NORTHWESTERN UNIVERSITY

Leading Teams in the Digital Age:
Team Technology Adaptation in Human-Agent Teams

A DISSERTATION

SUBMITTED TO THE GRADUATE SCHOOL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

for the degree

DOCTOR OF PHILOSOPHY

Field of Media, Technology, and Society

By

Lindsay E. Larson

EVANSTON, ILLINOIS

September 2021

Abstract

This dissertation imagines the near future of teamwork, when AI agents will join teams, interacting, collaborating, and completing tasks as a team member. Broadly, I seek to answer the questions: how do humans integrate a new AI teammate onto their team, and how does the AI teammate's function influence this integration process? Further, given the integral role of team cognitive processes: how do human team members adjust their transactive memory systems (TMSs) to accommodate agent teammate newcomers? To better understand this phenomenon, I propose the concept of team technology adaptation and elaborate a developmental stage model to explain how teams adjust their mental representations and interactions in response to the introduction of an AI teammate. I studied the effects of an AI newcomer on team functioning in a series of two studies. Study 1 used a sample of 365 MTurk workers to validate measures of cognitive processes derived from my stage model. Study 2 was a laboratory experiment including 63 teams (149 individuals) who adjusted to the addition of an AI newcomer that was randomly assigned to support teamwork, taskwork, or both teamwork and taskwork. The AI, named "Vero", was implemented using a Wizard of Oz methodology, with a confederate, pre-validated team function prompts, and visual animations. Teams performed three parallel problem solving and creative thinking tasks, first without an AI, and then in two subsequent rounds with Vero. Key findings are presented in Table 1.

In this dissertation, I introduce the concept of team technology adaptation, contributing to our current understanding and future exploration of how humans experience agentic team technologies and how it affects team processes and states. Further, I demonstrate that agent teammates occupy a unique position within the human-agent TMS that is important in predicting team behavioral process. Results also provide evidence for the important role of AI teammate

schema in the development of human-agent TMS. Finally, I find that it is *not* the presence of an agent teammate that only completes teamwork processes, but rather the lack of taskwork processes, that lead to less positive processes and outcomes in human-agent teams. These results have practical implications for how leaders prepare their teams to integrate AI teammates onto teams.

Acknowledgements[1]

First, I am so thankful for my academic leaders who led me through this process and made this dissertation possible. Thank you to my brilliant, creative advisor, Leslie DeChurch, who taught me how to be an academic. Thank you to Noshir Contractor for providing me with feedback and experiences that have made me a better scholar. Thank you to Malte Jung for strengthening this work with new perspectives. And thank you to Jeanne Brett, for advising and inspiring myself and countless other women and men in academia who walk in your footsteps.

I also want to thank the team that helped make this dissertation possible. A special thank you is due to Gwen Hodges (my right hand woman), Sherry Xue (tech/research extraordinaire), and my Vero army: Sam Pietenpol, Emma Breen, Louis Wong, Elaine Liu, Sidney Imeroni, Courtney Larson, Isabel Zhong, Megan Frame, Chee Anyanwu, Julia Gangi, Emilya Ershtein, Akhil Kommala, Lance Guapp, Abhi Vinnakota, Shea Christian, Max Johnson, Sophie Furlow, Charlie Chiang, Joshua Hong, and Shannon Lackey.

I want to thank my friend teams, from those back home to my friends I've made along the way, from the DELTA Lab alumni to my ATLAS Lab friends to the lunch bunch. I am forever grateful for their devil's advocacy, mentorship, camaraderie, care, and support.

Finally, I want to thank my parents for believing that I could do anything I set my mind to and that it would be ok even if I couldn't, my grandmothers for their constant love and support, and my siblings for being my first followers (and for sharing leadership now). I especially want to thank Jack for being on my team, every day, through every up and every down. I would not be where I am today without the love and support of all of my teams, and I am so thankful for each and every one of you.

[1] This dissertation is based on work supported by the Army Research Laboratory (W911NF1920140). The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documents.

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Executive Summary

Intelligent machines are joining teams. Beyond "augmenting" or "helping" people, intelligent machines are poised to become full-fledged team members. Their forms vary. At the time of this dissertation, some are embodied humanoid forms, like Pepper (Pandey & Gelin, 2018), other embodied artificial intelligence (AI), like Google Home (Kepuska & Bohouta, 2018), look like a small desk speaker, whereas disembodied AI can take the form of a voice (e.g., Siri, Apple.com, 2021), or icon (e.g., IBM Watson, High, 2012) (see Figure 1 for examples of present-day AI in 2021). Despite the obvious utility of automating certain organizational and team processes so that workers can now focus their energy on other outlets, there are also a myriad of challenges facing organizations that choose to incorporate artificially intelligent technological "teammates" onto their organizational teams. Intelligent technologies are still imperfect in their own programming, and there are many more challenges facing the humans who must now work alongside these technologies. Teamwork is already a challenge taught in business schools and leadership development courses around the world. However, now there is a whole new type of teammate facing those working in teams today. This dissertation imagines teams of the near future where new team members are AI agents that interact, collaborate, and complete tasks as a member of a team composed of other humans. How will the introduction of agent teammates change organizational teams as we know them today? More specifically, this dissertation asks: how do human teams adjust their transactive memory systems (TMSs) to accommodate agent teammate newcomers onto their teams?

In Chapter 2, I review the extant literature on the emerging organizational process of "team technology adaptation" from both a newcomer socialization perspective and a technology adoption perspective, integrating those two literatures in order to theorize about team technology adaptation in today’s organizations. From this review, I propose a stage model for team technology adaptation. I also review the implications for team TMS within each stage and present propositions for future research for TMS in human-agent teams. Team technology adaptation is similar to the process of newcomer socialization, but is different in that the newcomer socialization literature only considers human newcomers. Team technology adaptation considers intelligent agent newcomers. From my review of the two areas of research, I define team technology adaptation as the process of successful assimilation of a new agentic technological teammate through the iterative adjustment of both the human and technological teammates to the new affective, cognitive, and behavioral demands of the team. The current state of AI does not require us to consider the feelings, progress, or career trajectory of the AI, as the newcomer socialization literature typically does for human newcomers. However, the corner of newcomer socialization literature that examines the effects of newcomers on others in the organization and team prove useful for theorizing about team technology adaptation. Likewise, the technology adoption literature considers the process of technology being adopted by humans, but typically does so from a one-on-one perspective, rather than in a larger group or team setting. Additionally, the technology adoption literature does not consider the technology as having its own agency, as artificially intelligent technologies typically have some degree of agency. Thus, Chapter 2 provides a detailed review of the relevant literature to provide a background on the process of team technology adaptation and from where the idea derives, as well as implications for TMS development and evolution in these human-agent teams.

In Chapter 3, I detail Study 1, a scale validation study of MTurk workers. Because of the nascent nature of the phenomenon of interest in this dissertation, many of the processes and states that are the subject of propositions from my stage model do not have pre-established scales with which to measure in a laboratory study. In order to test many of my propositions, I had to develop my own measures. Thus, I defined my new constructs, and I developed a list of possible items for each construct. Then, I randomly assigned MTurk workers to one of 8 pre-selected videos of robots and instructed each participant to imagine a team they had been on in the past, and to imagine the robot was about to enter that team. Then, I had each participant respond to the preliminary list of items. I conducted item analyses, and refined each scale for use in Study 2.

In Chapter 4, I detail Study 2, a laboratory experiment studying the effects of AI function on team technology adaptation and human-agent team TMS. Study 2 examined teams of humans as they first worked together on one interdependent round of team problem-solving and creativity tasks, and then completed 2 more rounds of similar tasks with an agent newcomer. Participants completed surveys before, during, and after working with the agent teammate to fully examine human-agent team TMS evolution. The goal of this study was to test hypotheses developed from propositions developed in Chapter 2. I found that team member expectations for an AI teammate influenced the formation and evolution of human-agent team cognition. Agents occupy a unique place in the human-agent TMS such that communication was impacted, depending on the quality of the developed human-agent TMS. I also found that team members preferred an AI teammate that completed taskwork functions, as compared to AI teammates that only engaged in teamwork functions. In particular, teams did not dislike when an AI teammate completed teamwork processes per se, but rather teams did not like when an AI teammate did not complete taskwork functions as well. These findings support the idea that human expectations for technologies have a critical role in subsequent team processes and states, and humans receive AI teammates differently, depending on their team function. Findings from Study 2 are summarized in Table 1.

In conclusion, this dissertation establishes, tests, and builds the groundwork for our understanding of team technology adaptation to intelligent agents. Organizations are becoming "smarter", increasingly incorporating intelligent technologies alongside human employees as it benefits efficiency, productivity, and the overall "bottom line". However, it is also critical to understand the effects of team technology adaptation on the human teammates of these new "smart" technological teammates. The review of the literature and proposed stage model in Chapter 2 as well as the laboratory study in Study 2 (Chapter 4) develop new theory outlining the phenomenon of team technology adaptation. Study 1 develops and provides validation of 6 new measures of human-agent teaming. Study 2 provides findings for how the process of team technology adaptation affects human-agent team TMS. Overall, this dissertation proposes and establishes the concept of team technology adaptation and provides future directions for further examination of the effects of intelligent technologies as teammates.

CHAPTER 1. INTRODUCTION

Intelligent machines are joining teams. Beyond "augmenting" or "helping" people, intelligent machines are poised to become full-fledged team members. Their forms vary. Machine learning algorithms are used in top management teams to comb through millions of data points to find patterns to help Fortune 500 companies make steering decisions (Strier, 2017). Intelligent agents are scraping file systems to help hospital billing office teams expedite the insurance claims process in hospitals across the US (Waystar, 2020). AI-enhanced chatbots are helping customer service teams answer customer questions when they visit the company website (Io & Lee, 2017). Medical professional teams are teaming up with intelligent agents and machines to diagnose, treat, and operate on their human patients (Lanfranco, Castellanos, Desai, & Meyers, 2004). More and more, humans are incorporating artificially intelligent technologies onto teams as teammates to help the team improve human teamwork, and experts suggest the use of intelligent technologies in our teams will only grow from here (Volini et al., 2020).

Despite the increasing prevalence of artificially intelligent teammates in organizational teams, the research in related areas (i.e., work on newcomer socialization and technology adoption) does not adequately account for this emerging process. For example, the newcomer socialization literature does not adequately account for the uncertainties human team members face in collaboration with a completely novel AI teammate with which they have little prior work experience. Similarly, the technology adoption literature does not adequately account for the autonomy of the AI teammate nor the relational dynamics concerned in bringing on a new, agentic teammate. Work on trust in human-robot interactions summarizes this conundrum well: "While people are by their nature mistrustful of strangers and novelties, automatons are entities on a much higher level of unknown" (Lazanyi & Hajdu, 2017, p. 216). Thus, these areas of research do not wholly account for the inclusion of a completely new type of teammate that often significantly augments or completely transforms human team member roles and relations (Fiore & Wiltshire, 2016; Kellogg, Valentine, & Christin, 2020; Larson & DeChurch, 2020).

This dissertation imagines teams of the near future where new team members are AI agents that interact, collaborate, and complete tasks as a member of a team composed of other humans. Broadly, I seek to answer the question: how does the introduction of agent teammates change organizational teams as we know them today? This dissertation addresses the question: how do human teams adjust their transactive memory systems (TMSs) to accommodate agent teammate newcomers onto their teams? I begin to answer this question by proposing a new kind of socialization process, team technology adaptation. I define team technology adaptation as a two-part process: (1) work group adjustment to the new technology teammate via team-level communication and negotiation, and (2) the technology teammate acquisition of knowledge, skills, and attitudes related to team collaboration. Both of these processes occur through iterative adjustment processes on the part of both the technological agent and the work group.

I integrate related work on newcomer socialization and technology adoption theory to propose a stage model of team technology adaptation to establish and foster the future study of this critical yet underdeveloped process in organizational teams. I use a mixed methods approach composed of field interviews and a laboratory study to investigate the effects of team technology adaptation on team cognition. I empirically examine the effects of team technology adaptation on team transactive memory systems by conducting field interviews with hospital team members working with AI teammates to expedite the insurance billing process. Finally, using a Wizard of Oz methodology in a laboratory setting, I examine the effects of team technology adaptation on the development and evolution of team TMS in teams completing a problem-solving task.

This dissertation makes three contributions. First, I propose a new process, team technology adaptation, to address the gaps in the current literature via an integration of current related areas of research. Team technology adaptation, as an emergent process, represents a direction for future research, and the definition of the new concept allows room for the anticipated advancements in AI technology. Second, I empirically test the theory developed from the theoretical development of team technology adaptation via an experimental laboratory study. Third, I examine team technology adaptation from the team-level of analysis, which answers the call for more consideration of organizational processes from more than simply the individual perspective. Socialization always happens in the context of others, so the findings of this dissertation account for the multilevel nature of socialization.

Organization of Studies

Integrating research and theorizing across multiple disciplines, I develop a stage model of team technology adaptation in human-agent teams. Through this stage model, I provide theoretical grounding for the development of a process of team technology adaptation. In a laboratory study, I test components of the theory developed in the stage model of team technology adaptation. For the purposes of the laboratory study, I also develop new scales to measure human-agent teaming constructs.

In Study 1, I develop and conduct scale validation of 6 new human-agent teaming constructs: human-agent TMS, agent-human TMS, human-agent team dynamic restructuration, group valence toward AI, AI teammate schema, and human-agent TMS evaluation. I explain the process of item development and refinement as well as present the analyses that aided in scale validation decisions from this study.

In Study 2, I conducted a laboratory experiment studying team technology adaptation in teams completing a team problem solving task. Study 1 examines teams of humans with prior working experience with one another who work with an agent newcomer. The goal of this study was to understand how the introduction of an agent newcomer affects the evolution of cognition in human-agent teams. Participants completed surveys before, during, and after working with the agent teammate on problem-solving and creativity tasks so that I could fully examine human-agent team TMS evolution.

CHAPTER 2. A MODEL OF TEAM TECHNOLOGY ADAPTATION

This dissertation focuses on artificial intelligence agents that interact, collaborate, and complete tasks as a member of a team composed of other humans. Specifically, I focus on the process of introducing a new AI agent teammate onto an organizational team. I seek to answer the question: how does the introduction of agent teammates change organizational teams as we know them today? I begin to answer this question by proposing the concept of team technology adaptation and providing a stage model of team technology adaptation to provide a grounding for future research. Within my stage model, I also detail implications for team TMS, a critical challenge particularly salient to the future of human-agent teaming. The empirical study of this dissertation also focuses on the development and evolution of team TMS in human-agent teaming.

I define team technology adaptation on a team as a process that breaks down into two key parts: 1) the team acquisition of knowledge, skills, and attitudes needed to accommodate the AI teammate in the affective, behavioral, and cognitive processes of the team via team-level communication and negotiation, and 2) the AI teammate acquisition of knowledge, skills, and attitudes necessary for group collaboration via iterative adjustments in response to team norms, climate, and interactions. For example, team technology adaptation may look like a team with an agent teammate that monitors team affect and provides interventions to the team members in order to boost team affect. In a scenario where a team may need an affect intervention, an agent teammate may know that intervention approaches that are more abrupt have been less effective in the past and the agent teammate knows to be gentler in delivery of interventions for maximum effectiveness. Likewise, the human team members have learned how the agent teammate typically delivers interventions and how to respond to the interventions in a way that demonstrates an understanding of the agent teammate's intentions as helpful rather than offensive or rude. In line with the newcomer socialization and technology adoption literatures, the end result of successful team technology adaptation is more productive team processes, such as effective communication and collaboration between agent teammates and human team members, and emergent states, such as high levels of trust between AI teammate and human team members (Anderson & Thomas, 1996; Sarker et al., 2005).

Conceptualizing an Agent Teammate

This dissertation focuses on a specific type of technology known as AI agents. In my conceptualization of team technology adaptation, I borrow from existing work on technology as a teammate to define *technology* as the "devices, software, protocols, and other interventions that target the members of the team with the goal of improving team processes." An *agent* is a technology that performs "taskwork as part of the larger team… satisfying its role on the team" (DeCostanza et al., 2018, p. 4). A technology is essentially a tool for team members to utilize whereas an agent is a technology that has its own roles, responsibilities, and/or agency as a member of a team. Another important distinction is the difference between robots and artificial intelligence. Robots are "embodied agents with physical features roughly resembling human characteristics." AI is an agent that performs "tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages" (Artificial Intelligence, 2019). This dissertation focuses on AI agent teammates, which I refer to as agents or agent teammates throughout this dissertation.

One distinction that I make clear in my dissertation is that the newcomer entry that I focus on is that of an agent teammate. Although separately defined above, it is important to define what this means for the purposes of this work because when combined, an "agent teammate" encompasses ideas that have not yet been combined in a single conceptualization of technological teammates, and there are unique implications of the various assumptions that come along with each part of the label. The "agent" piece of the conceptualization implies that the agent teammate is intelligent, agentic, and adaptive. To elaborate, the agent teammate must display behaviors indicative of some degree of human-like intelligence, on par with or uniquely contributing to team process in some way that is advanced enough to be perceived as human-like. An agent teammate must also be agentic, displaying some degree of independence in which the agent teammate can act of its own volition, without the constant guidance or supervision of a human teammate. The agent provides a unique perspective suggesting that it is not simply carrying out the intentions of others. Also, an agent must be adaptive. Although adaptability is related to the idea of intelligence in that it must have human-like cognitive abilities, it must also be able to learn and react appropriately to new situations. The agent must be able to modify its behavior in response to changing task, team, and situational demands.

The second piece of the conceptualization, the "teammate" piece, implies that the agent is a teammate, meaning it is interdependent, displays intrinsic motivation to perform, and is social. In particular, the agent must perform work tasks that are mutually reliant on work tasks performed by teammates. The agent must also exhibit concern for the quality and quantity of team output and engage in goal-directed behaviors. Finally, the agent must exhibit concern for constructive social interactions with teammates. This includes engagement in behaviors that build relationships with others on the team and contribute to overall team process. In Table 2, I define the two components of my conceptualization of an agent teammate and provide exemplar behaviors of each component in a team setting.

A Review of the Relevant Literature

In order to understand how teams adapt to AI, I draw on and synthesize work on newcomer socialization and technology adoption (see Table 3 for descriptions of key elements of this work). The area of newcomer socialization examines the needs and demands of bringing a new employee into a team (Moreland & Levine, 1982) or organization (Chao et al., 1994). Relatedly, Tyre and Orlikowski (1994) define technology adaptation as the “adjustments and changes following installation of a new technology in a given setting. In this dissertation, the newcomer socialization literature and the technology adoption literature are useful because these processes share many qualities with the process of team technology adaptation. However, there is a distinct need for the process of team technology adaptation as a separate concept. I summarize key ideas from each perspective as well as where each falls short in addressing team technology adaptation in Table 4.

Newcomer Socialization

This dissertation integrates research from multiple disciplines to theorize on changes in team cognition in teams with technology as a teammate. One such area used in this dissertation is the literature on newcomer socialization. The area of newcomer socialization examines the needs and demands of bringing a new employee into a team (Moreland & Levine, 1982) or organization (Chao et al., 1994). Socialization is a critical topic in the organization sciences, and in teams science in particular, as it is how new team members are brought on to the team which influences future newcomer, team member, and overall team success in the organization (Chen, 2005; Chen & Klimoski, 2003). Likewise, organizations spend extensive resources in terms of organizational time and money to onboard newcomers (Bauer, Morrison, & Callister, 1998; DeMarco, 1996).

One particular iteration of newcomer socialization happens specifically in the context of a work group, and is the iteration of newcomer socialization most relevant to this dissertation. Work group socialization is defined as “newcomer acquisition of knowledge, abilities and attitudes needed to perform a work role, and the assimilation of the newcomer into the proximal work group via exposure to its norms, psychological climate, rituals and rites de passage, and the concurrent accommodation of the work group to the newcomer over time” (Anderson & Thomas, 1996). Anderson and Thomas (1996) detail that their definition critically includes two aspects to the process of socialization: 1) learning process and 2) outcomes (assimilation of the newcomer and reciprocal impact of the newcomer on the rest of the work group). The learning process of socialization occurs as a newcomer acquires the “knowledge, abilities, and attitudes” required for their new role. One of the outcomes critical to this definition include the assimilation of the newcomer onto the team, sometimes requiring the newcomer to change their own thoughts or behaviors to be included or identify with the group. The second outcome critical to this definition is the reciprocal impact of the newcomer on the rest of the group, as the group may shift and evolve to accommodate, onboard, or welcome the newcomer onto the team, and suggests an affective component to newcomer socialization.

In this dissertation, the newcomer socialization literature is useful because the process of newcomer socialization is similar to that of the technology as a teammate introduction process. In the process of newcomer socialization, there is an individual entering a pre-existing team structure with its own pre-established norms and transactive memory systems. The leader(s) of that team typically take it upon themselves to introduce the newcomer and to onboard the newcomer to the norms and work styles of the team so that the transition process is as easy as possible. The concerns here are making sure the newcomer is prepared to handle both the task-related and relationship-related demands of the team.

On the other hand, the process of implementing and introducing a new technology that will act as a teammate on a team is similar in some ways, but very different in other ways. In a team using technology as a teammate, the team is still accepting a newcomer onto the team (the new technology), but this is a new kind of newcomer with which they have no prior working experience. This new technology likely requires some sort of user training to work alongside it and to understand how it operates so that the human team members can better coordinate with the new technology. Human team member roles may shift and change with the integration of a new technological newcomer.

Some of the concerns present in human newcomer socialization are not present when considering team technology adaptation. Newcomer socialization implies a human newcomer. This concept considers the “reciprocal impact” of the newcomer on the team and vice versa. However, as technological advances stand presently in 2020, there are no sizeable concerns regarding many variables typically considered in newcomer socialization research such as the “career work role” of a “newcomer performance” scale used in Chen & Klimoski, 2003 and Chen, 2005, or “newcomer empowerment” (i.e., Chen, 2005). Likewise, the technological agent comes with the necessary “knowledge, abilities, and attitudes needed to perform a work role” before it enters the team, so there is no need for the acquisition of this knowledge from other members of the team or a team leader.

