to specific medical procedures, while paramedics have more general skills that allow them to perform a wider range of procedures related to their broader task contexts. Team task contexts and team characteristics must, therefore, be jointly accounted for when comparing results across studies. However, existing paradigms for doing so (e.g., Hollenbeck et al., 2012) are rarely used in the design of team task experiments or in interpreting findings by meta-analytic efforts to consolidate empirical findings.

A Panel Discussion on the Utility of a Teamness Approach

Amid the growing number of team constructs in the literature, some key questions remain: Why do certain teams exhibit more team-like properties than others? Why does the extent of a group's team-likeness vary over time, despite meeting commonly adopted definitions of what or who a team is? Can we predict the extent to which a team may exhibit emergent team properties for a given set of goals? Many such questions can be thought of as pertaining to specific dimensions of emergence in teams, namely team cohesion, coordination dynamics, team process phases, and transactional memory systems. Limiting the study of these questions only to a set of constructs, however, fails to address a broader question: how can we compare or translate empirical findings across teaming domains while still accounting for context?

According to Cooke et al. (2024), constructs like team composition, interdependence, and shared goals are continuums best considered together through a multidimensional construct called "teamness." Although a newly defined concept, recent empirical works support the utility of teamness for investigating team process dynamics (e.g., Abdelshiheed et al., 2024; Doherty et al., 2023). In theory, characterizing instances of teaming through teamness dimensions can also allow nuanced comparisons and predictions for teaming across team task contexts. However, the concept of teamness needs further refinement to address the needs of team researchers; for instance, there are likely many teamness dimensions beyond those currently identified by Cooke et al. (2024).

In sum, this panel discussion on outstanding issues in team cognitive science and the utility of teamness aims for the audience to (1) learn some of the various perspectives in team cognitive science and the research methods they entail; (2) develop an understanding of the multidimensionality of teamwork; (3) hear panelists' insights on the utility of teamness for interpreting empirical findings on specific dimensions of variability in teaming; and (4) engage in discussions on the human factors implications of a teamness approach when designing and evaluating systems in modern teaming contexts. To foster a nuanced discussion toward these objectives, our panelists comprise cognitive scientists representing a wide range of expertise.

The flow of the discussion is planned as follows. Moderators will first provide an overview of teamness as a concept. Panelists will then give short presentations on the team settings, frameworks, and methods featured in their research. They will then respond to structured questions regarding the broader state of team science frameworks and methods, the generalizability of team research findings across applied team research domains, and the utility of teamness as a multidimensional paradigm for their basic and applied research. This will be followed by a Q&A session and closed with a summary statement from each panelist and the moderators.

Moderators

Myke C. Cohen is an Ira A. Fulton Schools of Engineering Dean's Fellow and PhD student in Human Systems Engineering at Arizona State University, and an Associate Research Engineer at Aptima, Inc. His research broadly focuses on the collective decision-making processes, social dynamics, and ethics of collaborations between people and technology. He holds an M.S. in Human Systems Engineering from Arizona State University and a B.S. in Industrial Engineering from the University of the Philippines Diliman.

Dr. Nancy Cooke is a professor in Human Systems Engineering in the Fulton Schools of Engineering at Arizona State University and Founding Director and Senior Scientific Advisor for ASU's Global Security Initiative's Center for Human, AI, and Robot Teaming. Dr. Cooke is a Past President of the Human Factors and Ergonomics Society and the past chair of the Board on Human Systems Integration at the National Academies. Cooke's research is on individual and team cognition and its application to human-robot-AI- teaming, especially methodologies to elicit and assess individual and team cognition. Cooke's research is funded by DoD and is widely published.

Invited Panelists

Dr. Jamie C. Gorman is a Professor in Human Systems Engineering and Director of the Center for Human Artificial Intelligence and Robot Teaming (CHART) at Arizona State University and Senior Research Personnel with the NSF Institute for Student-AI Teaming at the University of Colorado. Dr. Gorman studies team dynamics in complex social and technological settings, with foci on modeling and measuring real-time team cognition as dynamical systems. His research incorporates a variety of methodologies, including communication analysis, perceptual-motor coordination, motion and eye tracking, and neurophysiology, which has been funded by DoD, NSF, and industry grants. He is a member of the Human Factors and Ergonomics Society (HFES) and serves on the editorial boards of Human Factors and the Journal of Experimental Psychology: Applied. He received an Ely award from HFES in 2011.

