Effective Human-Artificial Intelligence Teaming

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A team is defined as an interdependent group of individuals, each with distinct roles and responsibilities, who work toward a common objective (Salas, Dickinson, Converse, & Tannenbaum, 1992). This definition implies that a team is a special type of group. With advances in artificial intelligence (AI), AI agents can fulfill critical roles and responsibilities for a team; often those roles and responsibilities that are too dull, difficult, dirty, or dangerous for humans. Are these human-AI teams different from all human teams? Are human teammates different from AI teammates? What does it take for AI to be a good teammate? These and other questions have been addressed in my laboratory over the last decade. One critical finding that has emerged from many studies is the importance of interaction that can manifest as the communication or coordination required to exploit the team's interdependencies (Cooke, 2015; Cooke, Gorman, Myers, & Duran, 2013).

Based on years of study of all-human teams and observations of teams in synthetic environments (including Remotely Piloted Aircraft System ground control and Noncombatant Evacuation Operation scenarios), the theory of interactive team cognition emerged (Cooke, 2015; Cooke, Gorman, Myers, & Duran, 2013). This theory holds that interaction is key to teams, especially action-oriented teams, and that team cognition should be treated as a process, should be measured at the team level, and should be measured in context. Empirical results have indicated that team interaction is, in fact, more predictive of team effectiveness than individual performance (Duran, 2010).

Interactive team cognition has implications for measuring team cognition and for intervening to improve team cognition. For instance, we have developed measures that rely heavily on interactions in the form of communication and message passing (Cooke & Gorman, 2009). With the goal of having unobtrusive measures in context, and collected in real-time, automatically, we have relied on communication flow and the timing of the passing of pertinent information. Interventions to improve team cognition can also involve manipulating interactions. For instance, perturbation-training involves blocking a particular communication channel so that team members need to explore other ways to coordinate. Perturbation training has led to the development of more adaptive teams (Gorman, Cooke, & Amazeen, 2010).

Similarly, when an AI agent or "Synthetic Teammate" is included on a three-agent team, interaction also proves to be critical (McNeese, Demir, Cooke, & Myers, 2018). The synthetic teammate was not a good team player, as it failed to anticipate the information needs of its fellow human teammates. That is, it performed its task of piloting the air vehicle well but did not provide the human team members (navigator and sensor operator) with information in a timely manner or even ahead of time. Humans do this naturally and get better at it as they practice the task. Interestingly, the human team members "entrained" or stopped anticipating the needs of others on the team, as if modeling the synthetic teammate. Thus, even though the synthetic teammate was pretty good at its own taskwork, it was not effective at teamwork, resulting in a gradual decline of teamwork on the entire team.

In another condition we tested a team with an expert human sitting in the same seat as the synthetic teammate. This expert subtly coached the team's coordination by asking for information when it would not come in a timely manner (McNeese, Demir, Cooke, & Myers, 2018). This condition resulted in teams becoming more effective than the synthetic-teammate teams or even teams with three naïve humans. This "coordination coaching" also appears to work to improve the effectiveness of mock code-blue resuscitation teams in a hospital setting (Hinski, 2017).

Other interesting findings include an inverted U-shaped relation between team interaction stability and team effectiveness (Demir, Cooke, & Amazeen, 2018). The best performing teams are neither rigid nor random in their interactions, but are flexible and adaptive when they need to be, and they can exhibit resilience by quickly returning to the prior state. Examining team dynamics has given us a view into the communication dynamics of the team which for us represents team cognition (Gorman, Amazeen, & Cooke, 2010). Also, extending this system view beyond the three agents and to the vehicle, controls, and environment in which they act, we have demonstrated how signals from these various components of the system can be observed over time. Given a perturbation, then one can observe changes in particular system components, followed by others. These patterns provide an indication of system interdependencies and open many possibilities for understanding not only teams, but system complexity (Gorman, Demir, Cooke, & Grimm, 2019). It is intriguing to consider using a system's time to adapt to a perturbation and then to return to a resting place as an index of context-free team effectiveness.

Overall, we find that there is much more to team effectiveness than having the right teammates on the team with the right skills and abilities. The teammates need to be able to navigate the team interdependencies in adaptive and resilient ways. Effective teams learn to do this over time. AI agents need to also have this ability and without it, it can be a disruptive force to the system that is a team.

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