Technology Adaptation

Another related area is that of the technology adaptation literature. Tyre and Orlikowski (1994) define technology adaptation as the “adjustments and changes following installation of a new technology in a given setting. Much of this work emanates from early work on technology acceptance, which is the idea that “a user’s actual adoption/use of a technology will be dependent on his/her intention to adopt that technology” (Sarker & Valacich, 2010, p. 790). The Technology Acceptance Model (TAM; Davis, 1989) suggests that perceptions of usefulness and the ease of using the technology are two primary factors of an individual’s likelihood of accepting (i.e., regularly utilizing) the technology. Usefulness and ease of use are factors suggested to influence an individual's attitudes and behaviors towards the technology which in turn influences overall technology acceptance. Venkatesh and Davis (2000) extended this theory by proposing that social influence and cognitive instrumental processes are antecedents to the original TAM’s predictors of perceptions of usefulness and ease of use.

Similarly, the concept of team technology adaptation derives from the technology acceptance and adoption literature. Technology adoption by groups has been defined as an “adoption decision regarding a certain technology made collectively by the group through a process of communication and negotiation (leading to some degree of consensus among members regarding the adoption decision)” (Sarker et al., 2005, p. 45). The technology adoption literature falls short in fully articulating the concept of team technology adaptation in that it does not assume agency in the technology being adopted by users. The language of “adoption” and “adaptation” implies that the humans have all the agency, and does not imply a “relationship” between an agentic technological teammate and humans. In order to successfully socialize technology onto teams as a teammate, there must be a sense of a relationship (Larson & DeChurch, 2020) that is not fully captured in the concept of technology adoption.

Team Performance Adaptation

One other area of research that aids in the understanding of team technology adaptation is the area of team performance adaptation. Team performance adaptation is defined as the "cognitive, affective, motivational, and behavioral modifications made in response to the demands of a new or changing environment, or situational demands" (Baard, Rench, & Kozlowski, 2014, p. 50). The bulk of research on team performance adaptation focuses on how teams in organizations might be forced to adapt to economic, political, social, or cultural shifts that affect an organizational team (Bell & Kozlowski, 2008; Chan, 2000; Ilgen & Pulakos, 1999; Smith, Ford, & Kozlowski, 1997). The team performance adaptation literature provides a grounding for how to think about how teams react to changing demands in terms of the level of adaptation, the adaptive mechanisms used to adapt, and the complexity of the team tasks. Technological changes also present a challenge to team performance adaptation, and cognitive processes and states are suggested as a critical aspect of successful team performance adaptation (Burke et al., 2006).

In the case of a human-agent team, the addition of a new agent onto a team presents a new or changing demand for a team. The agent is an individual entity brought on to a team that has adaptation implications at the team level. In particular, an agent newcomer provides great changes in the complexity of the more coordination-heavy tasks teams work to complete. Teams must adapt team affective states and behavioral and cognitive processes in order to successfully adapt to the internal environment changes brought about by a new kind of teammate.

Team Technology Adaptation: Antecedents and Outcomes

Based on review of the extant literature related to newcomer socialization and technology adoption, I propose that team technology adaptation is influenced via four main types of antecedents (see Table 5): 1) newcomer characteristics, 2) team characteristics, 3) team task characteristics, and 4) situational characteristics. I also propose exemplar outcomes of team technology adaptation based on the literature, such as newcomer performance (i.e., Bauer, et al., 2007; Chen, 2005; Chen & Klimoski, 2003), team performance (i.e., Sarker & Valecich, 2010), social structures (i.e., Desanctis & Poole, 1994; Majchrzak et al., 2000; Morrison, 2002), action processes, and interpersonal emergent states. Similar models and study of such models have been proposed in the newcomer socialization area (i.e., Anderson & Thomas, 1996; Arrow & McGrath, 1995; Bauer et al., 2007) and the technology adoption area (i.e., Brown, Dennis, & Venkatesh, 2010; DeSanctis & Poole, 1994; Majchrzak et al., 2000), but the team technology adaptation model presented in this dissertation integrates the two spaces into a single model relevant to this particular process.

Cognitive Processes & Team Technology Adaptation

A key indicator of successful team technology adaptation is the development of productive cognitive processes on the new human-agent team. In particular, successful team technology adaptation requires the development of transactive memory systems (TMS) that take into account the new agent team members brought onto the team in the process of team technology adaptation. A transactive memory system is “the shared division of cognitive labor with respect to the encoding, storage, retrieval, and communication of information from different domains that often develops in close relationships (Hollingshead 2001, p. 1080)” (Lewis & Herndon, 2011, p. 1254). Transactive memory systems are a cognitive process enacted by teams that reflect the team’s usage of the expertise distributed among team members (Zhang, Hempel, Han, & Tjosvold, 2007). Humans form TMS based on a process of constructing “TEP units” which are the basis of creating TMS and represent the mental linkage of tasks with the required expertise and a person who has that expertise (Brandon & Hollingshead, 2004). TEP units form a person's mental representation of the distribution of knowledge and a mental map guiding who to go to for differing tasks based on their TEP units developed. A person on a team creates TEP units to build a TMS, and the person modifies their TMS based on evaluation of the accuracy, sharedness, and validation of the TMS as they work in their groups. TMS in groups is indicated via team member specialization, credibility of expertise, and effective coordination of knowledge tasks based on the TMS (Liang, Moreland, & Argote, 1995). TMS development has been shown to be influenced by factors related to team composition, team task characteristics, and team context (Ren & Argote, 2011).

Team TMSs have been examined in the newcomer socialization literature to some extent. One study examined the effects of membership change on group TMS and performance and found that groups tend to rely on oldtimer TMS structure when a newcomer is brought onto the team (Lewis, Belliveau, Herndon, & Keller, 2007). However, the study also found that doing so is harmful to overall team performance because relying on old, outdated TMS structures means teams are not updating and reconfiguring their TMS structures based on the addition of the newcomer and therefore experience inefficient TMS processes.

Likewise, the technology adoption space includes some research examining TMS in teams adopting new technologies. Much of this work focuses on the benefits of using technology to enhance TMS processes in teams (Gray, 2000; Lewis & Herndon, 2011; Schreiber & Engelmann, 2010; Yuan, Fulk, & Monge, 2007). For example, in a field study of IT support in two South Korean firms, IT support was shown to benefit the development of TMS and related team processes, such as knowledge sharing and knowledge application (Choi, Lee, & Yoo, 2010). Thus, the adoption of technologies to aid in team TMS were found to be helpful to team TMS processes, but cannot yet fully replace human TMS (Lewis & Herndon, 2011).

With the introduction of a new kind of teammate to a team, the human team members involved in team technology adaptation need to restructure their pre-existing TMS to incorporate the expertise and abilities of the new agent team member. This area of work is still in the early stages as innovations in automation and robotics continue to advance. For example, Liu and Hinds (2009) posit that bringing on robots to an incident response team has implications for the coordination of human-robot teams, specifically in terms of TMS specialization, credibility, and coordination. Another study on human-agent teams examined the role of explanation of behaviors exhibited by an agent team member on overall team coordination (Harbers, Bradshaw, Johnson, Feltovich, van den Bosch, & Meyer, 2011). The study found that explanation of behaviors of an agent team member had positive effects on human experience working with the agent, but the study found inconclusive results for the effect of behavior explanation on team performance.

As the area of human-agent teaming in general is still in its infancy and there is little work on human-agent cognitive processes in teams, we know relatively little about human-agent transactive memory systems. Because of the differing expectations humans have for humans compared to agents, when a new agent team member enters a team, the human team members likely have to augment their pre-existing TMS to include the expertise of the agent. However, lack of experience working alongside an agent likely causes human team members to struggle to incorporate these new teammates into the team TMS. Further, the current state of the TMS literature does not account for a new type of agent teammate. While the behavioral indicators of TMS (specialization, credibility, and coordination) should still apply to a human-agent TMS, the referents of the behavioral indicators are important to assessing and studying TMS in human-agent teams. For example, current measures of human team TMS (i.e., Lewis, 2003) only imply inquiry about the human-human interactions and working relationships. Because of the inherent differences in how humans respond to and interact with agents, there is a need to examine a new iteration of TMS as a construct: the human-agent TMS. In order to fully assess the TMS of humans and agents on a single team, we must understand how the agent is incorporated into the team TMS specifically.

A Stage Model of Team Technology Adaptation

This dissertation focuses on transactive memory system development and evolution as teams undergo the process of team technology adaptation. Below, I detail a stage model (Ashforth, Sluss, & Harrison, 2007) for team technology adaptation based on my review of the relevant literatures. I propose that team technology adaptation occurs in 4 main stages: Anticipation, Evaluation, Reconstruction, and Socialization (see Figure 2). Within the elaboration of each stage of the team technology adaptation process, I detail what is happening to the TMS processes and structures as teams undergo team technology adaptation. From this explanation, I provide propositions regarding how transactive memory system structures and processes develop and evolve as teams undergo team technology adaptation. These propositions are the focus of the empirical work in the remainder of this dissertation. Propositions are listed in Table 6 along with whether they are tested in Study 2.

Stage 1: Anticipation

Stage 1 is the Anticipation stage. Stage 1 derives from the Anticipation stage of newcomer socialization stage models (i.e., Nicholson, 1987), but the sources of influence in anticipation differ somewhat in team technology adaptation compared to newcomer socialization. This stage occurs before the agent newcomer enters the team. At this stage, human team members have working experience with one another, so they have developed affective, behavioral, and cognitive processes and states (Kozlowski & Ilgen, 2006; Marks, Mathieu, & Zaccaro, 2001).

In this stage, human team members learn they have an agent newcomer joining their team, so the human team members begin to form expectations of the agent newcomer in terms of the newcomer's expertise, team roles, and responsibilities. In human newcomer socialization, people have been shown to rely on stereotypes, such as gender stereotypes, to infer expertise before meeting a person or learning more about them (Hollingshead & Fraidin, 2003). Humans also expect human newcomers to be passive, dependent, and conforming (Moreland & Levine, 1989). Expectations in agent newcomers are likely based on information the human team members gather from their organization, leadership, and other external sources as well as any relevant past experiences or attitudes towards autonomous technologies. Both the newcomer socialization (i.e., Chen, 2005; Chen & Klimoski, 2003) and the technology adoption literatures (i.e., Sarker & Valecich, 2010) suggest that incumbent expectations for the newcomer influence the subsequent success of socialization. When bringing on newcomers to teams, the incumbent teammates, the teammates who were already members of the team before the introduction of the newcomer, respond differently to the newcomer based on pre-existing attitudes towards automation, technology, and agents. Humans all have experience meeting and working with new humans on teams, so schemas for informing our interactions with a new human are developed from past experiences. However, humans do not all have experience meeting and working with new agent teammates.

Lack of experience with agent teammates and autonomous technology in general means humans need to rely on pre-existing attitudes and expectations towards automation and agents which influence the formation of agent newcomer schemas. Research suggests humans tend to view automation as highly consistent in its quality of output (Wiener & Curry, 1980; Connors et al., 1994; Madhavan & Wiegmann, 2007). In the case of an agent newcomer, humans expect perfection (Dzindolet et al., 2002). One possible explanation for why humans expect perfection from technology is because they see technology as a perfect tool rather than as an imperfect human teammate. Humans tend to be much more forgiving in expectations of humans, leaving room for a more forgiving and realistic relationship to develop.

Further, humans use cognitive schema based on previous experiences and expectations to shape their interactions. The expectations for agents result in human incumbents building relationships with agent newcomers based on their expectations of high agent performance and reliability (Lerch et al., 1997; Madhavan & Wiegmann, 2007). Likewise, the agent possesses expectations regarding team norms, functions, and its own role on the team it is about to join stemming from its specific programming.

TMS in Stage 1. In this stage, team incumbents construct an TMS. However, the complexities of working alongside an agent teammate force incumbent team members to augment their team cognitive processes (Larson & DeChurch, 2020). Current TMS research typically examines team TMS in terms of team-level specialization, credibility, and coordination behaviors (Lewis, 2003). However, the addition of a new agent teammate changes the way humans form TMS with agent teammates. Because humans have implicit schemas based on their expectations regarding agent performance and expertise, humans form a different dimension of TMS that includes the agent as a unique entity in the TMS. Human team members differ in the structure of their metaknowledge based on their differing schemas of agent versus human teammates. Metaknowledge is knowledge that team members have regarding team member expertise distribution (Mell, van Knippenberg, & van Ginkel, 2014). TMSs are essentially made up of metaknowledge (knowledge of what team members hold certain expertise) and the expertise distribution itself. For example, because humans hold expectations of perfection and reliability towards agents, humans likely shift their metaknowledge structures such that they perceive the agent to hold more expertise relative to other humans on the team.

In particular, humans likely form added dimensions of TMS that include the agent as a unique entity, meaning the ***Human-Agent Team TMS*** consists of human-agent team-level TMS coordination (Lewis, 2003), Human-Human TMS, Human-Agent TMS, and Agent-Human TMS. Human-Human TMS represents the perceptions of TMS specialization and credibility among the human team members (Lewis, 2003). ***Human-Agent TMS*** represent the human team member perceptions of TMS specialization and credibility regarding the agent team members. ***Agent-Human TMS*** represents the human team member assessments of the agent's metaknowledge, which can be thought of as the agent's perceptions of TMS specialization and credibility, specifically.

This TMS is likely shaped by two primary factors: 1) incumbent team member TMS, and 2) incumbent expectations regarding the incoming agent teammate. Based on previous research on membership change in human teams, human team members who worked together on a team previously and developed a TMS with one another tend to rely on their previous TMS, even when a newcomer arrives (Lewis, Belliveau, Herndon, & Keller, 2007). In the Anticipation Stage, the humans likely also use their pre-existing TMS as a guide for forming TMS with the agent teammate newcomer.

> **Proposition 1**: Humans in agent newcomer teams require the development of unique dimensions of TMS that account for the agent's expertise and expertise utilization: 1) a Human-Agent TMS and 2) an Agent-Human TMS.

Proposition 2: Human-Agent Team TMS is shaped by two primary factors: 1) prior incumbent team member TMS, and 2) incumbent expectations regarding the incoming agent teammate.

Humans also have a positivity bias towards technology (Cacioppo et al., 1997; Parasuraman & Manzey, 2010; Hoff & Bashir, 2015), which likely influences the creation of TMS structures. Specifically, human team members are likely to apply their positivity bias towards technology and their expectations of general high performance to their creation of Human-Agent Team TMS. In research on human newcomers, perceptions of superior expertise predict the extent to which incumbent team members incorporate newcomers into their existing TMS (Kane, Argote, & Levine, 2005). In general, when human newcomers enter teams and are perceived as highly skilled in a particular task domain, team members may heavily rely on that team member to complete those types of tasks (Trainer et al., 2020; Choi & Thompson, 2005; Nemeth & Ormiston, 2007). When an AI newcomer enters a team, the team's assumptions of performance perfection cause teams to renegotiate the team TMS such that they shift expertise reliance heavily towards the AI newcomer. Human team members use their pre-existing TMS and incorporate the agent, but because of the expectations of perfection from the agent, humans assume very high levels of expertise and credibility of expertise in the agent, likely lessening human team member perceptions of other team members' relative expertise and expertise credibility. More simply, perceptions of the overall team's TMS specialization and credibility are lower since the team's perceptions of expertise are thought to reside heavily in the agent rather than distributed throughout the team. This likely results in lower Team TMS specialization and credibility, but stronger levels of perceptions of Human-Agent TMS specialization and credibility compared to a Human-Human TMS in a team bringing on a human newcomer.

Proposition 3: Humans expect high levels of expertise from an agent teammate and reconstruct their Human-Agent ***Team*** TMS such that the Team TMS is lower in specialization and credibility than it was prior to agent entry.

Proposition 4: Team members report higher Human-Agent TMS specialization and credibility in a team with an agent newcomer compared to Human-Human TMS specialization and credibility in a team with a human newcomer.

Moreover, Lewis and colleagues (2007) found that incumbent team members expect newcomers to specialize in areas of expertise that the team incumbents were not experts in themselves. An assumption when a team brings on a newcomer is that the newcomer is adding to the team's expertise in some way. Thus, when leadership puts an agent newcomer onto a team, team members are likely to assume the same - that the agent newcomer contributes to the team expertise in some way that was previously lacking. In combination with human expectations of perfection from agents, human team members assume that the agent newcomer fills in the "missing" expertise areas of the team, and the human team members add those newcomers to their TMS accordingly.

Proposition 5: Human incumbents are more likely to expect agents to take on "missing" expertise.

Stage 2: Evaluation

Stage 2 is the Evaluation stage. Stage 2 derives from much of the technology adoption literature wherein the first step in technology adoption is simple use and familiarization with the new technology (Brown, Dennis, & Venkatesh, 2010; Venkatesh, Morris, Davis, & Davis, 2003). Based on findings and theorizing on the technology adoption process (i.e., Sarker & Valecich, 2010), human team members begin to develop a group valence towards technology when they first encounter the technology agent. A group valence is developed through a process in which teams share and express opinions regarding the agent and begin to form a consensus regarding their degree of positive or negative feelings towards the agent (Hoffman & Maier, 1964; Hoffman & Kleinman, 1994; Meyers & Brashers, 1999; Sanders & Baron, 1977). Stage 2 also derives from the newcomer socialization process stage of "encounter" which is when team members first meet and begin to learn about their new teammate and the teammate begins to learn about the team (Anderson, Riddle, & Martin, 1999; Anderson & Thomas, 1996). Research on human teams has demonstrated that team expectations about the relative knowledge of team members influences how groups proceed to work on tasks together (Hollingshead, 2001; Hollingshead & Fraidin, 2003; Moreland & Myaskovsky, 2000).

Stage 2 occurs as the agent enters the team. The agent begins to complete its role on the team based on its own expectations of its role on the team and/or its specific programming. In this stage, human team members begin to learn how to work well with and alongside the technology. Humans may also view the agent as a perfect tool rather than as an imperfect teammate in this stage, since historically, humans have used technology as a tool rather than as a partner or team member. Expectations of perfection make it possible for the agent teammate to quickly lose credibility in the team if it does not act according to expectations, particularly at the beginning of the agent entry process.

In this stage, human team members begin to notice differences between their prior expectations of the agent and the realities they experience from beginning to work alongside the agent. The differences in incumbent expectations and initial observations from working with the agent in this stage help shape team member ***AI teammate schemas***. Team member AI teammate schemas center around how the human team members plan to continue interacting with the agent team member. More simply, team members begin to reconcile expectations with reality to shape whether they interact with the agent as a perfect tool or imperfect teammate.

> **Proposition 6**: Human team members develop a group valence towards the agent team member via group-level communication and consensus-building. Group valence toward AI influences the development of team AI teammate schemas.

TMS in Stage 2. Research shows that when teams are disbanded and reorganized into new groups, TMSs are re-established almost immediately (Baumann, 2001). However, findings on membership change in teams suggests that newcomer entry is often a highly stressful event in a team's life cycle which forces team members to communicate and re-establish cognitive processes (Levine & Choi, 2004) and switch from implicit to tacit coordination (Wittenbaum et al., 1998). However, disruptions to existing TMS structures also negatively affect team learning and learning transfer processes which are critical to evaluation of TMSs (Baumann, 2001; Lewis et al., 2005). As in research on technology adoption (Sarker & Valecich, 2010), human team members likely use their group valence towards the agent to influence interactions with the new agent and the evaluation of their TMS structure. In this stage, the team begins to utilize the TMS structure based on their expectations and past TMS that they created prior to the agent entry onto the team. Team members also begin to evaluate the credibility of their TMS structure based on their interactions with the agent and the extent to which those interactions align with their expectations. Team member reconciliation of these differences shape team member AI teammate schemas and evaluation of TMS structure. When humans in human-agent teams begin to engage in the process of evaluating their human-agent tms structures, they undergo a process I define as ***Human-Agent TMS Evaluation***, which is the extent to which team members feel they had to make team-level changes to team cognitive structures after working alongside an agent teammate.

> **Proposition 7**: Team member AI teammate schemas regarding the new agent team member influence the evaluation of the TMS structure ("human-agent TMS evaluation").

Stage 3: Reconstruction

Stage 3 is the Reconstruction stage. Stage 3 derives from the technology adoption literature where a goal in technology adoption is for the group to "adopt" the technology, or for the entire group to use the technology for its intended purposes (Sarker & Valecich, 2010). Stage 3 also derives from the newcomer socialization literature wherein team members negotiate new team norms based on the addition of the newcomer (Anderson & Thomas, 1996; Ashforth, Sluss, & Harrison, 2007). However, adjustment in the newcomer socialization literature focuses heavily on the adjustments the newcomer must make, whereas in team technology adaptation, both the agent newcomer and human teammates must make accommodations for the newly configured team. All parties (the human and agent team members) understand that the new agent teammate has a place on the team as a team member. The human team members navigate the exact team role of the technology and how they must reciprocally adjust team processes and dynamics to accommodate all new team members. In this stage, humans accept the autonomy of the technology and humans begin to iterate on their own behaviors to accommodate the new team member.

This stage occurs as the team begins to make accommodations for the agent team member. In human newcomer socialization, the distribution and pattern of group communication changes when a new team member is added (McGrath, 1991). When an agent newcomer enters a team, the human team members start to change their behaviors to accommodate the agent through communication and negotiation among team members. Human team members also try to reconcile the difference between their expectations and the reality of working with and alongside the agent team member. The agent may change its behaviors to improve its socialization onto the team based on trial and error and learning. Similar to newcomer socialization, this stage may result in changes in leadership dynamics, role structures, group cohesion, and group norms (Arrow & McGrath, 1993).

TMS in Stage 3. In this stage, teams engage in reconstruction of the team TMS based on their sustained interactions with and alongside the agent newcomer. I refer to the process of reconstruction of team TMS to accommodate a new agent team member as well as reconcile the differences between expectations and reality of working with an agent newcomer as ***human-agent team dynamic restructuration***. Human teams that engage in reflection on their expertise specialization prior to newcomer entry have been shown to have better TMS process and increased team performance compared to teams that do not reflect on their expertise and continue to rely on old TMS structures (Lewis et al., 2007). Thus, when teams engage in higher levels of human-agent TMS evaluation, they will find a need to reevaluate their team cognitive structures to better incorporate the agent teammate compared to the cognitive structures they developed based on their initial expectations. From the identification of a need to reevaluate cognitive structures, teams will then need to engage in greater levels of dynamic restructuration to make their cognitive structures more accurately portray the agent in the structures. Further, frequent communication may provide better opportunities for teams to develop TMS convergence (Brandon & Hollingshead, 2004; Derry et al., 1998; Blickensderfer et al., 1997; Wittenbaum et al., 1999).

