Preface to the Special Issue on Collaboration, Coordination, and Adaptation in Complex Sociotechnical Settings

Jamie C. Gorman and Nancy J. Cooke, Arizona State University-Polytechnic, Mesa, and Eduardo Salas, University of Central Florida, Orlando

Sociotechnical systems comprise integrated human and machine entities that, when functioning as an integrated, coordinated unit, can address a wide range of problems that are too complex to be addressed by individuals or machines working alone. However, the design and implementation of modern work systems tends to place primary emphasis on technological innovation without equal consideration for the social component—the teams and groups of humans—that uses that technology. There is a polarity between high technologies and the social systems that use them that can give rise to errors when a sociotechnical system is asked to respond in a manner not anticipated by the designers of the technology. Poor coordination of system-level response following Hurricane Katrina and failed emergency communications during the campus shootings at Virginia Tech are clear reminders that technology alone does not lead to an adaptive response. In complex sociotechnical systems, adaptation emerges from collaborated and coordinated response to a novel event in a manner not specified in the initial design or implementation of the system.

The primary goal of this special issue is to gain new insights into what we have learned and are learning about the nature of coordination, collaboration, and adaptation in complex sociotechnical settings. We especially encouraged research conducted in field or synthetic-task environments and theory relevant to current or future applications of teams and groups. We feature 13 articles that present new and innovative work in emerging human factors research areas, such as human-robot interaction, large brainstorming groups, and nonlinear dynamics of team coordination.

A second goal of this special issue is to combine multidisciplinary perspectives. The 13 articles are consistent in the sociotechnical theme but come from a range of researchers working in different areas, such as computer science, psychology, engineering, and medicine. Also appended to the 13 special topic articles are three perspective pieces we solicited from communication and group learning scholars and psychologists from diverse disciplines with backgrounds in communications, computer science, education, industrial organizational psychology, information science, and philosophy. The perspective pieces also enhance the multidisciplinary nature of the special issue. With these 13 articles and the perspective pieces, we think we have delivered on the special issue goals and have done so with broad strokes across disciplines.

We think the special issue speaks for itself. But in the remainder of this preface, we briefly highlight three key issues and recurring themes in sociotechnical settings to frame the topics addressed in the articles and perspective pieces.

First, complex sociotechnical systems are, naturally, complex. Complex systems adapt to environmental uncertainty through self-organized (viz. “self-regulated”; Cummings, 1978) processes without a central executive or blueprint guiding that adaptation. Complex systems that are robust to environmental uncertainty, therefore, are adaptive by maintaining a level of
autonomy in how they adapt to uncertainty. This has intuitive appeal for performing in uncertain (ill-defined) task environments. But there are issues stemming from a lack of direct control of sociotechnical adaptation that present problems for designers and developers of technology and information systems. For example, it is difficult, if not impossible, to foresee latent errors when humans interact with technology in real time in a novel situation (Reason, 1990; Smith, 2000). One need only look to the much-analyzed accidental release of toxic gas at Bhopal or the nuclear meltdowns at Chernobyl and Three Mile Island to find these types of failures of human-systems integration (Meshkati, 1991; National Research Council, 2007).

Complex systems evolve through the cooperation and coevolution of multilevel, nonlinear component processes (Hardy, 2001), and attempts to solve a complex coordination or collaboration problem top down, through purely technological means, or attempts to centralize and directly control coordination and collaboration lead to unanticipated consequences and, ironically, new sets of coordination problems under novel conditions (Kling et al., 2001). Because of the complexity of the self-organized adaptive response, the results may be unpredictable from a priori knowledge of the system’s components: Sociotechnical flexibility is gained at the expense of rigid, top-down control. The coordination and collaboration phenomena addressed in this special issue provide insight into self-regulated adaptive processes that emerge only at the sociotechnical level of analysis.

The contributors to this special issue keep the topic of sociotechnical complexity in plain focus. Miller, Weinger, Buerhaus, and Dietrich examine adaptive coordination processes in intensive care units. They present several coordination models in developing a theory of adaptive coordination processes that unfold across multilevel information spaces. Guastello focuses on complexity and adaptation in emergency response teams defending against outside attackers, quantifying complexity and adaptability using nonlinear dynamics. Bearman, Paletz, Orasanu, and Thomas address root causes of breakdowns and disconnects in coordinated decision making in complex sociotechnical systems (e.g., manned space flight), in which certain types of disconnects may not be resolved by simply providing operators with more information. De Vreede, Briggs, and Reiter-Palmon examine issues of complexity in (very) large-group problem solving. Their research on creativity in large groups carries implications for collaborative problem solving by “teams of teams.” Taking a 30,000-foot view on this topic, Fiore et al. contribute a theory of macrocognition in teams. They present a model of complex collaborative problem solving, including a set of propositions that may act as a guide for future research.