Dr. Stephen M. Fiore is Director, Cognitive Sciences Laboratory, and Pegasus Professor with the University of Central Florida's Cognitive Sciences Program in the Department of Philosophy and School of Modeling, Simulation, and Training. He maintains a multidisciplinary research interest that incorporates aspects of the cognitive, social, organizational, and computational sciences in the investigation of learning and performance in individuals and teams. His primary area of research is the interdisciplinary study of complex collaborative cognition and the understanding of how humans interact socially and with technology. He is Past President of the International Network for the Science of Team Science, and Past President for the Interdisciplinary Network for Group Research. He has been funded by organizations such as NSF, DARPA, AFOSR, ONR, and ARL He is co-author of a book on "Accelerating Expertise" (2013) and is a co-editor of volumes on Shared Cognition (2012), Macrocognition in Teams (2008), Distributed Training (2007), and Team Cognition (2004). Dr. Fiore has also co-authored over 250 scholarly publications in the area of learning, memory, and problem solving in individuals and groups.

Dr. Wayne Gray is a Fellow of the Cognitive Science Society, the Human Factors & Ergonomics Society (HFES), and the American Psychological Association (APA). In 2008, APA awarded him the *Franklin V. Taylor Award for Outstanding Contributions in the Field of Applied Experimental & Engineering Psychology*. He is a past Chair of the Cognitive Science Society and the founding Chair of the Human Performance Modeling technical group of HFES. He was also the Executive Editor for the Cognitive Science Society's first new journal in 30 years, *Topics in Cognitive Science* (*topiCS*). In 2012, he was elected a Fellow by the Alexander von Humboldt Foundation and spent his sabbatical in research at the Max Planck Institute Center for Adaptive Behavior and Cognition (ABC) in Berlin. He also received an *IBM Faculty Award* from IBM's *Cognitive Systems Institute*.

Dr. Sounak Banerjee received his PhD in Cognitive Science from Rensselaer Polytechnic Institute in August 2024. He studies human expertise and skill learning in complex tasks. Currently, he is analyzing team coordination behavior in small human teams using performance data from a complex cooperative game. Sounak holds a bachelor's degree in Computer Science from the University of Calcutta, West Bengal, India and a master's in Information Technology from DA-IICT, Gujarat, India. Before starting his PhD, he conducted research on Natural Language Processing and Machine Learning at Indian Institute of Technology Kharagpur, Conduent Business Services Bangalore, and Indian Statistical Institute Calcutta.

Dr. Leanne Hirshfield is an Associate Research Professor in the Institute of Cognitive Science at University of Colorado, Boulder. Hirshfield directs the System Human Interaction with NIRS and EEG (SHINE) Lab at the University of Colorado. She is also on the leadership team for the NSF AI Institute on Student AI Teaming (iSAT), where she directs human-computer interaction (HCI) research focused on the design, implementation, and evaluation of AI Partners to support group collaboration in classrooms. Hirshfield is also PI on a Multi-University Research Initiative through AFOSR that focuses on supporting individuals and teams to maintain "cognitive security" in both high and low information density environments. Hirshfield's SHINE Lab research explores the use of non-invasive neurophysiological measurement (e.g., fNIRS, EEG, eyetracking, heartrate) to passively classify users' social, cognitive, and affective states in order to enhance usability testing and adaptive system design, with a focus on human performance and human-agent teaming. In particular, Hirshfield has extensive experience using brain measurement to measure states relating to trust, team cohesion, negative affect, and cognitive load. She works primarily with functional near-infrared spectroscopy (fNIRS), a relatively new non-invasive brain imaging device that is safe, portable, robust to noise, and can be implemented wirelessly; making it ideal for research in human-computer interaction.

Dr. Daniel Nguyen received his BA in Psychology at Texas A&M University in 2017, then went on to receive his MS and PhD in I/O Psychology at Florida Tech in 2020 and 2023. His research interests and experiences are focused on work teams, with a focus on human-agent teaming (HAT) which has led him to a broader interest in related human-factors topics such as human-performance and trust in automation. Currently, Daniel works at Aptima Inc. as an Associate Scientist, and continues to be involved in HAT research in applied settings.

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