Proposition 8: Teams that identify a greater need to reevaluate their human-agent TMS will engage in more human-agent team dynamic restructuration.

Proposition 9: Frequent communication will be positively related to human-agent team dynamic restructuration.

Extant research on human membership change shows that reliance on incumbent team member TMS structure results in TMS process inefficiencies and lower overall team performance (Lewis et al., 2007). The TMS process inefficiencies will affect how effectively teams are able to utilize their TMS structures. TMS reliance on incumbent TMS structure occurs as a result of incumbents maintaining old specializations and failing to reflect on the changes the team underwent with the introduction of a newcomer. Thus, human-agent teams that do not engage in dynamic restructuration likely have similar issues.

Proposition 10: Teams that do not engage in human-agent team dynamic restructuration will experience TMS process inefficiencies.

Stage 4: Socialization

Stage 4 is the Socialization stage. This stage derives from the "socialization" or "stabilization" phase in the newcomer literature where the newcomer becomes a full member of the team (Anderson et al., 1999; Kram, 1988; Nelson, 1987; Nicholson, 1987). In the technology adoption area, research typically examines similar variables under the construct of "usage behavior" (Sarker & Valecich, 2010).

This stage occurs when the agent has fully assimilated onto the team as a full team member. This stage implies that both the agent teammate and humans fully adapted to the new team norms. Further, the humans have accepted the technology as an agentic and productive member of the team, understanding the role of the technology and how to better complete their own roles to further the team-level goals. The humans have fully adapted to the newly adjusted team norms, and they have accepted the agent as a productive and valuable member of the team. Meanwhile, the agent has also fully adapted to the new team norms and, because of the adjustments made by all parties in the team, is able to maximize its functions on the team.

TMS in Stage 4. In Stage 4, teams have achieved agent assimilation into the team. The implications for TMS in Stage 4 means that teams have also achieved a high level of TMS convergence. TMS convergence represents high levels of accuracy, sharedness, and validation of TMS structures among team members (Brandon & Hollingshead, 2004). TMSs have been shown to help improve overall team performance in human teams (Austin, 2003; Faraj & Sproull, 2000; Lewis, 2003, 2004; Lewis et al., 2007). Because of the unrealistic expectations that humans hold for agent team members, dynamic restructuration is likely imperative for most human-agent teams to achieve optimal team performance. Thus, teams that undergo dynamic restructuration of their Human-Agent Team TMS likely experience higher performance than teams that do not engage in dynamic restructuration. Further, teams that undergo dynamic restructuration likely achieve better TMS convergence and TMS utilization.

> **Proposition 11**: Human-agent team dynamic restructuration is the process through which TMS structure shapes team performance, TMS convergence, and appropriate TMS utilization in human-agent teams.

However, one important factor that likely impacts the relationship between Human-Agent Team TMS and dynamic restructuration is the function of the AI teammate on the team. In general, teamwork can be thought of as the combination of the skills of members on the team as well as how the team works together to complete their goals, or “team process.” Team process is defined as “members’ interdependent acts that convert inputs to outcomes through cognitive, verbal, and behavioral activities directed toward organizing taskwork to achieve collective goals" (Marks, Mathieu, & Zacarro, 2001, p. 357). A teammate can contribute to a team in many ways, and these ways of helping generally fall within two broad categories of team process: taskwork processes and teamwork processes. Taskwork processes can be thought of as working toward the completion of the team tasks at hand, and teamwork processes can be thought of as how the team goes about completing those tasks. Examples of taskwork processes include putting together a presentation for the next board meeting or implementing a new marketing strategy, whereas examples of teamwork processes include managing the conflict two team members might be having over which direction to take for the presentation you are putting together for the next big board meeting or keeping the team motivated when the initial marketing strategy does not go according to plan and the team needs to come up with a completely new strategy.

Overall, teams need both taskwork and teamwork processes to work together to achieve team goals. However, some team members are better suited to facilitating more of one type of team process than another based on their relevant knowledge, skills, and abilities (Canon-Bowers et al., 1995; Stevens & Campion, 1994). Some teammates are better suited to helping with affect management or strategy formulation and planning, whereas other team members may prefer to be in charge of the taskwork itself - executing the plans laid out by the teamwork experts.

The same is true for our technological teammates, depending on the intended purpose of the AI teammate. AI teammates are already in organizations, engaging in both taskwork processes, such as risk modeling and analytics, and teamwork processes, such as employee performance management (Balakrishnan, et al., 2020). However, in these situations, the AI is conceptualized as more of a tool rather than as a teammate. Thus, when organizations truly begin to incorporate AI onto teams as agentic teammates, there are differing effects on team cognitive processes and outcomes, depending on the function of the AI teammate.

Specifically, humans have certain expectations for an incoming AI teammate in terms of the team functions that the AI teammate engages in. When the agent enters a team, the team needs to reconcile expectations of the AI teammate with the reality of the AI teammate. In particular, team members need to reconcile their prior TMS structures with the reality of the AI teammate and how the AI teammate actually fits into their cognitive structures. Therefore, if an AI teammate's functions do not align with a team's expectations of the AI teammate functions, the team needs to engage in a larger degree of dynamic restructuration than teams that have an AI teammate that better aligns with their a priori assumptions of the AI teammate's functions. Because humans tend to have expectations of high performance and expertise for an AI teammate (more taskwork-oriented processes), humans likely need to reconcile those expectations to a greater extent if the AI teammate engages in team functions that are unexpected of an AI teammate (more teamwork-oriented processes).

Proposition 12: The relationship between TMS and human-agent team dynamic restructuration varies based on the function (taskwork vs. teamwork) of the AI teammate.

Program of Research Summary

This dissertation aims to provide a better understanding of how to best lead organizational teams through team technology adaptation. Grounded in the stage model and propositions developed in the current chapter, I proceeded in two steps. First, I developed measures of the novel constructs introduced in the stage model, and conducted a measurement validation study, reported in Chapter 3. Second, I translated eight of the ten propositions into testable hypotheses and designed a laboratory experiment to test them, reported in Chapter 4.

The measures developed and refined in Chapter 3 were implemented in the study reported in Chapter 4. Two propositions (5 and 6) from the current chapter were not tested because they fell outside of the scope of Study 2 reported in Chapter 4. Proposition 4 involves a comparison of agent teammate newcomers to human newcomers, which was not a condition defined in Study 2. Proposition 5 requires a separate investigation of expectations of kinds of expertise in an agent teammate, which also fell outside of the scope of Study 2. All other propositions were translated into testable hypotheses in Study 2. Chapter 5 concludes this dissertation with a concluding discussion of the findings, limitations, and future directions that resulted from this dissertation.

CHAPTER 3. STUDY 1: DEVELOPMENT AND VALIDATION OF HUMAN-AGENT TEAMING SCALES

The purpose of Study 1 was to develop and validate scales to be used to examine the development of human-AI team cognition evolution in teams bringing on an AI teammate onto their pre-existing team. These scales were developed from the theory proposed earlier in this dissertation and tested later in this dissertation in Study 2. Many of the constructs being examined in this dissertation have not yet had a scale developed for them as they are new and emerging constructs. Because of this, new scales had to be developed and validated prior to being able to examine these constructs in Study 2. Specifically, new scales/dimensions were developed for the constructs of Human-Agent Team Transactive Memory System (Dimensions: Human-Agent Team TMS Coordination, Human-Agent TMS Specialization, Human-Agent TMS Credibility, Agent-Human TMS Specialization, and Agent-Human TMS Credibility), Human-Agent Team Dynamic Restructuration, Group Valence towards AI, AI Teammate Schema, and Human-Agent TMS Evaluation. TMS Convergence was not validated in this Study as it was not specific to human-agent teaming, but rather was a general team TMS scale created based on a theory paper (Brandon & Hollingshead, 2004). Psychometrics were run for TMS Convergence as well as all other new scales used in Study 2.

The new scales/dimensions were developed using a multi-step process. First, I defined the constructs I wished to create a scale for. Table 7 presents the names and definitions of focal constructs. Items were written based on the theorizing I did for my earlier model development. Next, I needed a way to test the psychometric properties of the scale. Given that most people have not worked on a team with an AI, and examining the properties of these scales requires that participants can complete the scale, I developed a vignette type study where I showed participants short videos of an AI and then asked them to imagine this AI was joining a team. In this way, by varying the AI depicted in the videos I could infuse some variation in perceptions and expectations regarding the AI.

I located videos on YouTube of different AI teammates in popular culture working with humans to use as a subject for which Mechanical Turk users could watch the video and respond to the new Human-AI Teaming scales based on the AI teammate in the YouTube video. I collected data from 381 individuals on Mechanical Turk who each saw one of 8 possible YouTube videos of a different AI teammate. The AI teammates varied in their amount of perceived competence and warmth so that I could achieve a satisfactory amount of variance in the types of AI teammates that MTurk workers could respond to. Once the data was collected, I then conducted item analysis for all items within each scale to review the reliability of the items in each scale. From there, I removed items from each scale that did not seem to be capturing the construct as well as the others. Table 8 presents a summary of items created for the MTurk worker validation effort and the items removed or kept after the MTurk worker validation effort.

Scale Development

From the conceptual development of my new constructs, I know that my constructs are latent constructs and cannot be directly measured, so I had to develop items to measure the manifestation of my constructs. Similarly to that of the construct of Transactive Memory Systems proposed in Lewis' (2003) scale development of TMS, a human-agent TMS implies that when a human-agent TMS exists, is causes "specialized knowledge, mutual trust in others' knowledge, and smooth, coordinated task processing, and… specialization, credibility, and coordination covary because they have a common cause" (Lewis, 2003, p. 591), but the human-agent TMS takes into account the unique assumptions that the human team members bring into their team experiences with an agent team member, and humans likely develop and renegotiate their TMS differently such that an agent team member are uniquely incorporated and renegotiated within the human-agent team TMS when compared to how humans are incorporated into the same TMS. Unique to the human-agent team TMS is the incorporation of the Human-Agent and Agent-Human Specialization and Credibility dimensions. The Human-Agent TMS dimensions consider the human team member perceptions of the agent within the team TMS, and the Agent-Human TMS dimensions consider the human team member perceptions of the agent's perceptions of the team TMS. Higher reports on Human-Agent TMS dimensions mean that human team members perceive the agent as being highly credible and/or highly specialized in the team TMS. Higher reports on Agent-Human TMS dimensions mean that human team members perceive the agent as believing the team members are generally highly credible and/or highly specialized in the team TMS.

With respect to the newly developed construct of human-agent team dynamic restructuration, dynamic restructuration occurs within a team when team members perceive that they had to make changes to or redevelop their TMS in some way to accommodate the new agent teammate. Higher values of dynamic restructuration represent a greater degree of adjustment and reconstruction that teams had to do to accommodate a teammate compared to lower scores on dynamic restructuration. Technology valence represents the general consensus among team members regarding their positive or negative feelings toward a technology (in this case, an agent teammate). Higher scores on technology valence represented a greater degree of positive affect and attributions towards the technology. AI teammate schema is a latent construct that represents the mental structures that team members have regarding the performance, agency, and expertise assumptions that a team member brings with them before they ever begin working on a team with a technological agent. Higher scores on AI teammate schema mean that a person has expectations of performance, agency, and/or expertise for the agent teammate. Human-agent TMS evaluation represents the extent to which team members felt that they had to make changes as a team with respect to their cognitive structures and how the agent fit within their cognitive structures after working with the agent teammate. Higher scores on human-agent TMS evaluation mean that a team felt that they needed to reevaluate their Human-Agent TMS to a greater degree than did those reporting lower scores on human-agent TMS evaluation.

All constructs, with the exception of Human-Agent TMS, were first-order factors, with no sub-dimensions to any of the scales. Human-Agent TMS represented a second-order factor with 4 first-order factors: Human-Agent TMS Specialization, Human-Agent TMS Credibility, Agent-Human TMS Specialization, and Agent-Human TMS Credibility. Using the conceptual definitions of each construct I outlined above, I created a battery of items to assess each construct to present to participants. Then, I tested this measurement model, and the reliability and validity of each initial scale, within a study of Mechanical Turk workers. See Table 8 for a summary of the items included in the study and which items stayed and were cut from this study. Below, I describe the scale development and validation effort.

Sample

Participants for Study 1 were recruited using the Amazon Mechanical Turk platform. Participants were screened on the Mechanical Turk platform so that participants all had obtained at least a Bachelor’s degree and English was listed as their first language. Worker qualifications were specified such that participants had to be from the United States with a HIT approval rating from 90%-100% and number of HITs approved from 500-1,000,000. To be included in the final analyses for Study 1, participants also had to pass attention checks that assessed whether they were paying attention to the questions they were being asked. After checking the attention checks, 16 participants were removed from the dataset for a final total of 365 participants from MTurk for the purposes of scale validation.

Procedure and Task

MTurk workers were presented with a link to a Qualtrics survey where they were instructed to think about a team they have been on or are currently a member of, which I referred to as their “reference team”. We then had the MTurk workers watch a Youtube video of a robot and imagine that the robot was going to join their reference team and to respond to my new scales as though they were about to work on their reference team with the new robot as a new teammate. Robot videos were selected to represent an array of competence and warmth so that a large variance could be achieved in item/scale responses.

Robot videos were randomly assigned to a participant from a selection of 8 different robots (commercially-available robot Pepper, public figure robot Sophia, IBM Watson, fictional robot CASE from the movie *Interstellar,* fictional robot TARS from the movie *Interstellar*, fictional robot K-2SO from the movie *Rogue One: A Star Wars Story*, research robot Vero designed for this research, or Rove, research robot designed for this research. An important distinguishing feature of these robots was their presentation of embodiment, from completely disembodied (Vero, Watson) to human-like (Sophia). Table 9 provides pictures and links to the videos used for each robot in Study 1.

Internal Consistency -- Item Analysis and Reliability

The primary goal of Study 1 was to create a list of items for each scale to form a scale that was internally consistent. I began with a longer list of items for each construct that I presented to all MTurk workers. Once I had collected all of the data and removed participants that did not pass the requisite attention checks, I computed item-total correlations and coefficient alpha for each scale (DeVellis, 1991; Spector, 1992). I went back and forth between this data and the individual items to better understand each item and how it fit within each scale according to the sample of MTurk workers in my sample. Specifically, I examined alpha values for each scale/subscale and all initial scales had alpha values ranging from .70 to .97. I also examined the average item-total correlations for each scale. According to Briggs and Check (1986), in scales with less than 10 items, this is sometimes a better indicator of internal consistency since alpha is sensitive to the number of items in a scale. They suggest a range of .2-.4 for Average Inter-Item Correlation for scales of 10 items or less. Average Inter-Item Correlations of the initial items ranged from .21-.82.

Both the alpha values and internal consistency metrics for all new scales were acceptable, based on extant research in the area. This suggests that my scales as they were developed were generally sufficiently measuring the same construct. However, because I started out with testing more items than were necessary for each scale, one goal of this study was to create scales that were as short as possible to avoid participant survey fatigue and to help participants keep within the time constraints of future data collection wherein I would be using my scales. To shorten my surveys, I also examined the inter-item correlation of each item to the scale to be sure it was sufficiently strongly correlated to the overall scale. Most items did sufficiently strongly correlate to the overall scale, and if an item did not sufficiently strongly correlate to the overall scale, I reviewed the item, and either removed it from the scale or kept it in if it seemed like an item that was substantively related to the overall construct I was trying to measure, but may not make as much sense to MTurk workers who were only imagining working with a new AI teammate rather than actually experiencing working with a new AI teammate. From this process, I was able to shorten the number of items in each scale down to fewer items, with the exception of the Human-Agent Team TMS items. See Table 10 for a summary of this process and the resultant alpha and average inter-item correlations for each scale.

Contribution

Study 1 contributed to the validation efforts of 4 new scales to measure human-agent teaming in some way: human-agent team dynamic restructuration, group valence toward AI, AI teammate schema, and human-agent TMS evaluation. It also provided validation for 2 new dimensions of Human-Agent Team TMS, each consisting of 2 sub-dimensions: Human-Agent TMS (specialization and credibility) and Agent-Human TMS (specialization and credibility).

The scale for human-agent team dynamic restructuration can be used to measure the extent to which teams feel that they needed to cognitively adapt in order to better accommodate a new AI teammate onto their team. The scale for group valence toward AI can be used to measure the extent to which teams have a positive or negative valence of affect towards an AI teammate. The scale for AI teammate schema can be used to measure a person's assumptions of performance, agency, and expertise of a technological teammate. The scale for human-agent TMS evaluation can be used to measure how accurate team members perceive their existing TMS structures and the degree to which they feel they need to adapt their existing TMS structures because of a technological teammate. Finally, the new dimensions of Human-Agent and Agent-Human TMS provide new dimensions of TMS specialization and credibility to use to test how a technological teammate fits into a team's TMS structures in terms of how the humans perceive the agent and how the humans perceive the agent's perceptions of the team TMS. Together, these scales can help better facilitate the study of human-AI teaming by allowing us to measure human-AI teaming states and processes.

CHAPTER 4. STUDY 2: AN EXPERIMENT ON AI TEAMMATE FUNCTION IN TEAM TECHNOLOGY ADAPTATION

In teams of the near future, technology will take on the role of a teammate in teams of humans that have little to no experience working alongside intelligent technological teammates. The impending challenges presented by a new form of teammate raise the question: How does the introduction of agent teammates change organizational teams as we know them today? In order to begin to answer this question, I elaborate the concept of team technology adaptation and propose a stage model of team technology adaptation in Chapter 2. The creation of a stage model is in line with newcomer socialization approaches, which suggest that stage models "continue to provide a useful heuristic for thinking through the challenges that newcomers (and their employers) tend to face" (Ashforth, Sluss, & Harrison, 2007, p.9). From the stage model, I create propositions regarding the stages of team technology adaptation. In particular, I examine what happens to team cognitive processes when human team members bring on an agent newcomer.

In Study 2, I develop and test hypotheses derived from the propositions posed in Chapter 2. Study 2 of this dissertation examines the effects of agent newcomer entry on incumbent team cognitive processes and team performance as the team undergoes the process of team technology adaptation. This chapter presents the results of a pilot study which tests the procedure of the research as well as findings from the pilot study. This chapter also reports a full experiment designed to answer research questions and test hypotheses derived from the propositions presented in Chapter 2 and highlighted as studied in Table 6. Specifically, I test hypotheses derived from Propositions 1, 2, 3, 6, 7, 8, 9, 10, 11, and 12. The hypothesized relationships are established and elaborated below and are pictured in Figure 3.

Hypotheses

This chapter details a study dedicated to testing pieces of the stage model of team technology adaptation proposed in Chapter 2. Broadly, Study 2 aims to answer the question: how do human teams adjust their transactive memory systems (TMSs) to accommodate agent teammate newcomers onto their teams? Moreover, Study 2 investigates the influence of the AI teammate's function in how humans accommodate an AI teammate newcomer onto their team. Below, I detail selected propositions within the stage model and form hypotheses from the propositions.

Stage 1: Anticipation. Stage 1 occurs prior to the entry of the agent newcomer. In this stage, humans learn about the impending addition of the agent newcomer, but do not know much more about the newcomer. Humans have pre-existing expectations of the newcomer's expertise, roles, and responsibilities based on information from the organization, team leadership, and any other relevant past experiences. In this stage, the agent has expectations regarding team norms, team functions, and its assigned roles and responsibilities on the team. The agent's expectations come from its programming. In Stage 1, the incumbent team members have a pre-existing TMS from working with one another in the past that does not include the agent.

In Stage 1, I suggest Proposition 1: Humans in agent newcomer teams require the development of unique dimensions of TMS that account for the agent's expertise and expertise utilization: 1) a Human-Agent TMS and 2) an Agent-Human TMS. In this proposition, I suggest that teams require the addition of new dimensions of TMS in order to effectively incorporate their new agent teammate into their cognitive structures: Human-Agent TMS and Agent-Human TMS. Human-Agent TMS includes Human-Agent Specialization, which represents the agent's role in the team knowledge structures, and Human-Agent Credibility, which represents the team’s beliefs about the reliability of the agent’s knowledge of the team's cognitive structures. The Agent-Human TMS includes Agent-Human Specialization, which represents the team’s perceptions of the agent’s differentiated structures of team member knowledge, and Agent-Human Credibility, which represents the team’s perceptions of the agent’s beliefs about the reliability of other members’ knowledge. By considering these additional dimensions of TMS, we are better able to account for the total TMS structures within a human-agent team since the differences in the human team members’ perceptions and expectations of the agent’s knowledge, abilities, and role may vary between one another and differ from the realities of working with the agent teammate. Thus, these new dimensions help better account for such variance in TMS structures on human-agent teams. Specifically, the newcomer socialization and technology adoption literatures suggest that successful team technology adaptation, as facilitated through human-agent team TMS dimensions, would result in more productive team processes, like communication, emergent states, such as team viability and team cohesion, and team performance.

Hypothesis 1: Human-Agent team TMS specialization and credibility and Agent-Human TMS specialization and credibility predicts (a) communication, (b) team viability, (c) team cohesion, and (d) team performance to a greater extent than TMS specialization and credibility alone in human-agent teams.

I also suggested Proposition 2: Human-Agent Team TMS is shaped by two primary factors: 1) prior incumbent team member TMS, and 2) incumbent expectations regarding the incoming agent teammate. The human-agent team TMS is the TMS that human team members form when they are made aware that they will soon have an agent newcomer join their team but have not yet learned much about the agent newcomer. Research shows that in human teams bringing on a human newcomer, the incumbent team members rely on their pre-existing TMS to continue teamwork activities even when the newcomer arrives (Lewis et al., 2007). Further, humans use their expectations of technology to shape how they interact with and use the technology (Lerch et al., 1997; Madhavan & Wiegmann, 2007). When artificially intelligent technological teammates join pre-existing teams of humans, humans are likely to respond to the entry of the agent newcomer by using their pre-existing cognitive structures to organize their cognitive structures in ways that align with their past experiences and existing cognitive schemas. This means teams likely use their prior TMS structures and processes as a base for their TMS. Further, teams use what knowledge resources they possess about the newcomer to assess how to fit the newcomer into their TMS. In the case of an agent newcomer, team members have little to no prior experience working with an agent teammate, so human incumbents resort to broader technology-relevant schema to shape expectations of the agent newcomer and fit the agent newcomer into their TMS. Thus, incumbent TMS and incumbent expectations shape the formation of the human-agent team TMS.