A second key issue is that technological interventions do not increase sociotechnical system effectiveness if they are not supported by the social (team and group) components of the system. Early sociotechnical research revealed that isolated “tinkering” with either the technical or social components of the system may not result in the desired improvement of overall system effectiveness. Trist and Bamforth (1951) found that improvements in safety and efficiency using the (then-new) long-wall coal mining method required coevolution of the underlying mining culture. More recently, the introduction of electronic health records in the medical industry to enhance care provider coordination and reduce dosing and treatment errors have been met with reluctance and misuse by medical professionals (e.g., Jha et al., 2009; Johnson, Johnson, & Zhang, 2005; Patel, Kushniruk, Yang, & Yale, 2000). Implementation of electronic health records would benefit from a deeper understanding of information exchange in the underlying medical culture (Weir et al., 2003). Another contribution of this special issue is to combine current research and theory examining effective sociotechnical collaboration and coordination in the presence of technological intervention.

The topic of technological intervention and underlying social and cultural process is well represented in this special issue. Lewis et al. examine technological intervention by identifying appropriate levels and features of automation for multirobot urban search and rescue, finding that some task features are better candidates for automation than others. Shah and Breazeal address human-robot teaming by
examining coordination issues in two-person teams. Their research is a preemptive strike on the effects of technological innovation, as greater application of human-robot teaming is just on the horizon. Strauch does not directly address technological intervention but focuses on the effects of underlying culture on errors in complex sociotechnical settings, where cultural barriers are exacerbated under times of increased stress or high workload. McComb, Kennedy, Perryman, Warner, and Letsky address the nature of acquisition of shared cognition in the context of a technological intervention, finding that collaborative technologies can streamline the acquisition process.

A third key issue in complex sociotechnical settings is that adaptation emerges from collaborated and coordinated interactions at a team or group level. Thus, assessment of and training for sociocultural adaptation needs to focus on the team or group level, emphasizing the role of coordinated and collaborative interactions in adaptive response to a novel event. The recent tragic earthquakes in Haiti, which claimed the lives of so many, were responded to with a historic outpouring of volunteerism and support. With such an outpouring, relief for those injured and dying should have been immediate. However, as with Hurricane Katrina 4 and a half years earlier, emergency response was marred by deficient interaction and coordination bottlenecks at the sociotechnical level. A 2010 CNN report, for example, claimed that plenty of doctors had arrived on scene but that lack of coordination meant they were not getting to areas where they were most needed (CNN, 2010).

Since we first called for contributions to this special issue, we again see the need for improved collaboration, coordination, and adaptation in complex sociotechnical systems. A third contribution of this special issue is to present multiple perspectives on team coordination and collaboration assessment and team training designed to elicit an adaptive response in nonroutine, critical conditions.

Several articles in the special issue deal with team training and assessment. Burtscher, Wacker, Grote, and Manser present a study of anesthesiology teams adapting to nonroutine events. Their study presents an innovative, temporally based analysis of coordination with implications for the development of novel feedback and team training programs. The article by Marquardt, Robelski, Jenkins, and Hoeger focuses on the implementation of crew resource management training in the automotive industry, identifying several benefits of team-based training. Driskell, Salas, and Hughes describe the development of a collective measure of team orientation. They validate their measure using cognitive and team performance measures. Gorman, Cooke, and Amazeen directly address the problem of training adaptive teams. Their results indicate that more bottom-up, process-oriented team training may valuably supplement more traditional knowledge-based or procedural approaches for training adaptive teams.

In summary, the contributions to this special issue are diverse. The invited perspective pieces appended to the special issue articles serves also to increase the diversity of research approaches. If this special issue provides a diversity of insights and innovations into what we have learned about the nature of coordination, collaboration, and adaptation in complex sociotechnical settings, including current gaps and areas in need of future research, then we have accomplished our goals.

ACKNOWLEDGMENTS

We would like to thank Douglas J. Gillan and William C. Howell for editorial assistance. This special issue would not be possible without their efforts.

REFERENCES


Jamie C. Gorman received his PhD in cognitive psychology from New Mexico State University, Las Cruces, in 2006 and is a postdoctoral research associate at Arizona State University-Polytechnic and the Cognitive Engineering Research Institute in Mesa, Arizona. Beginning August 2010, he will be an assistant professor in the Human Factors Program at Texas Tech University.

Nancy J. Cooke received her PhD in cognitive psychology from New Mexico State University, Las Cruces, in 1987 and is a professor in applied psychology at Arizona State University-Polytechnic and science director of the Cognitive Engineering Research Institute in Mesa, Arizona.

Eduardo Salas is trustee chair and professor of psychology at the University of Central Florida, where he also holds an appointment as program director for the Human Systems Integration Research Department at the Institute for Simulation and Training. He earned his PhD in 1984 in industrial and organizational psychology from Old Dominion University.