Hypothesis 2: Prior incumbent TMS and incumbent expectations of agent newcomer positively predicts human-agent team TMS.

From Stage 1, I also posited Proposition 3: Humans expect high levels of expertise from an agent teammate and reconstruct their Human-Agent Team TMS such that the Team TMS is lower in specialization and credibility than it was prior to agent entry. In this proposition, I suggest that there are differences in human incumbent reports of team specialization and credibility of the TMS because of the impending introduction of an agent newcomer. Research on human expectations of technology suggests that humans expect perfection from the technology they interact with (Dzindolet et al., 2002). Human incumbents in teams bringing on an agent newcomer shift their cognitive structures of expertise to represent their perceptions of the distribution of expertise and knowledge among teammates. Because humans expect technology to be consistent and perfect in their performance, human incumbents reform their cognitive structures to represent a perfect or expert agent entering the team. Structurally, this means incumbents shift their perceptions of team specialization and credibility such that the agent has greater expertise relative to the incumbents. Placing greater emphasis on the expertise of the incoming agent inevitably draws perceptions of incumbent expertise away from incumbents and towards the agent causing a shift in team TMS specialization and credibility such that both are less robust after the impending addition of an agent newcomer.

Hypothesis 3: Prior incumbent TMS specialization and credibility is greater than human-agent team TMS specialization and credibility, respectively.

Stage 2: Evaluation. In Stage 2, the agent newcomer first enters the team, and the team begins to interact and work with the agent newcomer. The humans begin to notice the differences between their expectations of the agent newcomer and the experienced realities of working with the agent. The agent begins to complete its roles and responsibilities based on its own programming. In Stage 2, the human team members begin to incorporate the agent into an updated TMS structure based on their expectations of the agent and their past team TMS. The team begins to evaluate the utility of this TMS.

From Stage 2, I posit Proposition 6: Human team members develop a group valence towards the agent team member via group-level communication and consensus-building. Group valence influences the development of team AI teammate schemas. In Study 1, I aim to test the influence of group valence towards the agent newcomer in the development of team AI teammate schemas. Group valence towards a technology represents the general positive or negative attitudes that a group develops regarding a team technology (Sarker & Valecich, 2010). A team's AI teammate schema is a mental representation of how we think about a technology that then shapes our subsequent interactions with the technology. I conceptualize AI teammate schema as a person's perceptions of the technological agent's performance, agency, and expertise. The technology adoption literature has demonstrated that teams adopting new technologies develop group valences towards the technology that then influences the subsequent success or failure of technology adoption. Proposition 6 suggests that the group valence towards the technology is going to influence the success of a piece of the team technology adaptation stage model, team AI teammate schema. Specifically, the more positive a team's attitude towards a technology, the more positive the team AI teammate schema. This relationship is particularly important for the study of team technology adaptation because it tests the extension of technology adoption findings on group valence to the mechanism proposed in the stage model, team AI teammate schemas.

Hypothesis 4: Group valence towards the agent newcomer positively influences team AI teammate schema.

In Stage 2, I also suggest Proposition 7: Team member AI teammate schemas regarding the new agent team member influence the evaluation of the TMS structure. In Study 1, I aim to specifically test the impact of AI teammate schemas on the human-agent TMS (a dimension of the human-agent team TMS that focuses on the human perceptions of the agent in the team TMS). In the stage model, team AI teammate schemas are the cognitive structures representative of the technological agent's performance, agency, and expertise that help team members decide how to interact with the agent. In Stage 2, team members begin to work with the agent and augment their AI teammate schemas based on their interactions with the agent. For example, expectations of perfection in the agent newcomer may cause incumbents to possess an AI teammate schema of the newcomer that emphasizes very high performance capabilities such that the incumbents believe the technology is the expert in the relevant task domains of the team at that time. For a human newcomer, these expectations would be unrealistically high and cause tension because of the dissonance between expectations and reality. In human-agent teams, unrealistic expectations of the agent newcomer emerge in the development of incumbent team members' AI teammate schemas. Whether these AI teammate schemas prove to be correct and useful or incorrect and harmful to the team influence how teams evaluate the effectiveness of their human-agent TMS. However, teams that expect agent newcomers to act based on unrealistic expectations find that their human-agent TMS needs to be reevaluated.

> **Hypothesis 5:** Team AI teammate schema positively influences human-agent TMS evaluation, such that when teams possess an AI teammate schema of high performance and expertise, teams are more likely to report a need to reevaluate their human-agent TMS.

Stage 3: Reconstruction. In Stage 3, the team begins to accommodate the agent newcomer. This requires action from both the humans and the agent newcomer. The humans begin to change their behaviors to accommodate the agent newcomer through a reconciliation of their prior expectations of the agent versus the realities they experience by actually working with the agent. The agent also starts to adapt its behaviors to improve socialization onto the team based on trial and error and learning. In this stage, the team works to reconstruct the team TMS based on their sustained interactions with the agent newcomer via team communication and negotiation.

In Stage 3, I propose Proposition 8, which suggests that teams that identify a greater need to reevaluate their human-agent TMS will engage in more human-agent team dynamic restructuration. Human-agent team dynamic restructuration is the process through which teams reconstruct their human-agent team TMS to accommodate a new agent teammate. Team behaviors such as reflection and communication have been shown to be beneficial for augmenting TMS processes and structures (Brandon & Hollingshead, 2004; Derry et al., 1998; Blickensderfer et al., 1997; Lewis et al., 2007; Wittenbaum et al., 1999). I propose that dynamic restructuration is triggered by human-agent TMS evaluation. When teams acknowledge a greater need to reevaluate their cognitive structures in human-agent teams, those teams will also engage in more dynamic restructuration, compared to teams that acknowledge a lesser need to reevaluate cognitive structures.

Hypothesis 6: Human-agent TMS evaluation will positively influence human-agent team dynamic restructuration.

In Stage 3, I also suggest Proposition 9: Frequent communication is positively related to dynamic restructuration. In human-agent teams, communication behaviors are a critical behavioral process through which teams can renegotiate their understanding of the distributions of expertise and knowledge among team members. Communication should be a behavioral process through which teams engage in dynamic restructuration.

Hypothesis 7: Communication frequency is positively related to human-agent team dynamic restructuration.

In Stage 3, I also suggest Proposition 10: Teams that do not engage in dynamic restructuration experience TMS process inefficiencies. Essentially, Proposition 9 suggests that engagement in the dynamic restructuration process is beneficial for TMS process efficiency, and not engaging in dynamic restructuration is harmful for TMS process efficiency. TMS processes are the encoding, storage, and retrieval of information and expertise within a group (Lewis et al, 2007; Wegner, 1986; Wegner, Giuliano, & Hertel, 1985). Thus, TMS processes are more efficient when teams can efficiently and effectively encode, store, and retrieve relevant expertise and information on the team when the team needs it. The stage model of team technology adaptation suggests that dynamic restructuration is necessary because teams naturally misconstruct their human-agent team TMS because of incorrect expectations about the agent newcomer. Therefore, in order to have efficient TMS processes, teams need to engage in dynamic restructuration of their human-agent team TMS.

Hypothesis 8: Human-agent team dynamic restructuration positively influences TMS utilization.

Stage 4: Socialization. In Stage 4, teams have reached agent assimilation. The humans have fully adapted to the new team norms that arose in response to agent newcomer entry. The human team members also accept the agent as a productive member of their team. The agent is fully adapted to the new team norms and is able to maximize its role on the team. In Stage 4, the team reaches TMS convergence wherein all team members (humans and agents) agree on the representation of the team TMS (i.e., accuracy of team knowledge, sharedness in the structure, and validation of the entire team). Teams also appropriately utilize their TMS.

In Stage 4, I suggest Proposition 11: Human-agent team dynamic restructuration is the process through which TMS structure shapes team performance, TMS convergence, and appropriate TMS utilization in human-agent teams. This proposition suggests that in order for teams to maximize positive team performance and cognition outcomes, teams must engage in dynamic restructuration. Positive outcomes are still related to the TMS structure, but dynamic restructuration acts as a process that enhances the TMS structure in its accuracy, sharedness, and validation according to team members. In other words, teams that engage in dynamic restructuration edit their human-agent team TMSs to more accurately reflect the agent roles and responsibilities and the new team norms developed by the team to accommodate the agent newcomer such that they experience overall performance improvements. Restructuring human-agent team TMSs also allows teams to more likely reach TMS convergence and appropriately utilize their human-agent team TMS.

Hypothesis 9: Human-agent team dynamic restructuration mediates the relationship between TMS structure and team performance, TMS convergence, and appropriate TMS utilization in human-agent teams. Teams that engage more in human-agent team dynamic restructuration have greater team performance, TMS convergence, and TMS utilization, than teams that engage in human-agent team dynamic restructuration to a lesser extent.

Finally, in order to better understand the process of team technology adaptation, I also examine how the function of the AI teammate influences the development and evolution of team cognition and team performance in human-AI teams. The literature on teams has largely taken a functional approach and maintains the important distinction of teamwork and taskwork in thinking about how team members contribute to team processes. Team process is defined as "members' interdependent acts that convert inputs to outcomes through cognitive, verbal, and behavioral activities directed toward organizing taskwork to achieve collective goals" (Marks, Mathieu, & Zaccaro, 2001, p. 357). Team processes that help the team complete actual tasks or objectives are called taskwork processes, and team processes that contribute to how the team uses their skills and abilities in coordination with one another to work together are called teamwork processes.

Importantly, team processes are a critical reason human teams either succeed or fail (Guzzo & Dickson, 1996), and research suggests teams must engage in effective teamwork and taskwork in order to succeed (Burke, Wilson & Salas, 2003; Morgan, Glickman, Woodward, Blaiwes, & Salas, 1986; Fisher, 2014; LePine et al., 2008). By definition, taskwork processes are critical to completing team tasks, but effective teamwork processes are critical for effectively completing taskwork. Teamwork is said to be influenced by contextual, compositional, and cultural factors (Dihn & Salas, 2017). Some research has also acknowledged limitations to the benefits of teamwork processes for positive team outcomes when teamwork processes are not implemented properly or are not implemented under the "right" conditions (i.e., Porter, Gogus, & Yu, 2010). Thus, the synchronization and coordination of team processes has been identified as a major challenge for effective human-AI teaming (DeCostanza et al., 2018).

Technological teammates are already present in organizational teams, contributing in both taskwork and teamwork processes (Wiltshire & Fiore, 2018). Automated agents work in cockpit pilot teams in taskwork, navigating and monitoring plane routes (Mosier, Skitka, Dunbar, & McDonnell, 2001). Another example of a technological teammate focused on taskwork processes is the Amazon warehouse robot that moves packages around the warehouse, reading barcodes on the warehouse floors to navigate and get packages along to its human warehouse worker teammates to quickly ship packages all over the country. AI teammates can also be useful for teamwork processes, such as team monitoring, intervention, planning, and empowering and engaging teams and leaders (Banks & Lizza, 1991; Sycara & Lewis, 2002; Sycara & Lewis, 2004; Webber, Detjen, MacLean, & Thomas, 2019). Teamwork agents are also in development for use in organizational teams to diagnose and recommend interventions to combat team conflict detected via sentiment analysis on meeting transcripts.

Despite the potential usefulness of agent teammates in particular roles, what may be more impactful to overall human-agent team effectiveness may be the degree to which human teammates are willing to accept certain team functions from an agent teammate. Overall, there are roles for AI teammates in both teamwork-focused and taskwork-focused functions, depending on the needs of a particular team. However, because of our expectations for an AI teammate, the function of an AI teammate, and whether the actual functions align with our preconceived schema for an AI teammate, likely influences the overall success of team technology adaptation. Team process has been shown to be a critical mediator of the cognition-performance relationship in human teams (Mathieu et al., 2000), so it is likely that how an agent contributes to team process affects the cognition-performance relationship in human-agent teams as well.

Specifically, I propose Proposition 12: The relationship between TMS and human-agent team dynamic restructuration varies based on the function (taskwork vs. teamwork) of the AI teammate. This proposition takes into account the varying skills an AI teammate may have or the various responsibilities the AI teammate was brought onto a team to accomplish. Because humans come into human-agent team collaboration with expectations of technological teammates of performance, agency, and/or expertise, teams that have a new taskwork-focused AI teammate need to engage in dynamic restructuration to a lesser extent due to their expectations more closely aligning with their taskwork-focused AI teammate. However, teams with a new teamwork-focused AI teammate likely have similar expectations of performance, agency, and expertise for their new AI teammate, but this AI teammate aligns to a lesser extent with their expectations than those in teams with a new task-focused AI teammate. As such, teams with a new teamwork-focused AI teammate likely need to engage in dynamic restructuration to a greater extent to reconcile those differences in expectations that shaped their Human-Agent TMS. For teams that have a teammate that does both taskwork and teamwork functions, since those team members' expectations are still in alignment with part of the AI teammate's functions (the taskwork-focused functions), those teams likely respond similarly to the taskwork-focused only AI teammate teams.

Hypothesis 10: The relationship between Human-Agent Team TMS and human-agent team dynamic restructuration is stronger among teams with an agent that completes teamwork functions compared to teams with an agent that completes taskwork functions.

Pilot Study

The pilot study was conducted in order to examine the task procedures so that further data collection was more likely to assess the variables of interest. The pilot study aimed to answer the question: How does the entry of an agent teammate affect overall team performance and team performance improvement? Participants completed a problem-solving task in teams twice, first with only human teammates and second with the entry of an AI agent teammate. The study used Wizard of Oz methodology in which participants thought they were interacting with an AI agent teammate that was actually a human confederate posing as an AI teammate. Participants were put into teams with either an "Active" or "Passive" agent teammate. Active agent teammates interacted as they saw fit, whereas passive agent teammates only spoke when asked a direct question. The pilot study generally tested the procedure. We also collected open-ended responses from participants to gain a better understanding of their experiences during the task to better inform the full study procedure. Below, I detail the methodology, results, and overall contribution of the pilot study to the larger proposed study.

Method

Participants and procedure. Participants were students of an undergraduate course on leadership of teams titled "Team Leadership and Decision Making" at a midwestern university in the United States (N = 12 teams of 3 or 4 people per team). Data was collected during the Covid-19 disruption, so classes were shifted to remote delivery. The class was taught in the videoconferencing platform Zoom, which is also where this pilot study was conducted. Student participants were randomly assigned to groups of 3 or 4 people, and placed into "breakout rooms," a feature in the Zoom platform. Participants and the overall procedure were facilitated via the course instructor and a course TA (teaching assistant) to give participants information regarding study process and timing. Participants were given a brief introduction to the topic of human-AI teaming, and then given instructions. The task was the "survival task", which is typically used to assess a team's ability to problem-solve (McGrath, 1984; Straus, 1999). The survival task is a type of team task wherein team members are presented with a survival scenario, such as landing on the surface of the moon, ~200 miles away from where you were supposed to land, with the goal of safely reaching your original landing spot with only the items you can carry with you (Hall & Watson, 1970). Team members are also presented with a list of 15 items that they must rank in order of most to least important to their survival. Team members completed the task first individually, and then once they had come up with individual rankings, team members came together as a group to come up with an updated group ranking of the items.

The teams completed two rounds of the survival task. The first round, they completed first individually for 10 minutes, and then came together for 15 minutes to complete a group ranking. In the first round, teams completed a "moon survival" task. After the second round was completed, students were informed that they would be joined by the "ATLAS AI". The ATLAS

AI was presented to students as an artificially intelligent teammate, designed to help teams in their team task. For the second round, teams completed the task first individually, and then when they came together, they were joined by ATLAS AI. In the second round, teams completed a "Lost at Sea" survival task. The two tasks have a similar procedure and difficulty level.

In reality, the ATLAS AI was a confederate human without video using a voice augmentation software. ATLAS AI confederates were undergraduate and graduate student research assistants trained to act as ATLAS AI. Confederates were provided with a "cheat sheet" of information that they as ATLAS AI "knew". There was one ATLAS AI confederate assigned to each team. Confederates were assigned to one of two conditions: Active or Passive. In the Active condition, the ATLAS AI could interject in the team conversation as they saw fit. In the Passive condition, the ATLAS AI was instructed by the research team to only respond to the team when directly questioned. For example, team members were instructed to say "Hey ATLAS" followed by their question if they wanted to interact with the ATLAS AI. Participants were provided a Qualtrics link with instructions and a place to record their individual and team rankings as well as to answer a few survey questions between round 1 and round 2 as well as after round 2.

Measures

Team performance. Participant team performance scores were calculated based on the difference scores between the rankings of the participant and the rankings of a subject matter expert. The rankings of the 15 objects for each Round for each individual and group were subtracted from the expert rankings to create a difference score for each individual and each group, for each round. These difference scores were then aggregated to the team level so that each team had an average individual score as well as a team score. These scores were then standardized using the *scale* function in R (R Core Team, 2020). Scores were standardized so that we could remove the "test" effects, or the effects that may have been present due to varying experiences of difficulty between the two tasks for each team. Once the aggregated individual score and team score were standardized, a difference score was computed to examine the improvement from the individual to the team part of each round. A difference score was calculated for Round 1 and for Round 2. Then, I computed a difference of the differences score, which is the improvement teams experienced from Round 1 to Round 2.

Conclusion

The pilot study provided several insights that inform the design of the full study proposed in this dissertation. Overall, the pilot study procedures were effective. The use of the Zoom video conferencing platform allowed the teams to easily move back and forth between a main room for instructions and small team breakout groups, and to be introduced to the AI only after forming into teams and working together. Using the Zoom platform allowed all team members to join remotely from different physical locations. The Zoom platform also enabled the AI to join from a different physical location which preserved the Wizard of Oz paradigm and ensured that all team members and the AI were equivalently distanced. This procedure would have been problematic if all of the teammates were collocated and only the AI was remote, for example. Furthermore, the Wizard of Oz approach of showing an image and having a confederate pretend to be an AI worked. I considered using a voice synthesizer and wanted to ensure that participants would believe that it was an AI were it to exhibit a typical human voice as is the case with popular technologies such as Siri, Alexa, and Google Home.

Following the completion of the pilot study tasks and survey questions, participants responded to open-ended questions. First, participants were asked "What did you like about working with the AI on your team? What worked well?" I asked participants this question to understand what they saw as the benefits to using the ATLAS AI. I wanted to see if participants were using the AI in the ways that we had designed the AI role. Responses suggested that participants viewed the ATLAS AI as "smart", "a good reference for an opinion about things we weren't sure on", and "helpful in determining what was most important". Overall, responses suggest that the participants were using the AI in the intended manner - to act as an intelligent, competent teammate. However, some of the language used in some participant responses to this question also suggested that participants saw the AI as a tool rather than a teammate (i.e., "It was a useful resource that helped us affirm our beliefs"). This pattern in some responses suggested to me that it may take longer than a single round of the problem solving task for more complex relationships to develop such that participants view the AI as a teammate they work alongside rather than a tool they use. Thus, I use 2 problem-solving tasks in my full study.

Participants were also asked "What did you dislike about working with the AI on your team? What was particularly challenging about working with the AI?" I asked this question in order to understand any unintended difficulties participants may have experienced while working with the AI. This question illuminated some participant frustrations with working with ATLAS AI such as "it was annoying to listen to", "was weird", and "trusted it maybe too much". Overall, participant responses to this question suggest that participants did experience frustrations with the technology. To some extent, the frustrations are normal and expected. However, in order to avoid unnecessary or excessive frustrations beyond frustrations as a result of having a new kind of teammate, in my full study, I know to present both the introduction and role explanation of the AI as clear as possible and to be sure that my AI confederates have extensive practice in their role to avoid potential mistakes that cause unnecessary frustrations.

The last open-ended question was "Overall, how did the addition of the ATLAS AI influence your team, interpersonally or with respect to the tasks? Be as specific as possible." In this question, I wanted to understand if participants had any takeaways that I had not intended or thought about. In general, participant responses to this question confirmed that teams found that working with the AI was helpful for performance and functioning. One way I had not anticipated the AI would be helpful to teams was in team process. For example, one team member reported, "We only used it for disagreements or when we were at a loss." This suggests that the AI was not only used to increase performance, but also used to negotiate conflict of opinion among team members. The ATLAS AI was not intended to help team process directly, but inadvertently, having a different kind of team member who was not affectively involved in the decision making process (was not able to have its feelings hurt if a decision did not go its way) may have helped some teams in their team processes. Another participant said, "Since she's a computer I felt like I could trust her after awhile" which may suggest that the AI changed team process because of its perceived reliability. Responses like this one caused me to more thoroughly consider the role of team perceptions of reliability of the AI teammate in overall team processes. Another common response to this open-ended question was that teams did not have enough time to figure out the best way to interact with the AI. This response suggested the need for more time for team processes to develop with the AI on the team, another motivation for adding a second round of the problem-solving task to the full study. Finally, participants in general seemed to believe ATLAS AI was an agent teammate rather than a confederate, providing validity to the Wizard of Oz methodology. One participant said, "I think the AI freaked us out and we weren't sure if we could trust her. In general though, she helped us come to a conclusion on some of the objects. For example, we were deliberating on whether to rank the small mirror high on the list and she said it was a good idea so we did." This response shows that participants saw the AI as a "she" rather than an "it", which presents some evidence for the believability of the Wizard of Oz design.

Overall, the procedure generally seems to allow participants to have a meaningful experience in the task working alongside agent teammates. With the modifications outlined above, the procedure should allow for adequate study of TMS development and evolution in teams undergoing agent teammate entry.

Laboratory Study

Participants

The sample for Study 2 consisted of university students recruited from a mid-size midwestern university as well as community members from a listserv created by university members for the purposes of collecting data from non-student participants and to collect data from more diverse populations. The study was conducted within a larger project, part of the ARL (Army Research Lab) STRONG (Strengthening Teamwork for Robust Operations in Novel Groups) program. I recruited approximately 180 participants, and the final sample consisted of 149 individuals in 63 teams. Participants were recruited for a single 3 hour session where they worked on a team with 1 or 2 other humans in a humans-only team to build team entitativity and then were introduced to an agent newcomer and told to complete additional problem-solving and creativity tasks as a human-agent team. Participants answered survey items and completed an additional individual decision-making task at the very beginning and very end of the data collection effort. Table 11 details the data collection procedure, measures collected, and hypotheses tested at each stage of data collection.

Design

This study used a 3 (manipulation conditions: taskwork only, teamwork only, or combined taskwork and teamwork) x 2 (team size: 2 humans plus an AI teammate or 3 humans plus an AI teammate) design. A manipulation check was conducted via survey items right after the final task was completed, asking participants to identify which taskwork and teamwork behaviors the AI teammate engaged in. Team size was directly manipulated by the experimenter based on participant numbers in the session on that given day, but participants were always assigned to a random team once the team sizes were determined for that session.

Procedure

Pre-measures survey. About 1 week in advance of their scheduled session date, participants were sent a link to a ~1 hour long Qualtrics survey to be completed individually. In the survey, participants completed 3 rounds of problem solving and creativity tasks in order to expose participants to each of the tasks ahead of time as well as to collect "individual performance" on the problem solving and creativity tasks to use as a baseline comparison for when they would later complete those same tasks as a team. Specifically, participants completed 3 problem-solving survival scenario tasks with an objectively correct answer and 3 creativity alternative uses tasks, where participants were instructed to brainstorm as many novel uses for a particular object as possible within a given time frame. Participants had 10 minutes to complete the individual problem solving tasks and 5 minutes to complete the creativity task. The pre-measures survey also included some psychometric survey questions unrelated to this dissertation.

Round 1 Team Tasks: Humans only team (team formation). The procedure of the team tasks was similar to the pilot study procedure. Data collection was facilitated via the online video conferencing software, Zoom. Participants were randomly assigned to teams and placed into "breakout rooms" in the Zoom platform. The sessions were facilitated by study team members who gave participants information regarding study process and timing. Participants were provided with a Qualtrics link with instructions and a place to record their team task responses as well as any survey questions responses throughout the session.

Once participants arrived at the Zoom study session, they were randomly assigned to teams, given instructions on the flow of the study session, and sent into breakout rooms by team, with a Qualtrics survey to guide them through Round 1 of team tasks. As the conceptual framing of this dissertation explores the adaptation and socialization of human-AI teams, an essential aspect of the study was that team members have enough experience working together to have developed a shared TMS. I accomplished this by randomly assigning participants into teams of 2-3 humans who worked together on tasks prior to the entry of an agent teammate. Teams completed a pair of team tasks, one task with a set of objectively correct answers and another task that was more subjective in output and required different processes for collaboration. Specifically, teams completed one of the same problem-solving survival scenario tasks and one of the same creativity alternative uses tasks from the pre-measures survey, but were instructed to now complete it as a team. Descriptions of all problem-solving and creativity tasks used in the study are located in Appendices A1-A6. This first round of tasks as a humans-only team were intended to help build team entitativity prior to the agent entry. Teams had 10 minutes to complete each task, which totaled 20 minutes per round of tasks. During this round, communication frequency and team performance were collected.

Post Round 1 Survey. Following the completion of Round 1 team tasks, teams were instructed to complete a batch of survey questions in their survey link individually. Teams were brought back into the main room so that all teams in the session could stay on the same pace. In this survey, participants answered questions to assess their TMS.

Vero Introduction. Once all participants completed the Post Round 1 Survey, participants were introduced to Vero, their incoming AI teammate. Participants were shown a ~ 5 minute video, informing them of Vero's development, capabilities, and behaviors. Vero was presented to participants as an artificially intelligent teammate, designed to help teams in their team tasks. In reality, Vero was a confederate research assistant, using a Zoom background animation that modeled behaviors such as "listening" or "waving", to complement their spoken interactions. Vero confederates were undergraduate and graduate student research assistants trained to act as Veros. Confederates were provided with a "script" with information that they could offer up to the team. Scripts differed based on the condition the Vero was trained in. Taskwork only and Combined condition Veros had scripts that contained item information, ranking preferences, item definitions, and creative idea suggestions, relevant to the specific task the team was engaged in at that time. Teamwork only and Combined condition Veros had scripts that contained teamwork intervention statements, such as "Everyone on the team should share their ideas! We all have something to contribute", relevant to the specific task the team was engaged in at that time. In the full study, there were no "active" or "passive" AI teammate conditions. Instead, all teams had one Vero confederate that acted as an "active" AI teammate. See Appendixes C1-C3 for copies of the script for each condition.

Post Vero Introduction Survey. After participants viewed the Vero Introduction video, they were directed back to their Qualtrics link to answer a few survey questions related to the Vero Introduction video they had just watched. In particular, participants responded to questions regarding human-agent team dynamic restructuration, human-agent team TMS, and their technology expectancies.

Round 2 Team Tasks. Once all team members completed the Post Vero Introduction survey, teams were sent back to their same teams from Round 1 with the addition of their new Vero AI teammate to complete another round of team tasks (1 problem solving survival task and 1 creativity alternative uses task, both the same as tasks they completed individually in the pre-measures survey). Teams followed the same procedure for Round 2 as they did for Round 1, but they were also joined by Vero, who was able to contribute based on their condition script. Teams were randomly assigned a Vero condition, and their Vero only exhibited the behaviors of their particular condition for the entirety of the session. During this round, communication frequency and team performance were collected.

Post Round 2 Survey. Following the completion of Round 2 team tasks, teams were instructed to complete another batch of survey questions in their survey link individually. Teams were brought back into the main room so that all teams in the session could stay on the same pace. In this survey, participants answered questions to assess human-agent team dynamic restructuration and group valence toward AI.

Round 3 Team Tasks. Once all team members completed the Post Round 2 survey, teams were sent back to their same teams from Round 2 to complete a final round of team tasks (1 problem solving survival task and 1 creativity alternative uses task). Teams followed the same procedure for Round 3 as they did for Round 2. During this round, communication frequency and team performance were collected.

Post Round 3 Survey. Following the completion of Round 3 team tasks, teams were instructed to complete a final batch of survey questions in their survey link individually. Teams were brought back into the main room so that all teams in the session could stay on the same pace. In this survey, participants answered questions to assess human-agent team dynamic restructuration, human-agent TMS evaluation, AI teammate schema, TMS convergence, and TMS utilization. Once all participants in the session were done with their survey questions, participants were debriefed and were then able to leave the session.

Manipulation

The design manipulated the team function of the AI teammate, which was whether the AI teammate engaged in only taskwork behaviors ("Taskwork only"), only teamwork behaviors ("Teamwork only"), or both taskwork and teamwork behaviors ("Combined"). AI teammate team function was measured right after the last round of team tasks (Human-AI teaming Round 3) was completed, using a 10-item measure asking participants the extent to which they believed their AI teammate engaged in teamwork or taskwork behaviors on a 5-point scale (strongly disagree to strongly agree; see Appendix B10 for full list of items). The teammate function measure was developed based on the taxonomy of team processes proposed in Marks, Mathieu, & Zaccaro, 2001. Five items in the scale asked about teamwork processes and five items asked about taskwork processes. The manipulation check was implemented to ensure that participants adequately and accurately perceived the function of the AI on their team.

Measures

TMS. TMS was assessed in the Post Round 1 survey at Time 1. This assessed the team's TMS prior to the agent entry. Teams completed a 15-item, 5-point disagree–agree response format, measure that assessed TMS specialization, credibility, and coordination (Lewis, 2003). See Appendix B1 for full measure.

Human-Agent Team TMS. Human-Agent Team TMS was assessed in the Post Vero Introduction survey at Time 2. This assessed the team's Human-Agent Team TMS based solely on their pre-existing incumbent TMS and their expectations of the agent newcomer after watching the Vero introduction video. Teams completed an adapted version of Lewis's (2003) measure that assessed TMS coordination, where "team" was replaced with "human-agent team". The adapted measure also included human-agent specialization and credibility and agent-human specialization and credibility, where participants answer Lewis's (2003) items for specialization and credibility based on their perceptions of the agent teammate's credibility and specialization with respect to the team tasks and goals ("human-agent TMS") as well as their perceptions of the AI teammate's perceptions of team specialization and credibility ("agent-human TMS"). See Appendix B2 for full measure.

Incumbent team member technology expectancies. Team member expectations of the agent newcomer were assessed in the Post Vero Introduction survey at Time 2 by surveying participants before meeting the agent newcomer but after watching a short introduction video of the incoming AI teammate. Participants were asked about their expectations of the agent regarding the agent's performance, expertise, & agency. Incumbent team member expectations of the agent were assessed with 10 items, with a 5-point disagree–agree response format, developed for the purposes of this study. This measure is the same measure used for "AI Teammate Schema at Time 4", but the wording was changed to reflect whether the participants had met the AI teammate yet or not. In this case, the participants had not yet met the AI teammate, so the wording was in the future tense to account for this and the idea of "expectancies". See Appendix B3 for full measure.

Group valence towards AI. Group valence towards the agent newcomer was assessed in the Post Round 2 survey at Time 3 using 4 items, with a 5-point disagree–agree response format, developed for this study. Group valence assessed the degree of positive or negative attitudes towards the agent newcomer. See Appendix B4 for full measure.

AI teammate schema. AI teammate schema was assessed in the Post Round 3 survey at Time 4. AI teammate schemas are the cognitive representations of our expectations and observations of a technology or agent teammate. Once teams have the chance to work alongside an agent for one round of problem solving and creativity tasks, teams likely begin to reconcile their expectations of the technology ("Incumbent team member technology expectancies") with their observations of and interactions with the agent teammate. Thus, AI teammate schema was assessed using an adapted version of the "incumbent team member expectations of agent" measure. See Appendix B5 for full measure.

Human-Agent TMS evaluation. Human-Agent TMS evaluation was assessed in the Post Round 3 survey at Time 4. Human-agent TMS evaluation represented the extent to which a team believed their expectations of the agent were useful and accurate or needed to be altered. Human-agent TMS evaluation was assessed using a 7-item, 5-point disagree–agree response format, measure developed for the purposes of this study. See Appendix B6 for full measure.

Communication frequency. Communication frequency was assessed as a noninvasive measure of frequency of communication during each Round of team tasks. Team task interactions from each Round were recorded and transcribed. Communication frequency is the raw number of words spoken in each team by all team members.

Human-agent team dynamic restructuration. Human-agent team dynamic restructuration was assessed in the Post Vero Introduction survey (Time 2), the Post Round 2 survey (Time 3), and the Post Round 3 survey (Time 4). Human-agent team dynamic restructuration represents the extent to which participants feel that they and their team members altered their cognitive team processes to accommodate the agent newcomer or in reaction to the entry of the agent newcomer. Dynamic restructuration was assessed using a 7-item, 5-point disagree–agree response format, measure developed for the purposes of this study. See Appendix B7 for full measure.

Team performance. Team performance was assessed in the same way that it was in the pilot study for the survival problem-solving task. Creativity performance was assessed by calculating fluency, flexibility, and novelty for each individual or team creativity response. Fluency was assessed by counting the total number of non-repeating ideas each response contained. Flexibility was assessed by counting the total number of kinds of ideas that were represented in each response. Novelty was assessed by computing an output dominance score for each item and averaging that together to get a single novelty score for each response. Each of these creativity scores were standardized and averaged together to create a single creativity performance score. Problem-solving survival performance scores were also standardized. Before averaging creativity and survival problem-solving scores together to create a single score of "team performance", problem solving scores were inversed so that higher scores were representative of "better" performance and lower scores were representative of poorer performance so that high aggregated performance scores were representative of better scores as well. Team performance was assessed in each Round of team tasks for each task within each round, giving teams a problem solving score and a creativity score for each of the 3 rounds of team tasks, as well as an aggregated team score for each round. When denoted as "raw" scores, survival problem-solving scores are representative of the raw, unadjusted difference score, meaning that the lower a “raw” survival problem-solving score, the better the performance of that team on that survival problem-solving task.

TMS convergence. TMS convergence was assessed in the Post Round 3 survey at Time 4. TMS convergence represents the “optimal state of a transactive memory system, where all members have similar representations of the transactive memory system” (Brandon & Hollingshead, 2004, p. 640). TMS convergence represents the extent to which team members felt that their team was highly aligned in their perceptions of the team TMS with respect to accuracy, sharedness, and validation of the TMS across the team. Teams higher in TMS convergence report that their team TMS was accurate, shared, and validated across members of the team. Based on the description of these 3 dimensions by Brandon and Hollingshead (2004), I developed an item for each dimension for the purposes of this study. See Appendix B8 for full measure.

TMS utilization. TMS utilization was assessed in the Post Round 3 survey at Time 4. TMS utilization was assessed using a 4-item measure from Sherf, Sinha, Tangirala, and Awasty (2018). The 4 items were “We made use of each other’s expertise during project work”, “We asked the experts in our group to share and explain their thoughts on the project work”, “We leveraged each other’s expertise to make decisions”, and “We relied on each other’s expertise to divide up our project work”.

Team process. Team process was assessed in the Post Vero Introduction survey (Time 2), the Post Round 2 survey (Time 3), and the Post Round 3 survey (Time 4). Team process was assessed using a 10-item scale (Mathieu et al., 2019) that asked participants to rate each item on a 5-point disagree-agree scale. This scale was used to help validate the new constructs in this dissertation.

Team cohesion. Team cohesion was assessed in the Post Vero Introduction survey (Time 2), the Post Round 2 survey (Time 3), and the Post Round 3 survey (Time 4). Team cohesion was assessed using a 6-item scale (Braun et al., 2020) that asked participants to rate each item on a 5-point disagree-agree scale. This scale was used to help validate the new constructs in this dissertation.

Team potency. Team potency was assessed in the Post Vero Introduction survey (Time 2), the Post Round 2 survey (Time 3), and the Post Round 3 survey (Time 4). Team potency was assessed using a 3-item measure (Collins & Parker, 2010) asking participants to rate items on a 5-point disagree-agree scale. Items were “This team expects to be known as a high performing team”, “My team has confidence in itself”, and “My team believes it can be very productive”. This scale was used to help validate the new constructs in this dissertation.

Team viability. Team viability was assessed in the Post Vero Introduction survey (Time 2), the Post Round 2 survey (Time 3), and the Post Round 3 survey (Time 4). TMS utilization was assessed in the Post Round 3 survey at Time 4. Team viability was assessed using a 4-item scale (Resick et al, 2010) asking participants to rate items on a 5-point disagree-agree scale. This scale was used to help validate the new constructs in this dissertation.

Results

Below, I detail the results of my experimental study of AI teammate function in human-AI team processes and outcomes. First, I present the descriptive statistics of the variables of interest in my experimental study. Second, I present the results of my psychometric statistical analyses for all new items and scales developed for the purposes of this dissertation. Third, I present the results of the manipulation check and the tests of all hypotheses from Chapter 2. Table 12 presents the descriptive statistics of all study variables of interest.

Descriptives

Table 12 presents the descriptive statistics for key study variables across relevant time points. In this table, I report descriptive statistics for the individual and team performance scores. The individual performance scores come from the pre-measures survey at Time 0. These scores are at the individual level, as each person was instructed to complete the pre-survey prior to coming to the data collection session, and participants were not allowed to participate unless they had first completed the pre-survey. The individual performance data was collected in order to examine potential process loss or synergy that occurs when individuals join teams. On average, the descriptives table reports that participants scored better when they worked on the survival problem-solving task as a team compared to the average individual scores on the survival problem-solving task (survival scores reported in the table are “raw” difference scores, where lower scores are “better” than higher scores as lower scores represent a smaller difference between the team’s ratings and an expert’s ratings of the same items). The scores for the creativity tasks demonstrate a similar pattern. On average, teams generated more ideas (fluency), came up with more kinds of ideas (flexibility), and came up with more unique ideas (novelty) as a team than they did on average as individuals.

Psychometric Analyses

To finalize the items for each of the new scales, I followed the general outline of Phases presented in Lewis (2003). First, they completed an aggregation analysis to test whether the items are appropriate to aggregate to the team level, also my level of interest in this dissertation. Then, they completed a 3 phase analysis, which included: 1) examine internal consistency through item analysis and reliability, 2) examine dimensionality (if applicable) via a confirmatory factor analysis, and then 3) examine convergent and discriminant validity. I use this outline for scale validation below. In Table 13, I present a summary of within-team agreement and reliability of aggregated study variables.

Phase 1: Internal Consistency - Item Analysis and Reliability. I also wanted to be sure that each scale/subscale formed an internally consistent scale/subscale. Thus, I looked at item-total correlations and coefficient alphas for each scale/subscale at the individual level (DeVellis, 1991; Spector, 1992). Table 14 presents the item analysis and reliability results of all scales/subscales at the individual level. In this table, I provide the alpha and average item-total correlations for all items included from scale validation efforts from Study 1. I also include the results for the final set of items I use in my hypothesis testing based on scale validation efforts I conducted after Study 2 data collection was complete to show if any scales were changed and how internal consistency may have changed. Specifically, I only removed items from the AI teammate schema scale because of poor items within the scale. Evidence of poor item performance shows up in both the alpha and item-total correlations for the agency dimension in AI teammate schema in particular, with alpha values of 0.45 and 0.59 and item-total correlations of 0.14 and 0.23, at Times 2 and 4 respectively. Thus, this made me look more closely at the dimensionality of the AI teammate schema scale and the specific items more closely. I detail more regarding the removal of items from the AI teammate schema scale in the dimensionality section below.

Generally, the item-total correlations reported for the final items selected for hypothesis testing suggest that the items within each scale/subscale have a sufficiently strong relationship with the scale as a whole. Scale item-total correlations were above 0.35 for all scales at all time points with the exception of Human-Agent Team TMS at Time 2 ($r = 0.28$). Human-Agent Team TMS had a stronger item-total correlation at Time 4 ($r = 0.41$), suggesting that the items may correlate more strongly once participants had a chance to actually interact with the AI teammate whereas at Time 2, participants were only able to speculate as to how the agent teammate would fit into the Human-Agent Team TMS.

Moreover, the alpha reliabilities for all scales and subscales for the final items selected for hypothesis testing were acceptable, with all scales reporting alphas of at least 0.70 (as suggested by Nunally & Bernstein, 1978), with the exception of Agency at Time 2 and Time 4 (alpha = 0.66 and 0.68, respectively). Also, the items from the Agency dimension of AI teammate schema, when included as a larger part of AI teammate schema rather than as a single standalone dimension, reached an acceptable alpha value of 0.84 and 0.90 at Times 2 and 4, respectively. Altogether, these results suggest that each scale used in hypothesis testing was sufficiently internally consistent and suggest no deletions of items from the scales (with the exception of AI teammate schema, detailed more below) because item correlations and alpha reliabilities were sufficiently large.

Phase 2: Dimensionality -- Confirmatory Factor Analysis. Three new scales I developed for the purposes of this dissertation and hypothesis testing were theorized to have dimensions: Human-Agent TMS, Agent-Human TMS, and AI Teammate Schema. Human-Agent TMS and Agent-Human TMS were theorized to have 2 dimensions specific to human-agent teaming: Specialization and Credibility. Similar to the methodology in Lewis (2003), I expected to confirm a two-factor structure underlying my Human-Agent Team TMS construct. I performed a confirmatory factor analysis (CFA) to assess the fit of the three-factor solution compared to a one-factor solution using the individual-level data. Because my scale items were likely most salient to participants after working with the AI teammate, I used the Time 4 data for my CFA.

The hypothesized measurement model demonstrated good fit at the individual level compared to a one-factor solution, $\chi^2(85, N=149) = 175.36$, $p<0.01$, SRMR = 0.08, CFI = 0.89.

AI Teammate Schema was initially theorized to have 3 dimensions as well: Performance, Agency, and Expertise. However, exploratory factor analysis did not suggest evidence of dimensionality. Further, the results from alpha and item-total correlations for each item suggested that some items within AI teammate schema were not sufficiently loading onto the overall scale well. Thus, items were removed, and AI teammate schema was reconceptualized as a single factor scale.

Phase 3: Validity Testing. Finally, I assessed convergent and discriminant validity for each of my scales by examining correlations of my new scales to pre-established scales, using the guidelines for the multitrait multimethod matrix approach from Campbell and Fiske (1959). In the present study, the multimethods are defined by multiple time points of assessment. For all team-level constructs, there are also multiple raters of each team, providing multiple observers for each construct as well. The agreement of multiple raters was assessed via the $r_{wg(j)}$ statistics for each construct at each Time, presented in Table 13. As described above, the $r_{wg(j)}$ values were all sufficiently large to justify aggregation. The values also justify convergent validity of the constructs as this statistic is a measure of agreement among different "raters" of team constructs. I also examine correlations of each construct to itself at different time points to assess convergent validity as presented in Table 15 for all constructs assessed at multiple time points. Each new construct at Time 2 was significantly correlated with itself at Time 4, except dynamic restructuration. However, because dynamic restructuration is not salient to participants until they are able to work with the agent teammate, a lack of correlation between pre-working with the agent and other time points makes sense. We do see a very high correlation between dynamic restructuration at Time 3 and Time 4 ($r = 0.80$, $p < 0.001$), the two time points in which participants were finally able to work with the AI teammate. Human-agent TMS evaluation at Time 3 was also significantly correlated with itself at Time 4 ($r = 0.76$, $p < 0.001$). Thus, we see satisfactory convergent validity for all new constructs.

To further assess validity, I examined the correlations of my scales to established scales that were also collected in the data collection effort following each team task round: TMS (Lewis, 2003), team process (Mathieu et al., 2019), team cohesion (Braun et al., 2020), team potency (Collins & Parker, 2010), team viability (Resick et al., 2010), and TMS utilization (Sherf et al., 2018). For all new TMS-related dimensions, my theorizing suggested that these scales should all be related to the respective 5-item TMS dimensions from Lewis (2003) since they were derived directly from those measures, but adapted to assess the fit of an AI teammate into a team TMS. Thus, I would expect moderate correlations between Lewis (2003) TMS measures and each of my new TMS scales and subscales. However, I would also expect that they would not strongly correlate since my theorizing suggested that they should be unique constructs from the original TMS dimensions. To examine these relationships more closely, I present the correlations of each of my new dimensions of TMS to the Lewis (2003) dimensions of TMS in Table 16. This table generally demonstrates that my new dimensions are related to the original TMS dimensions, but not strongly correlated such that they are measuring the same constructs. In particular, at both Time 2 and Time 4, Lewis's specialization was significantly correlated to human-agent specialization ($r = 0.37$, $p < 0.01$; $r = 0.46$, $p < 0.01$, respectively) and agent-human specialization ($r = 0.46$, $p < 0.01$; $r = 0.49$, $p < 0.01$, respectively) when examining the dimensions at the same time point. Lewis's credibility was also significantly correlated to human-agent credibility and agent-human credibility at Time 2 ($r = 0.24$, $p < 0.01$; $r = 0.28$, $p <$

0.01. respectively) and at Time 4 ($r = 0.38$, $p < 0.01$; $r = 0.40$, $p < 0.01$, respectively). When compared to correlations between dimensions measuring the same referent (i.e., agent-human specialization compared to agent-human credibility), correlations were higher. For example, human-agent specialization at Time 4 was more correlated to human-agent credibility ($r = 0.61$, $p < 0.01$) than it was to Lewis's specialization at the same time point ($r = 0.46$, $p < 0.02$), and human-agent credibility at Time 4 was more correlated to human-agent specialization than it was to Lewis's credibility at the same time point. However, the same did not hold true for agent-human dimensions as the agent-human dimensions of specialization and credibility were more correlated to their respective Lewis dimensions than they were to one another ($r = 0.34$, $p < 0.01$).

Table 17 presents the correlations of all new constructs with established constructs. This table also generally demonstrates that my new constructs are related to established team processes and states constructs, but also not so strongly correlated that they are redundant. For example, we see that each of the new human-agent TMS dimensions (human-agent specialization and human-agent credibility) are more strongly correlated to Lewis's aggregated TMS measure at Time 4 ($r = 0.52$; $r = 0.53$, respectively) than team process at Time 4 ($r = 0.05$; $r = 0.13$, respectively). For agent-human TMS dimensions (agent-human specialization and agent-human credibility), the correlations with Lewis's TMS ($r = .33$; $r = .41$, respectively) are also stronger than those with team process ($r = .29$; $r = .33$, respectively). Overall, this shows that the new TMS dimensions are more strongly correlated with the cognitive construct of TMS than with the process construct of team process because the new TMS dimensions share cognitive content with TMS whereas there is less shared content with team process. AI teammate schema also demonstrates discriminant validity in being more strongly related to cognitive-related constructs at Time 4, like TMS (r = 0.41), than to team process (r = 0.06). Similarly, human-agent TMS evaluation, human-agent team dynamic restructuration, and TMS convergence also show similar patterns at Time 4, where they are all more strongly correlated to TMS (r = 0.46, r = 0.19, and r = 0.61, respectively) than to team process (r = 0.18, r = 0.09, and r = 0.54, respectively), as they share more theoretical content with TMS as a cognitive measure than they do with team process as a more process-oriented measure.

Further, I assessed discriminant validity of my new scales by using factor analysis of scale items with items from other scales to check that items from scales were distinct enough that they would still load onto their intended factors even in the presence of other related scale items. All scales successfully loaded onto their intended factors in these factor analyses. For example, I used the psych package in R to run a factor analysis, specifying a minimum residual solution, and using the default rotation, oblimin. In the first analysis, I included all items for human-agent TMS evaluation, dynamic restructuration, and team process, all at Time 4, and I forced a 3-factor solution. All 7 items for human-agent TMS evaluation loaded onto a single factor with an eigenvalue of 1.8, all 7 items for human-agent team dynamic restructuration loaded onto a second factor with an eigenvalue of 3.3, and all 6 items for team process loaded onto a third factor with an eigenvalue of 3.8. There were no cross-loadings greater than 0.20 in this analysis.

I repeated this procedure for each of my newly introduced constructs. With group valence toward AI (Time 3), TMS convergence (Time 4), and team process (Time 4), I also forced a 3-factor solution. Again, the items loaded cleanly onto their respective constructs: all 4 items for group valence loaded on a single factor with an eigenvalue of 2.88, all 6 items for team process loaded on a second factor with an eigenvalue of 2.44, and all 4 items for TMS convergence loaded onto a separate third factor with an eigenvalue of 0.44. Although the eigenvalue for TMS convergence was low, the items all loaded cleanly onto a single factor, and there were no cross-loadings greater than 0.20 in this model for any of the items included.

In a third factor analysis, I included items for AI teammate schema, team process, and team viability (all at Time 4), and I forced a 3-factor solution. Items from each construct loaded onto a single factor for each construct: all 8 items for human-agent team dynamic restructuration loaded onto a single factor with an eigenvalue of 5.17, all 6 items for team process loaded onto a second factor with an eigenvalue of 3.19, and all 4 items for team viability loaded onto a third factor with an eigenvalue of 0.23. There were no cross-loadings greater than 0.20.

In another factor analysis, I included human-agent specialization, agent-human specialization, and team cohesion (all at Time 4), and forced a 3-factor solution. All items cleanly loaded onto their respective dimensions/measure: all 5 items for human-agent specialization loaded onto a single factor with an eigenvalue of 2.1, all 5 items for agent-human specialization loaded onto a second factor with an eigenvalue of 2.6, and all 6 items for team cohesion loaded onto a third factor with an eigenvalue of 3.8. Once again, there were no cross-loadings greater than 0.20.

Finally, when trying to include human-agent credibility and agent-human credibility into a factor analysis either on their own or with other dimensions, the two dimensions cross-loaded onto one another with loadings greater than 0.20 for many items. After further investigation, I noticed that the same item was not loading as anticipated (Item 4 for human-agent credibility and Item 4 for agent-human credibility). Thus, I removed this item from each of the two dimensions and recalculated all statistics above in the final write-up of the psychometric analyses. In a factor analysis conducted after this deletion, I ran another factor analysis to check on the final loadings. I included human-agent credibility, agent-human credibility, and team cohesion (all at Time 4), and forced a 3-factor solution. All items cleanly loaded onto their respective dimensions/measure: all 4 items for human-agent credibility loaded onto a single factor with an eigenvalue of 0.81, all 4 items for agent-human credibility loaded onto a single factor with an eigenvalue of 0.65, and all 6 items for team cohesion loaded onto a single factor with an eigenvalue of 3.44. Although eigenvalues were lower for agent-human and human-agent credibility, there were no cross-loadings greater than 0.20. Table 14 shows the internal consistency reliabilities for each scale before and after any deletions from the scale, and the final write-ups above and the hypothesis testing and results reported below reflect the "final items selected for testing" as listed in Table 14 and in the Appendices. Overall, the results of factor analyses of new constructs suggested sufficient discriminant validity for all new constructs.

Aggregation Analysis. Finally, I examined median intragroup agreement (rwg) on final versions of all new scales (human-agent TMS, agent-human TMS, AI teammate schema, human-agent TMS evaluation, human-agent team dynamic restructuration, and TMS convergence). Human-agent TMS included 2 dimensions: human-agent specialization and human-agent credibility. Thus, I calculated $r_{wg(j)}$ for each of the subscales for each team as well. $r_{wg(j)}$ values presented in Table 13 are median $r_{wg(j)}$ values. Median $r_{wg(j)}$ values ranged from 0.80 for team viability at Time 2 to 0.97 for team cohesion at both Time 2 and Time 4. These results suggest that participant responses on the scales/subscales are homogenous. These results also suggest that aggregation of team member scores on these scales to the team level is statistically justified.

Manipulation Check

The AI teammate function manipulation was examined using ANOVA where the average score on the 5 items for taskwork created a "taskwork score" and the 5 items for teamwork created a "teamwork score". Two ANOVAs were run, one with taskwork score as the dependent variable, and a second one with teamwork score as the dependent variable. Taskwork score and Teamwork score means by condition are presented in Table 18. ANOVA results for the manipulation check are presented in Table 19.

In the ANOVA run to check the Taskwork Function manipulation, there was a significant effect for condition on taskwork scores, $F(2,146) = 59.73$, $p < 0.001$. In the ANOVA run to check the Teamwork Function manipulation, there was a significant effect for condition on teamwork scores, $F(2,146) = 60.94$, $p < 0.001$. The means presented in Table 18 show that the conditions that contained the taskwork function ("Taskwork only" and "Combined") scored at least 1.27 points higher than the condition that did not contain the taskwork function ("Teamwork only") on a 5 point scale. Similarly, the conditions that contained the teamwork function ("Teamwork only" and "Combined") scored at least 1.65 points higher than the condition that did not contain the taskwork function ("Teamwork only") on a 5 point scale. Overall, these results suggest that the manipulation was successful. Participants in each condition reported that their AI teammate exhibited the intended behaviors more than the participants in conditions that had AI teammates that were not supposed to exhibit those same behaviors.

I also analyzed the communication data to assess whether the AI teammate was contributing similarly to the human teammates on the team to be sure that the Wizard of Oz methodology was as effective as possible while also still being able to control the teammate function manipulation. In order to compare the Vero communication to human teammate communication, I used a paired samples t-test to compare the Vero word count for rounds 2 and 3 to the human teammate word counts from rounds 2 and 3 in 3 ways: 1) the word count of the least frequent communicator for each round, 2) the average word count of the team for each round, and 3) the most frequent communicator for each round. There was a significant difference between Vero and the human speakers in Round 2, with Vero speaking more than: 1) the least frequent human communicator ($t(61) = 5.60$, $p < 0.001$), 2) the average word count among human communicators on their team ($t(61) = 7.47$, $p < 0.001$), and 3) the most frequent human communicator ($t(61) = 2.94$, $p < 0.001$). There was a significant difference between Vero and the least frequent human communicator, with Vero speaking more than the least frequent human communicator ($t(61) = 3.67$, $p < 0.001$), but no significant difference between Vero and the average word count among human communicators on their team ($t(61) = 1.45$, $p = 0.15$), or between Vero and the most frequent human communicator on their team ($t(61) = 1.12$, $p = 0.27$). The significant differences in Round 2 are likely due to the long introduction paragraph in each Vero's script, which added a consistent 140-150 words to each Vero's word count for Round 2 only, depending on their condition, which is about 11% of the average total amount of words spoken by Vero in round 2. In Round 3, Veros are simply continuing to work with their teammates without an introduction paragraph, so we see much more similar levels of words spoken when comparing Vero to the average amount of words spoken on each team or the most frequent speaker on each team. Overall, these results suggest that Vero was an equal speaker on most teams as compared to the other humans on the team, which supports the experimental design that had the goal of the AI teammate being comparable to others on the team as much as possible while using a script to maintain experimental control.

Finally, I calculated frequencies for responses to 3 questions assessed at the very end of the session that asked about the believability of the AI teammate. Specifically, the questions asked: “Based on your interactions with Vero, Vero behaved more like a: 1) human, or 2) technology”, “Based on your interactions with Vero today, you would say Vero is most likely: 1) A human posing as an AI teammate, 2) A robot posing as an AI teammate, but is not actually "artificially intelligent", 3) An artificially intelligent teammate designed to help teams., 4) A "smart" chatbot, like those you interact with on organizational websites., or 5) Other", and "Based on your interactions with Vero today, Vero was most likely a: 1) human, or 2) technology. Table 20 presents the frequencies of responses for each question by condition and total. Overall, the frequencies presented in Table 20 suggest that the AI teammate Wizard of Oz methodology was successful: 86.58% of participants responded that Vero behaved more like a technology than a human. Further, only 4.70% of participants responded that Vero was most likely "a human posing as an AI teammate" while the other 95.30% of participants responded that Vero was most likely some other form of technology instead. Finally, when asked to choose what they thought Vero "most likely was", 93.29% of participants said that Vero was most likely a technology rather than a human. These frequencies suggest that participants overwhelmingly perceived Vero as some sort of technology rather than as the human confederate that they actually were. When examining the frequencies by condition, frequencies were similar across conditions, with no reasons for concern in differences in responses to the believability questions because of condition.

Effect of Manipulation on Focal Variables

Next, I wanted to see how all of the variables of interest were affected by the manipulation. For any significant differences between conditions in the ANOVA results, I conducted a post-hoc Tukey test to see exactly which groups were significantly different from one another. Table 21 presents the results of ANOVA tests examining differences in my variables of interest based on condition. Tukey test results are presented in Table 22. Table 21 shows that there were differences in words spoken by Vero based on condition at Time 3 ($F(2,59) = 4.06$, $p = 0.02$) and Time 4 ($F(2,59) = 8.25$, $p < 0.001$). Table 22 shows the results of post-hoc Tukey tests which show that at Time 3, Veros in the combined condition spoke significantly more words than Veros in the teamwork only condition, and at Time 4, Veros in the combined condition spoke significantly more words than Veros in both the teamwork only and the taskwork only conditions. There were also differences in total words spoken at Time 4 ($F(2,59) = 4.74$, $p = 0.02$), with the teams in the combined condition speaking more words than teams in both the teamwork only and taskwork only conditions. Because there are no significant differences in average words spoken by the human team members across all 3 rounds, the significant difference in total words spoken may come from the greater number of words spoken by Veros in the combined condition compared to the other 2 conditions. The combined condition Veros had scripts that contained all the information from both the taskwork only and teamwork only conditions, so it makes sense that these Veros would speak more than Veros in the other conditions.

Table 21 also shows that there were significant differences in aggregated (creativity and problem solving) team performance for round 2 ($F(2,62) = 10.04$, $p < 0.001$) and round 3 ($F(2,62) = 10.49$, $p < 0.001$), but not for round 1 ($F(2,62) = 1.12$, $p = 0.33$). There should not have been a difference in performance in round 1 because participants had not been exposed to the manipulation yet. Results of post-hoc Tukey tests for rounds 2 and 3 show that teams in the teamwork condition performed significantly lower than teams in the other two conditions. Examining the performance dimensions separately showed they were driven most by problem solving. There were also significant differences is problem solving performance for round 2 ($F(2,62) = 22.49$, $p < 0.001$) and round 3 ($F(2,62) = 27.63$, $p < 0.001$), but not for round 1 ($F(2,62) = 1.63$, $p = 0.20$). Results of post-hoc Tukey tests also show that teams in the teamwork condition scored significantly lower than teams in the other two conditions.

Regarding the constructs of interest, Table 21 shows that there were significant differences in scores for human-agent TMS evaluation ($F(2,60) = 24.16$, $p < 0.001$), human-agent team dynamic restructuration ($F(2,60) = 3.92$, $p = 0.03$), and technology valence ($F(2,60) = 23.62$, $p < 0.001$) at Time 3. Post-hoc Tukey tests, as presented in Table 22, show that teams in the teamwork only condition were significantly lower on human-agent TMS evaluation, human-agent team dynamic restructuration, and technology valence than teams in either of the other 2 conditions. At Time 4, there were significant differences based on condition for human-agent team TMS ($F(2,60) = 10.16$, $p < 0.001$), AI teammate schema ($F(2,60) = 28.77$, $p < 0.001$), and human-agent TMS evaluation ($F(2,60) = 13.68$, $p < 0.001$). Again, post-hoc Tukey tests, as presented in Table 22, show that teams in the teamwork only condition were significantly lower in scores on human-agent team TMS, AI teammate schema, and human-agent TMS evaluation at Time 4.

Hypothesis Tests

Hypotheses were tested using the R and RStudio open-source software for statistical computing (RStudio Team, 2020). Below, I detail the hypothesis, the analyses used to test the hypothesis, and the results of each hypothesis test. Notably, for all regression analyses, I grand-mean centered the data, and results reported below use the grand-mean centered data.

Hypothesis 1 suggested that human-agent team TMS specialization and credibility and agent-human TMS specialization and credibility predict (a) communication, (b) team viability, (c) team cohesion, and (d) team performance to a greater extent than TMS specialization and credibility alone in human-agent teams. To test this hypothesis, I tested the incremental validity of the addition of the new dimensions of human-agent and agent-human TMS specialization and credibility to a regression model with the Lewis (2003) dimensions of TMS specialization and credibility by running hierarchical linear regression models and comparing the R^2 value between the first model and the new model that added the new dimensions of human-agent teaming.

Results of Hypothesis 1 are presented in Tables 23-26. Hypothesis 1 was partially supported: Hypothesis 1a was supported, and Hypotheses 1b, 1c, and 1d were not supported. Hypothesis 1a tested the effects of TMS dimensions on communication at Time 4, and team size and condition vectors were added as controls. Results for Hypothesis 1a are presented in Table 23. The R^2 value for the TMS model was 0.15 (adjusted $R^2 = 0.07$), and the R^2 value for the second model was 0.34 (adjusted $R^2 = 0.22$) ($\Delta R^2 = 0.19$, $p < 0.05$). The significant ΔR^2 suggests that the addition of the human-agent and agent-human dimensions of specialization and credibility significantly added incrementally to prediction, suggesting that those dimensions help better predict communication behaviors at Time 4 than the TMS dimensions alone. Further, agent-human specialization was a significant predictor of communication at Time 4 (β = -426.33, $p < .05$). This finding suggests that for every 1 unit increase in A-H specialization, we can expect a 426.33 word decrease in communication at Time 4, after controlling for all other predictors in the model. Thus, Hypothesis 1a was supported.

Results for Hypothesis 1b, which tested the effects of TMS dimensions on team viability at Time 4, are presented in Table 24. The R^2 values for Model 1 and Model 2 were similar (R^2 = 0.28 and 0.30, respectively), and the adjusted R^2 value actually decreased from the first model to the second model, since the new dimensions were not sufficiently strong predictors of team viability. The $\Delta R^2 = 0.02$, which was not significant. Thus, Hypothesis 1b was not supported.

Results for Hypotheses 1c, which tested the effects of TMS dimensions on team cohesion at Time 4, are presented in Table 25. The R^2 values for Model 1 and Model 2 were similar (R^2 = 0.41 and 0.44, respectively), and the adjusted R^2 value decreased from the first model to the second model, since the new dimensions were not sufficiently strong predictors of team cohesion. The $\Delta R^2 = 0.03$, which was not significant. Thus, Hypothesis 1c was not supported.

Finally, results for Hypothesis 1d, which tested the effects of TMS dimensions on team performance at Time 4, are presented in Table 26. The R^2 values for Model 1 and Model 2 were 0.29 and 0.35, respectively, and the adjusted R^2 value was the same for the first and second models (0.25), since the new dimensions were not sufficiently strong predictors of team performance at Time 4. The $\Delta R^2 = 0.06$, which was not significant. Thus, Hypothesis 1d was not supported.

Hypothesis 2 proposed that prior incumbent team member TMS structures and incumbent team member expectations of the AI teammate newcomer would positively predict human-agent team TMS. In order to test this hypothesis, I first investigated whether this hypothesis required a multilevel model rather than a single level regression model due to the incumbent team member expectations residing theoretically at the individual level while the incumbent team member TMS resided at the team level theoretically. Moreover, all individuals are nested within teams in this study, and since this hypothesis has variables of interest at the individual level, it is necessary to check for nesting effects. Thus, using the “nlme” package in R (Pinheiro, et al., 2021), I constructed a random intercept model to assess the amount of variance in human-agent team TMS between and within teams. The intraclass correlation (ICC1) calculated from this model was <0.01 suggesting that team membership accounted for very little of the variance in human-agent team TMS scores. This result suggests that a multiple regression is sufficient for testing this hypothesis. TMS scores were aggregated to the team level, and each individual from the same team had the same value for TMS, but individual level scores of incumbent technology expectancies were used in the model.

Table 27 presents the results of a multiple regression of TMS and incumbent technology expectancies predicting human-agent TMS (which was the 3 dimensions of human-agent team coordination, human-agent specialization, and human-agent credibility aggregated together into a single outcome variable). As shown in the table, Hypothesis 2 was partially supported: incumbent technology expectancies significantly positively predicted human-agent team TMS (β = 0.58, p < .001), but TMS did not (β = -0.07, ns). After accounting for TMS from Round 1 of humans-only team tasks, for every 1 unit increase in incumbent technology expectancies, we can expect a 0.58 unit increase in human-agent team TMS at Time 2. The adjusted R^2 statistic for this model suggests that approximately 40% of the variance in human-agent TMS at Time 2 can be predicted by TMS and incumbent technology expectancy. Thus Hypothesis 2 was partially supported.

Hypothesis 3 proposes that prior incumbent TMS dimensions of specialization and credibility are greater than human-agent team TMS dimensions of specialization and credibility. To test this hypothesis, I needed to conduct a test to compare observed means. First, I conducted a Shapiro-Wilk normality test on the differences between the prior TMS dimensions and human-agent team TMS dimensions of Specialization and Credibility (each dimension was tested separately, and data were tested at the individual level for all analyses related to Hypothesis 3). The results of the normality test of differences suggested that Credibility score differences were not normally distributed, but Specialization score differences were normally distributed. Thus, to assess the differences in Credibility scores, I used a Mann-Whitney test to account for the lack of normal distributions, and to assess the differences in Specialization scores, I used a paired samples t-test since the data were normally distributed.

Results of Hypothesis 3 are presented in Table 28. Hypothesis 3 was partially supported: prior incumbent Specialization was not significantly greater than human-agent Specialization ($t = -0.75$, ns), but prior incumbent Credibility was significantly greater than human-agent Credibility ($V = 7572$, $p < .001$). For completeness, I also tested whether prior incumbent Coordination was significantly different from human-agent coordination, and interestingly, I did find significant differences. Coordination was also not normally distributed, so I used a Mann-Whitney test for coordination as well. As Coordination was not a priori hypothesized to be different in a particular direction, I used a 2-tailed test; $V = 9440$, $p <.001$). These results suggest that when incumbent team members consider the entry of an AI teammate, they do not report the AI teammate to be much different from the rest of the team in terms of the AI teammate's specialization of knowledge (specialization mean = 3.29, SD = 0.85; human-agent specialization mean = 3.34, SD = 0.68), but they do report differences in terms of the AI teammate's credibility and how they think the team will coordinate as a human-agent team (credibility mean = 4.15, SD = 0.61; human-agent credibility mean = 3.61, SD = 0.63) (coordination mean = 4.24, SD = 0.69; human-agent coordination mean = 3.39, SD = 0.60).

Hypothesis 4 proposed that group valence of the team towards the AI teammate positively influences the team AI teammate schema. To test Hypothesis 4, I conducted a hierarchical linear regression of group valence at Time 3 predicting team AI teammate schema at Time 5, controlling for condition. In my control model, I included only 2 vectors to account for the 3 conditions (taskwork only, teamwork only, and combined). Then, I created a second model, adding in group valence at Time 3. Finally, I tested for an interaction effect of group valence and condition. All variables were aggregated to the team level for this analysis.

Results of Hypothesis 4 are presented in Table 29. Hypothesis 4 was supported. Results from the control model suggest that condition had a significant effect on team AI teammate schema at Time 4. The intercept represents the effect of the omitted condition, teamwork only, and suggests that the teamwork only condition was significantly negatively related to team AI teammate schema scores at Time 4 (β = -0.73, p <.001), whereas the taskwork only and combined conditions were significantly positively related to team AI teammate schema scores at Time 4 (β = 1.06, p<.001; β = 1.08, p<.001, respectively). Thus, teams in the teamwork condition reported that their schema of their AI teammate was lower in performance, agency, and/or expertise whereas teams in the taskwork only and combined conditions reported that their schema of their AI teammate was higher in performance, agency, and/or expertise. The next model, which adds group valence at Time 3 as a predictor to the control model, provides support for Hypothesis 4. The main effect model suggests that group valence was a positive and significant predictor of team AI teammate schema (β = 0.63, p <.001), even after controlling for the strong effects of the manipulation. The change in adjusted R^2 between the control model and the main effects model is 0.26, suggesting a better fit of the model that includes group valence as a predictor. Overall, the main effects model's adjusted R^2 value suggests that 73% of the variance in team AI teammate schema is accounted for by group valence, controlling for the manipulation. Finally, the interaction model results in no significant interaction between group valence and the manipulation.

Hypothesis 5 proposes that team AI teammate schema positively influences human-agent TMS evaluation, such that when a team possesses an AI teammate schema representative of high performance, agency, and/or expertise, then teams are more likely to report a need to reevaluate their human-agent TMS. I used a hierarchical linear regression to test Hypothesis 5, regressing human-agent TMS evaluation at Time 4 on AI teammate schema, controlling for the manipulation. Again, I first ran a control model, regressing 2 vectors representing the manipulation on human-agent TMS evaluation at Time 4. Because I collected AI teammate schema at 2 time points, I ran two separate main effects models, one using AI teammate schema at Time 2 and another using AI teammate schema at Time 4. Notably, AI teammate schema at Time 2 assessed participants' expectancies of the incoming agent teammate prior to meeting the AI teammate whereas AI teammate schema at Time 4 assessed AI teammate schema after participants had a chance to interact and work alongside the AI teammate. Thus, theoretically, AI teammate schema at Time 4 best assesses Hypothesis 5. However, AI teammate schema at Time 2 is useful to disentangle whether AI teammate schema expectancies were the driving influence or if it was more developed AI teammate schema at Time 4 influencing human-agent TMS evaluation if there is any effect.

Results for Hypothesis 5 are presented in Table 30. Hypothesis 5 was supported. The control model shows that the manipulation had a significant effect on reports of human-agent TMS evaluation at Time 4. Specifically, the constant, which represents the effect of the teamwork condition, was significantly negatively related to human-agent TMS evaluation at Time 4 (β = -0.53, $p<0.001$), and taskwork only and combined conditions were significantly positively related to human-agent TMS evaluation at Time 4 (β = 0.78, $p<0.001$; β = 0.76, $p<0.001$, respectively). Thus, teams in the teamwork condition reported that they needed to reevaluate how they fit their AI teammate into their human-agent TMS whereas teams in the taskwork only and combined conditions reported less of a need to reevaluate how they initially fit the AI teammate into their human-agent TMS. The next model adds AI teammate schema at Time 2 (team technology expectancies) to the model. The manipulation conditions are all still significantly related to human-agent TMS evaluation, but technology expectancies are not (β = 0.20, ns). However, the third model tests the hypothesized relationship, and AI teammate schema at Time 4 (after the teams had a chance to work with the AI teammate) significantly positively predicts human-agent TMS evaluation at Time 4 (β = 0.70, $p<0.001$). The change in adjusted R^2 between the control model and the hypothesis test model is 0.30, which suggests that adding AI teammate schema at Time 4 to the control model helps to account for a notably greater amount of variance compared to the control model alone. The adjusted R^2 value for the hypothesized model suggests that 59% of the variance in human-agent TMS evaluation is accounted for by AI teammate schema at Time 4, after controlling for the manipulation. Further, the non-significant results of model 1a, the model that tested the effects of AI teammate schema expectancies, suggests that it is the AI teammate schema of teams once they have had a chance to work with the AI teammate, not simply their expectations of the AI teammate, that influenced a team's need to reevaluate their human-agent TMS.

Hypothesis 6 posited that human-agent TMS evaluation would positively influence human-agent team dynamic restructuration. To test Hypothesis 6, I conducted a hierarchical linear regression, regressing human-agent team dynamic restructuration at Time 4 on the manipulation vectors in the control model, and then I added human-agent TMS evaluation at Time 3 and Time 4 into the model as predictors in 2 separate models.

Results for Hypothesis 6 are presented in Table 31. In the control model, there was a significant effect of the combined condition (β = 0.42, $p<0.05$), suggesting teams in the combined condition were more likely to report engaging in human-agent team dynamic restructuration, compared to teams in the other conditions. In the main effects models, the main effect of human-agent TMS evaluation at both Time 3 and Time 4 was positive and significant

(β = 0.41, p<0.05; β = 0.42, p<0.05, respectively). This finding suggests that the more teams engaged in human-agent TMS evaluation, the more they reported engaging in human-agent team dynamic restructuration. Thus, Hypothesis 6 was supported.

Hypothesis 7 proposed that communication frequency would be positively related to human-agent team dynamic restructuration. In order to test Hypothesis 7, I ran a hierarchical linear regression, first regressing human-agent team dynamic restructuration at Time 4 on the manipulation vectors and team size. I controlled for team size to account for differences in the total number of words spoken in each team. In the second model, I added the main effect of communication frequency (operationalized as the total word count for each team across all rounds of the data collection session and grand mean centered).

Results for Hypothesis 7 are presented in Table 32. Hypothesis 7 was supported. In the control model, there was a significant effect of the combined condition (β = 0.47, p<0.05) and team size (β = -0.35, p<0.05) at Time 4. This means that teams in the combined condition were significantly more likely to report engaging in human-agent team dynamic restructuration, and smaller teams (2-human teams compared to 3-human teams) were more likely to engage in human-agent team dynamic restructuration. In the main effects model, the main effect of communication frequency was negative and significant (β = -0.0001, p<0.05), which suggests that the fewer total words spoken by a team, the more they reported a need to engage in human-agent team dynamic restructuration by Time 4.

Hypothesis 8 stated that human-agent team dynamic restructuration would positively influence TMS utilization. In order to test Hypothesis 8, I ran 3 different linear regression models to test the effects of human-agent team dynamic restructuration at Times 2, 3, and 4, since dynamic restructuration was assessed at all 3 time points. Theoretically, the most representative time point to assess the support of Hypothesis 8 would be human-agent team dynamic restructuration at the midpoint of the teams working with the AI teammate, which would be Time 3. However, because of the relatively short amount of time the participants were able to spend with the AI teammate compared to real-world organizational teams, Time 4 also presents a useful measure of human-agent team dynamic restructuration. Time 2 was included for completeness.

Results for Hypothesis 8 are presented in Table 33. Hypothesis 8 was not supported. The controls were not significant predictors of TMS utilization at Time 4. At all assessed time points, human-agent team dynamic restructuration was not a significant predictor of TMS utilization at Time 4.

Hypothesis 9 stated that human-agent team dynamic restructuration would also mediate the relationship between TMS and team performance, TMS convergence, and TMS utilization in human-agent teams. In order to test Hypothesis 9, I ran 3 separate mediation analyses following a 4 step process (Baron and Kenny, 1986). In step 1, I ran a regression model regressing the independent variable (TMS at Time 1) on the dependent variable (either team performance, TMS convergence, or TMS utilization). In step 2, I ran a regression model regressing TMS at Time 1 on the mediator, dynamic restructuration. In step 3, I ran a regression model regressing the mediator and the independent variable on the dependent variable. Finally, in step 4, I used the "mediate" package in R (Tingley, Yamamoto, Hirose, Imai, & Keele, 2014) to run a mediation analysis using the models from steps 2 and 3. I used these steps to test the Hypothesis for each of the 3 outcome variables proposed in the Hypothesis (team performance, TMS convergence, or TMS utilization).

Results for Hypothesis 9 are presented in Tables 34-36. Hypothesis 9 was not supported for any of the 3 hypothesized outcome variables. This is primarily because in order to have a mediation effect, the independent variable (TMS at Time 1) should have a significant effect on the mediator (human-agent team dynamic restructuration), but this was not the case (β = -0.06, ns). This is reported as step 2 in each of the results tables.

However, some of the other results presented in the results tables for Hypothesis 9 still demonstrate other interesting findings. First, in step 1 for each outcome variable, I tested the main effect of TMS at Time 1 on the outcome variables. Results of Step 1 for team performance regressed on TMS at Time 1 suggest a possible effect of TMS at Time 1 such that a team's TMS at Time 1 may negatively impact team performance, but these results were only marginally significant (β = -0.43, p = 0.07). Results of Step 1 for TMS convergence and TMS utilization suggest positive significant results of TMS at Time 1 (β = 0.65, p<0.001; β = 0.78, p<0.001, respectively). These results suggest that the higher a team rates their humans-only TMS prior to meeting the AI teammate, the worse their team performance (although this result was only marginally significant), and the better their TMS convergence and TMS utilization. One more interesting finding from the mediation analysis is in step 3 in Table 34, which looked at team performance as the outcome variable. In step 3 of this model, the effect of TMS at Time 1 is still marginally significant, but the effect of dynamic restructuration at Time 3 (the mid-point of working with the AI teammate for teams), is significant (β = 0.36, p=0.02). These results suggest that after controlling for the effect of TMS at Time 1, dynamic restructuration positively and significantly influences team performance at Time 4.

Hypothesis 10 proposed that the relationship between human-agent team TMS and human-agent team dynamic restructuration is stronger among teams with an AI teammate that is teamwork-focused compared to teams with an AI teammate that is taskwork-focused. To test Hypothesis 10, I ran 3 linear regression models. In the first, I only tested the main effects of the manipulation on human-agent team dynamic restructuration. In the next model, I added Human-Agent Team TMS to the model. Finally, I added the interaction terms to test the moderation effect of the manipulation.

Results for Hypothesis 10 are presented in Table 37. Hypothesis 10 was not supported. Similar patterns appear for the effect of the manipulation on the outcome variable, in this case human-agent team dynamic restructuration at Time 2: the taskwork only and combined conditions were both positive and significant predictors of human-agent team dynamic restructuration (β = 0.42, p<0.05; β = 0.42, p<0.05, respectively) whereas the constant, which represented the effect of the teamwork only condition, was a negative and significant predictor of dynamic restructuration at Time 2 (β = -0.28, p<0.05), which suggests that for teams in the taskwork only and combined conditions, participants reported higher levels of dynamic restructuration at Time 3, and for teams in the teamwork only condition, participants reported lower levels of dynamic restructuration at Time 3. In the next model, I find no significant effect of human-agent team TMS on dynamic restructuration at Time 3, after controlling for the manipulation (β = 0.30, ns). In the final model, I add the interaction terms of human-agent team TMS and the manipulation vectors of taskwork only and combined conditions, and find no significant interaction effects (β = 0.10, ns; β = 0.34, ns, respectively).

Post-Hoc Results

Post-hoc analysis was also conducted in order to better understand the relationship between condition and group valence towards the agent teammate. In order to further parse out this relationship, I ran a post-hoc, repeated measures ANOVA test of AI teammate schema at

Time 2 and Time 4, with team condition as the grouping variable. Results suggest that there was no significant effect of time on AI teammate schema alone ($F(1,60) = 1.83$, $p = 0.18$), but there was a significant condition by time effect ($F(2,60) = 26.89$, $p<0.01$). These results suggest that teams were changing in AI teammate schema over time differently based on condition. Examining the descriptive statistics for AI teammate schema by condition, at Time 2, team AI teammate schema means were between 3.62 and 3.72 for all conditions, but by Time 4, taskwork only averaged 3.91, combined averaged 3.93, and teamwork only averaged 2.85, over 1 scale point lower than the other two conditions. As a reminder, Time 2 assessed AI teammate schema prior to meeting the AI teammate, so these were technology expectancies, and Time 4 used the same items, but were administered after working with the AI teammate for 2 rounds of team tasks.

Discussion

In this chapter, I investigate the development and evolution of team cognition and performance in teams undergoing team technology adaptation. First, I present the results of a pilot study, testing the methodology for my full study. Next, I present the methodology and results of my full laboratory study, which tests hypotheses derived from propositions elaborated earlier in this dissertation in my stage model development. Overall, much of the stage model is supported by the results from this study, while other relationships proposed within the stage model were not supported. Broadly, I find evidence for a few major patterns. First, I found that teams use their technology expectancies to shape their subsequent interactions with the technology and the other humans on their teams. Second, I find that although teams like having an agent teammate that engages in taskwork, teams also had to adjust the ways they worked with one another more, when compared to teams with agent teammates that engaged only in teamwork. Below, I elaborate on the general patterns of findings from this study related to both the supported and unsupported hypotheses from my stage model of team team technology adaptation.

Expectations and Human-Agent Team Cognition

This experiment investigated how teams use their expectations in response to the addition of an agent teammate. I introduced novel constructs, processes and emergent states in human-agent teams that captured the functioning of a human-agent team, testing hypotheses derived from my stage model of team technology adaptation. Study 2 provided evidence for the influence of team member expectations in the evolution of human-agent team cognition.

First, team member expectations regarding an agent teammate influenced the formation of human-agent TMS. Teams anticipated challenges in an agent teammate's credibility of knowledge and the ability of the team to coordinate as a human-agent team prior to working with the agent teammate. Specifically, before teams worked with an agent teammate, they rated the agent teammate as lower on credibility than they did for their human only team they had just virtually met and worked with for two 10-minute team tasks. Moreover, there was a difference between human-only team TMS and human-agent team TMS in ratings of coordination. These items were more similar in their phrasing and the subject of interest in each item, where the only difference was whether the team was referred to as "our team" (for the human only TMS items) or "our human-AI team" (for the human-agent TMS items) (See Appendix B1 for exact items for each version). Again, team members entered into working with an AI teammate believing that coordination processes were going to be tougher compared to when they were working as a humans-only team without any knowledge of the AI teammate aside from their expectations based on pre-existing technology expectancies.

Further, I found that human-agent TMS structures were formed contrary to what the human team cognition literature would suggest. Specifically, rather than use TMS structures, as suggested in the extant literature on human teams (Lewis et al., 2007), teams based their human-agent TMS structures more on their expectations of the AI teammate. Such expectations included: how they anticipated it would perform, how agentic it would be, and what expertise it would bring to the team. This finding suggests that before we can begin to solely use what we know about human only teams and apply it to human-agent teams, we must first align human team member expectations of an incoming agent teammate with the actual capabilities of the agent teammate. Once expectations and actual capabilities are aligned, it is possible that more of what we know about team cognition in human teams might better translate to human-agent teams.

The Role of the Agent in Human-Agent Team Cognition

Study 2 also illuminated the critical and unique role of the agent in human-agent team cognition. First, I found that the development of human-agent and agent-human TMS predicted communication behaviors in human-agent teams, and communication behaviors were then predictive of subsequent human-agent team dynamic restructuration. This finding demonstrates the importance of the development of specific dimensions of TMS that accounted for the agent in the team TMS in positive behavioral team processes and subsequent development and renegotiation of team cognition processes.

In this study, I also manipulated the role of the agent teammate such that agent teammates completed either taskwork, teamwork, or both taskwork and teamwork. Taskwork agent teammates provided information about items in the survival task and suggested ideas in the creativity task. Teamwork agent teammates made process suggestions to their teams, such as motivating the team with encouragement, keeping them on task, trying to unearth unique information from other teammates, and tempering disagreement when necessary. Overall, when compared to teams with an agent teammate that did not engage in taskwork, teams with an agent teammate that engaged in taskwork: liked the agent more, reported the agent as higher in performance and expertise, reported the agent teammate as higher in human-agent TMS specialization and credibility, and performed better on problem-solving tasks. These teams also reported that their expectations were in alignment with the actual capabilities of the agent teammate and that they were easily able to incorporate the agent teammate onto their teams. However, these teams also reported that the agent team member joining their team prompted them to change their roles and expertise, refocus their efforts, and work with their teammates differently, compared to teams with a teamwork only agent teammate. In sum, everything about the taskwork agent teammates was positive for their teams, *but* these teams also admitted to needing to undergo higher levels of reconstruction of team roles and processes.

Investigating the negative side of the teamwork only agent teammate teams, analysis suggests *not* that teams strongly disliked teamwork functions from an agent teammate, but rather that when teams did not *also* get taskwork functions from their agent teammate, they liked their agent teammate less. Teams in the teamwork only condition also reported their agent teammate as lower in performance, agency, and/or expertise (i.e., their AI teammate schema) compared with either the taskwork only or the combined conditions. There were no differences in team reports of AI teammate schema between the taskwork only and combined conditions. Thus, it seems that it is not the presence of teamwork, but rather the absence of taskwork that led to less positive processes and outcomes in human-AI teams. Examining the post-hoc results presented earlier, all teams began the tasks with a very similar AI teammate schema, but by the end of the human-agent teaming tasks, AI teammate schema was very different, depending on condition, with the teamwork only condition over 1 scale point lower in AI teammate schema than the other two conditions at Time 4. Thus, results of the agent teammate function manipulation support a general idea proposed in this dissertation that when our expectations of an AI teammate do not align with the realities of working with that AI teammate, team outcomes suffer.

Agent teammate function also had a significant positive influence on team problem-solving performance. One primary explanation for this finding is that teams with agent teammates that engaged in taskwork had an agent teammate that was directly able to contribute knowledge to assist in ranking items. The knowledge would be directly useful to achieving a better score on the problem-solving task, if the AI teammate were fully trusted by the team and the team actually took the advice of the AI teammate. Moreover, because agent teammates that engaged in taskwork processes were well-liked, the lack of negative emotional reactions may have also contributed to better team outcomes in the taskwork teams and worse team outcomes in the teamwork only teams, as found in research on emotional contagion in human teams (Andersson & Pearson, 1999; Barsade, 2002).

Although problem-solving performance was affected by the AI teammate function, no differences were found in creativity scores. This finding prompts a deeper investigation into task type. A leading perspective in thinking about human-agent teaming in organizations is that agent teammates should complement human strengths to create the best possible human-agent teams (Guszcza & Schwartz, 2020). Within this line of thinking, one strength of humans that is often cited within this perspective is that of creativity, whereas agent teammates are thought to be more useful in problem-solving and knowledge-based tasks. Results of Study 2 align with previous findings on agent teammates being able to help with problem-solving team tasks such that they are able to help improve team performance (Tennent, Shen, & Jung, 2019).

However, we also see computer scientists developing machine learning algorithms to autonomously create art (Elgammal, 2019), suggesting that agent teammates may even be able to contribute to creative team tasks at some point in the future. The work on human-agent collaboration in creativity tasks is still relatively young (Hu, Feng, Mutlu, & Admoni, 2021), but early findings do suggest that robots are able to help facilitate humans in their own creative endeavors. However, other studies have been unsuccessful in showing that a robot can actually help improve human creativity in a drawing task (Alves-Oliveira et al., 2019). Important factors in successful human-agent collaboration in creative tasks seem to be the design of the agent (i.e., not giving the robot too much control over the creation of creative task outcomes relative to the human; Hu et al., 2021) and the specific parts of the creative process that the agent teammate is intended to engage in. In Study 2, the agent teammate's functions (taskwork, teamwork, or both) had no observable effect on creative outcomes, but a different design of the agent's interaction patterns or the specific role of the agent in taskwork processes may have resulted in more marked differences in creativity performance, and could be explored in future work.

Team Communication in Team Technology Adaptation

This study also suggests one possible behavioral mechanism in team technology adaptation: team communication. Although a more basic examination of communication was included in analyses (simple word count total), findings still suggest that human-agent team dynamic restructuration is a process that is influenced by how much teams communicate with one another. However, communication was also negatively related to human-agent team dynamic restructuration, meaning the more a team communicated, the less it engaged in human-agent team dynamic restructuration. This finding was counter to the initial hypothesis which anticipated a positive relationship between the two, with communication as the mechanism through which human-agent team dynamic restructuration might occur. One potential explanation for this finding derives from research on human team cognition in air traffic controllers. Specifically, this work demonstrated that teams with strong shared mental models were able to communicate less (Smith-Jentsch, Mathieu, & Kraiger, 2005). Shared mental models, or a shared understanding of knowledge shared by a team (Cannon-Bowers, Salas, & Converse, 1993), enabled teams of air traffic controllers to coordinate implicitly, which required less communication than teams of air traffic controllers with weaker shared mental models, and also helped streamline processes and aid in better team effectiveness. Thus, it is possible that teams that communicated less were possibly able to coordinate implicitly and did not require verbal communication as much in order to engage in human-agent team dynamic restructuration.

Human-Agent TMS Evaluation and Team Dynamic Restructuration

Interestingly, Study 2 provided mixed results for the role of human-agent TMS evaluation and human-agent team dynamic restructuration in team technology adaptation. I hypothesized that human-agent TMS evaluation would be the process teams would engage in to reconstruct their TMS structures, and the extent to which they reconstructed their TMS structures would be measured via reported human-agent team dynamic restructuration. I also suggested that those teams that engaged in human-agent team dynamic restructuration more would see benefits in subsequent team processes and outcomes. Results supported the former, but did not provide evidence for the latter. Human-agent TMS evaluation and team dynamic restructuration were both higher in taskwork teams compared to teamwork only teams. Higher values of human-agent TMS evaluation represented a team reporting that their TMS structures were appropriate and helpful already and did not require major overhaul because of the introduction of the new agent teammate. Higher values of human-agent team dynamic restructuration represented a team reporting that they engaged in reconstruction of their team processes to better accommodate the agent teammate. Thus, it is curious that teams with a taskwork agent teammate reported both higher human-agent TMS evaluation and higher human-agent team dynamic restructuration than teamwork only teams. Further, higher human-agent TMS evaluation predicted higher levels of human-agent team dynamic restructuration, after controlling for condition.

The patterns of human-agent TMS evaluation make sense if human-agent TMS evaluation is conceptualized as an evaluation of whether the agent teammate's capabilities meet the team's expectations. The taskwork agent teammates more closely match expectations of performance and expertise than the teamwork only agent teammate. For example, much of our interaction currently is with AI assistants such as Siri on Apple iPhones or Alexa on small countertop devices in our homes. We interact with these devices with commands and expect a quick and factual answer or behavior. The agent teammates that exhibited taskwork behaviors most closely resembled our existing AI teammate schemas whereas the teamwork only agent teammate did not.

Rather than a process that is capturing positive reconstruction of team cognition structures, it is possible that human-agent team dynamic restructuration was capturing a team's response to disruption of the agent teammate. Dynamic restructuration assessed whether the agent team member forced teams to change roles, refocus efforts, and play to different strengths. Teams with agent teammates that engaged in taskwork processes reported engaging more in dynamic restructuration than teams with agent teammates that only engaged in teamwork processes, but taskwork teams also liked their agent teammate more and experienced greater problem solving performance. Thus, dynamic restructuration may be representative of teams engaging more in the process of trying to integrate their agent teammate onto their team. It is possible that the teams in the teamwork only condition viewed their agent teammate as so different from initial expectations and there was just not enough time to successfully adapt team processes to better include the new agent teammate that was engaging in behaviors they were not ready to accept and accommodate. Further, teams in the teamwork only agent teammate condition may have simply experienced cognitive overload when trying to engage in human-agent team dynamic restructuration over such a fast-paced and relatively short period of time (e.g., (e.g., Jiang, Kalyuga, & Sweller, 2020; Sweller, 1994; van Gog, Paas, & Sweller, 2010). Although the design of Study 2 was such that it attempted to provide multiple teaming episodes over which teams might develop and reconstruct cognitive team processes, it is possible that reconciliation of expectations of the agent teammate and reconstruction of team processes to better accommodate the agent teammate was too much information for team members to take in and adjust to within about an hour of team tasks and survey responses.

Limitations and Future Directions

Although this study contributed greatly to an emerging and critical area of study on a new form of organizational teams - the human-AI team - this study did have a few limitations that present avenues for future research. One such limitation of this study was the validation of the new human-agent teaming constructs. Although validation efforts were done on a large sample of MTurk workers (as noted in Study 1), the sample in this study used to validate the measures and items used in Study 2 was a smaller sample, compared to the sample sizes typically used in scale construction and validation. Thus, further validation is recommended, using larger samples. Moreover, scale validation efforts are best when the scale can be validated among diverse populations. MTurk workers are generally more homogenous than is ideal for large-scale generalizability, so the scales developed in this dissertation would benefit from further validation in other samples of participants. Although this study did include university students and community members from all over the country because of the virtual nature of the study medium, further, more intentional, diversity efforts could help validate items and ensure that items are valid among many different populations to provide more accessibility in the samples that the measures can be used within. Also, it is possible that teams will respond differently to the measures based on other expectations of a technological teammate not directly addressed in this research or that different types of team tasks influence how we perceive our AI teammates to the measures. Thus, the measures developed in this study would benefit from validation in human-AI teams with AI teammates that vary more broadly in traits such as competence and warmth or in their team functioning related to the team tasks of interest. Therefore, the scales could also benefit from more validation efforts in samples of teams with various life spans, composition, size, and virtuality.

Another limitation of this study was the lack of accessibility to larger samples of teams that had already worked together rather than inducing team norms and structures within a 20-minute humans-only round of team tasks. Although extant research suggests that team TMS does begin to develop almost immediately (Baumann, 2001), it is possible that teams that have much longer life spans might respond differently to the introduction of an AI teammate to their team since they likely have thoroughly developed norms and processes that the AI teammate may have an even harder time integrating within. However, this does further support the need to consider how to best integrate AI teammates onto pre-existing teams.

Another future direction from this line of limitations is to test the findings of this study in varying team sizes. In this study, there were significant differences between team sizes of 2-humans compared to team sizes of 3-humans in reported levels of human-agent team dynamic restructuration, such that the smaller teams reported a greater degree of engaging in human-agent team dynamic restructuration than larger teams. As such, it is quite possible that there would be differences in findings when teams become even larger. For example, when teams become large enough to develop faultlines among team members, it is possible that certain subgroups will accept and trust an AI teammate more than others. These differences will not only influence the successful integration of the AI teammate but may also cause further disagreements or deepening of already-existing faultlines among subgroups. All in all, team lifespan and size should be further examined to parse out the nuances of team technology adaptation as team size and team composition varies.

This study also examined two types of tasks: a problem-solving task and a creativity task. These two task types were chosen in order to present teams with a task with a correct answer and a task without correct answers. According to McGrath's (1984) team task circumplex, these two task types cover "generate" and "choose" tasks, whereas "execute" and "negotiate" task types were not addressed in this study. Further, problem-solving and creativity tasks are both considered cooperative and conceptual tasks, leaving behavioral and conflict tasks also unaddressed in this study. Execute and behavioral tasks are more in line with what much of the human-robot interaction area tends to focus on in more basic research of the past (Sebo, Stoll, Scassellati, & Jung, 2020), so we know a bit more about human-robot interaction in these task types, but negotiate tasks are complex even in human team processes, as they inherently involve some form on conflict or competitiveness (Bazerman et al., 1988; Thompson, Peterson, & Brodt, 1996), so future work could examine how agent role influences team technology adaptation differently in these other two task dimensions.

The modality of this study presents another limitation that suggests many avenues for future human-agent teaming research. This study was conducted via the Zoom teleconferencing platform. Although much of the world was acclimated to conducting professional and personal meetings over Zoom or a similar platform, this may not have been the case for all participants, which may limit the application of these findings. Moreover, these results may not fully apply to non-virtual settings of human-agent teaming. AI embodiment has been shown to be a predictor of human receptiveness to AI (Qiu & Benbasat, 2009), so if all humans were in person, but the AI teammate was virtual or disembodied, results may not apply as well. Also, if AI teammates are embodied and in person with the rest of teammates, this may have its own unique impact of how the AI teammate is integrated onto the team. Thus, further investigation of embodiment and virtuality are necessary.

One limitation of this study specific to the delivery of the manipulation was that although the manipulation was found to be effective, the salience of the AI teammate as a “teammate” is less certain. Teams generally reported the manipulation of AI functions as successful. Teams in each condition reported significantly higher frequencies of their condition’s respective behaviors from the AI teammate than did those in other conditions. However, I did not measure the extent to which participants actually felt as though their AI teammate was a “teammate”. In reviewing study videos, there was a large range in the reception of the AI teammate from team to team, from praising the AI teammate and how helpful it was and wanting it to be their teammate on everything to finding the AI teammate completely useless. AI teammate confederate training was controlled as much as possible. Confederates were required to engage in multiple hours of training and approximately 10 hours of confederate practice with other research assistants and study team members before they were put into data collection sessions with real teams. Also, confederates were instructed and trained to stay on their condition-specific scripts at all times. All efforts were taken to be sure the AI teammate spoke as frequently as a normal teammate. Because of technological delays and the more clunky nature of scripts in live team sessions, confederates were often delayed in their response or not quick enough to respond in time to get all the statements in that they were supposed to, which may have influenced the perceptions of the AI teammate agency.

Finally, this study was conducted during the COVID-19 global pandemic, which presents some necessary cautions. In some ways, the pandemic provided an interesting means for forcing a fully virtual study. The ramifications of the pandemic on organizations may mean that more organizations will allow employees to work virtually indefinitely or at least provide more virtual work options to employees. In this way, the virtuality of the study and the disembodiment of the AI teammate may not be as limiting to the application of these findings. However, both participants and research study team members may have been influenced in ways we do not fully understand yet as much of the world (and, inevitably, at least some of our participants) was in a state of uncertainty, to say the least. Thus, it may be worthwhile to retest the findings of this study when there is less strife on a global level to affect participant responses and interactions.

CHAPTER 5. CONCLUSION

This dissertation delves into the unknown, anticipating organizational teamwork of the near-future, where organizations are rushing to incorporate the latest innovations in machine learning and AI into every aspect of organizational life. This dissertation, as proposed, aimed towards the future, but recent events have brought the future much closer to our present. As the world begins to reopen after a massive technological shift to fully virtual work due to a global pandemic, we are already returning to organizations very different from the organizations we left over a year ago. With this shift, the trajectory of integration of AI into our organizations has accelerated (Balakrishnan, et al., 2020), leaving an even more immediate need to understand how to prepare our organizational teams and leaders for team technology adaptation.

Yet, this future poses exciting directions for our organizational teams. In this dissertation, I lay the groundwork for theorizing on human-agent team cognition in teams integrating new AI teammates for the first time, with a focus on the implications for the humans in such teams, so that teams can fully capitalize on the vast opportunities posed by technological advancements. I propose a stage model, detailing how team technology adaptation impacts team cognitive processes and performance. Then, I develop multiple scales to examine human-agent teaming. Finally, I test hypotheses derived from propositions developed in my stage model to empirically examine relationships between new human-agent teaming cognitive constructs and important team outcomes. In this dissertation, I lay out a need to better understand the integration of agents into our organizational teams and a means to begin to provide organizational teams and leaders the tools to better understand human-agent team cognition and successfully engage in team technology adaptation.

Theoretical and Methodological Implications

This dissertation positions itself to contribute to the growing and critical area of human-AI teaming, focused on a more human-centered approach to human-AI teaming (Glikson & Woolley, 2020). In Chapter 1, I elaborate on the phenomenon on which this dissertation is based: the emerging influx of artificially intelligent technologies joining our organizational teams (Larson & DeChurch, 2020). I also review the gaps in the literature that I aim to help bridge in our understanding of human-agent teaming. At the time of writing this dissertation, no theory or model existed that fully encompassed the needs and demands of the humans in teams bringing on an intelligent agent newcomer to the team. Those enmeshed in the study of technology use in collaboration have made careful consideration of the design of technologies so that the technologies could be integrated to better meet the demands of humans and collaborate more efficiently with humans such that humans will be more likely to use the technology (i.e., Brown, Dennis, & Venkatesh, 2010; DeSanctis & Poole, 1994; Majchrzak et al., 2000). However, those who consider the humans in the human-technology collaboration, have only more recently entered the conversation surrounding artificially intelligent technologies as teammates (Chen, 2018), and the findings “remain scattered” in the organizational sciences (O’Neill et al., 2020, p. 1).

The theoretical development of a new organizational process in teams is one major contribution of this dissertation. In Chapter 2, I review the relevant literature that examines how humans enter teams, how humans adapt to new situations in general, and how humans collaborate with machines. From this, I establish a model of team technology adaptation. I define team technology adaptation as an iterative process of mutual adjustment wherein team members and an intelligent technology acquire the necessary knowledge, skills, and abilities to collaborate efficiently and effectively. This chapter provides a theoretical grounding for the future study of team technology adaptation. Further, the establishment of team technology adaptation as a process provides researchers with a framework for how to view the implementation of agentic technological teammates in the future.

Although current research does not take into consideration the affective states of the agent itself, future innovations may force teams to consider the thoughts, opinions, and feelings of an AI teammate. Human-agent collaboration has been described as the “complex and iterated interactions and collaborations” between humans and technology (Clark, 2001, p. 154). The inclusion of iterative adjustment into team technology adaptation also takes into consideration future software or hardware updates that AI teammates may undergo in the future. Thus, the theory proposed in this dissertation is built to accommodate future innovations that we cannot yet know, so that organizations and scholars alike may still try to prepare their organizational teams for the integration of future technologies based on the theory proposed in this dissertation.

In general, the empirical study in this dissertation provides support for the importance of alignment of cognition in teams when we bring AI teammates onto teams. Recent qualitative work on cognition in human-agent teams provides a preliminary model of team cognition emergence in human-agent teams, and found that perceptions of an agent teammate affected how coordination occurred in human-agent teams (Musick et al., 2021). Empirical findings from Chapter 4 elaborate on this relationship, suggesting that before teams even have a chance of working with an AI teammate they already anticipate that cognitive processes, such as TMS credibility and TMS coordination will be an issue with the AI teammate, as there were significant differences between TMS and human-agent team TMS on these 2 dimensions. This finding is counter to what we know about cognition in human teams, which suggests that teams use their existing TMS structures to incorporate new teammates onto their teams (Lewis et al., 2007). Further, we see that a team's cognitive schemas regarding an AI teammate influence subsequent group valence towards the AI teammate, suggesting the importance of expectations of technologies before teams ever meet the technology and have a chance to interact with it for themselves. Subsequently, the valence of the team towards the AI teammate influences how the team evaluates their placement of the AI teammate into their cognitive structures by the end of 2 rounds of working with the AI teammate.

In sum, our cognitive representations of technology as a teammate has repercussions for subsequent cognitive processes in human-agent teams. This finding suggests important implications for how organizations introduce technologies into teams for the first time. This may also have implications for how employees are trained (i.e., training employees to have certain expectations that will help to better align cognitive schemas with the realities of AI teammates organizations plan to integrate onto employee teams). Finally, these findings may have ramifications for the initial design of technologies so that a lack of certain expected functionalities in an AI teammate does not disrupt the integration of the AI teammate such that it is not received well or effectively by the team.

Another major contribution of Chapter 4 is the finding of the importance of AI teammate function on human-agent team cognition processes. Recent theorizing suggests that technology as a teammate can support team process and performance via teamwork and teamwork functions (Fiore & Wiltshire, 2016). In Study 2, I extend this theorizing and work. I found that teams reported more negative attitudes towards an agent teammate when the agent teammate newcomer engaged only in teamwork processes rather than taskwork processes. Findings suggest that teams don't like AI teammates that don't act in the ways we expect. Classic research on human teammate newcomers found that teams expect their newcomer teammates to be passive, dependent, and conforming (Moreland & Levine, 1989), so it is possible that teams perceived their teamwork only AI teammate as too active, independent, or non-conforming by making process suggestions such as “We all have a unique perspective to offer! Let’s hear from someone who hasn’t spoken in a while!” Further, our expectations of technologies influence cognitive structures, but once these expectations are found to misalign with reality, teams work and interact with AI teammates differently.

Alternatively, work on robot intervention in managing team conflict suggests that teams are more or less receptive to intervention depending on the trigger of the intervention (Jung, Martelaro, & Hinds, 2015). The study found that task-directed triggers of conflict “backfired” and the robot’s interventions were counterproductive in reducing team conflict in those situations. This could be one explanation as to why the teamwork only agent teammates were received less positively than the taskwork agent teammates. In the teamwork only teams, the agent teammate made process suggestions that may have been perceived as a negative team process by appearing to call out certain members of the team or all of the team for doing something negative which may have been perceived as too aggressive or inappropriate, creating unintended conflict and subsequent negative affect towards the teamwork only agent teammate.

This dissertation also furthers the necessary theorizing and research of organizational human-agent interaction at the team level, focused on the humans in the human-agent interaction and how the humans are affected by the integration of a new AI teammate onto their teams. The examination of human-technology collaboration at the team-level remains relatively nascent. Extant research on human-agent interaction historically overwhelmingly focuses on the dyadic level, between a single human and a robot. Often, the research is more basic, related to how the two entities interact with one another rather than how they complete complex tasks interdependently in larger interdependent teams. Further, much of this work studies agent teammates that are not quite “artificially intelligent” or highly agentic, as defined and studied in this dissertation. Finally, the organizational sciences have much to offer in the study of the *humans* in human-agent teaming in the workplace, with extant research on the effects of intelligent technology on humans in the workplace in a nascent stage (Kellogg, Valentine, Christin, 2020). Thus, this dissertation provides the groundwork for examining human-agent team cognition in teams undergoing human-agent team technology adaptation.

There are notable exceptions to the nascent nature of human-agent teaming in the human-robot interaction space, which has been examining the effects of advanced technologies in groups and teams since the turn of the 21st century. This dissertation contributes and builds upon this work and our current understanding of human-robot interaction. Jung and Hinds (2018) argued a need to elaborate on our understanding of “robots in the wild”, or to better understand robots in the relevant contexts they will be used in our day-to-day lives. In this dissertation, I focus on AI agent integration into workplace teams, where the agent is working in a team completing problem-solving and creativity tasks with human team members. Although conducted in a laboratory setting, I tried to make the team experiences as realistic as possible, making team members work as a humans-only team before being joined by an agent teammate, by recruiting participants across wider populations than only in a student population, and incentivized performance in teams so that teams would be motivated to participate in a manner more consistent with their day-to-day work motivation levels where performance matters.

Another contribution of this dissertation is the theoretical elaboration and refinement of new dimensions of transactive memory in human-agent teaming. In the theoretical development of TMS in human-agent teaming, I proposed two new dimensions of TMS: human-agent TMS and agent-human TMS. However, the findings and further conceptualization of human-agent TMS suggests that what I have referred to as human-agent and agent-human TMS only account for half of the human-agent TMS. In Table 38, I present a new conceptualization of human-agent team TMS wherein the TMS dimension accounts for knowledge that is either a) direct or b) meta-knowledge, and the perspective of either a) the human team member or b) the agent team member. In this reconceptualization, what I referred to as the human-agent TMS can be more appropriately thought of as the human-agent TMS from the human's perspective, and what I referred to as the agent-human TMS can be more appropriately thought of as the human-agent TMS meta-knowledge from the human's perspective. Further, I suggest that, as technology continues to advance and scientists strive towards fully autonomous, human-like agents, future research would also benefit from taking into account the agent's perceptions of the human-agent TMS. Thus, I suggest two new dimensions of human-agent team TMS, the human-agent TMS from the agent's perspective, and the human-agent TMS meta-knowledge from the agent's perspective. The human-agent TMS from the agent's perspective is the agent's perception of the human-agent TMS, and the human-agent TMS meta-knowledge from the agent's perspective is the agent's perception of the human teammates' perceptions of the human-agent TMS.

Finally, this dissertation provides details on the development of scales that researchers can use to fully understand agent integration onto a human team. As suggested by Wiltshire and Fiore (2018), new technologies broaden our conceptualizations of team cognition and how technologies may fit within these structures. The scales developed in this dissertation provide researchers with new tools to better understand and study human-agent teaming and technology as a teammate. Specifically, I provide the results of psychometric analyses of response from real teams who believed they were working alongside an actual technology that was supposed to be acting as a teammate. First, I provide additional dimensions of transactive memory systems to accommodate the unique addition of an agent teammate into a team transactive memory system: Human-Agent Specialization and Human-Agent Credibility. Psychometric analysis results suggest these two dimensions account for unique aspects of team cognitive structures, and these new dimensions of TMS can be used to study the unique contributions of agents to a team TMS in future research, as more research efforts are put into better socializing an agent teammate onto organizational teams.

Further, I validate two measures that assess the evolution and development of cognition in human-agent teams: human-agent team dynamic restructuration and human-agent TMS evaluation. Human-agent team dynamic restructuration assesses the extent to which participants report that the team went through the process of reconciling dissonance between their expectations and the reality of working with the AI teammate on their team. Human-agent TMS evaluation assesses the extent to which participants reported a need to undergo dynamic restructuration. Dynamic restructuration could be used as a continuous measure to examine the extent to which teams reported undergoing the process, whereas human-agent TMS evaluation could be used to examine the causes of undergoing dynamic restructuration. Human-agent TMS evaluation is particularly interesting in its potential use as a measure to decide whether a team may require an intervention such that the team is facilitated through the process of dynamic restructuration.

Two more scales validated in this study were team AI teammate schema and team technology valence. Team AI teammate schema assesses the cognitive representation of team members for a technological teammate, and this scale can be used to assess both expectations and existing schema after working with an AI teammate for a time. Team technology valence assesses the attitudes and affective valence of team members towards a technological teammate. These measures could be used to track changes in schema regarding or group attitudes towards a technological teammate, which could be useful for the implementation of new technologies and potential interventions by management if schema or valence towards the AI teammate is not occurring as intended within a new team.

Finally, I also develop and validate a measure to assess TMS convergence in teams. This measure was developed based on the conceptual development of TMS convergence by Brandon and Hollingshead (2004). This scale is a useful measure of how team members perceive their transactive memory systems, and whether teams feel that they have convergence in their cognitive structures. TMS convergence encompasses the idea that TMS structures are ideally accurate, shared, and validated among all team members, and this measure attempts to measure this via a 6 item scale. This scale extends the measurement of transactive memory systems by providing a scale with which to measure beyond just how the individuals on the team felt about the structure of the TMS, but rather to measure the metaperceptions of team members about the quality of the TMS (in terms of sharedness, accuracy, and validation, specifically).

Practical Implications

This work also provides a few practical implications for teams and leaders in organizations attempting to integrate AI as a teammate into their organizational teams. First, the ways in which management frames the introduction of an AI teammate is critical to subsequent team technology adaptation. Work on newcomer socialization has shown that perceptions of newcomer experience influences subsequent team expectations of the newcomer which influence social exchanges and perceived newcomer role performance (Chen & Klimoski, 2003). Further, in social settings, anthropomorphic robots were more likely to incur unrealistically high expectations in social ability than non-anthropomorphic robots (Kwon, Jung, & Knepper, 2016). Work that considers technology as a teammate rather than a tool demonstrates that the encouragement of shared team goals helps support more positive team process in human-agent teams (Musick et al., 2021; Nass et al., 1996; Walliser et al., 2017; Wynne & Lyons, 2018). In Study 2, Vero was presented as 1) having relevant expertise to the team tasks, 2) a non-anthropomorphic entity, and 3) having shared team goals with the humans on the team.

Study 2 also demonstrated that teams communicated similarly in their human-agent team as they did in their humans-only teams, which is in contrast with findings that have shown that human-robot teams tend to communicate less than human teams. In general, human teams are better off when they communicate more with one another (Marks, Zaccaro, & Mathieu, 2000; Warkentin & Beranek, 1999). However, recent meta-analytic results suggest that communication quality is a stronger predictor of team performance than communication frequency (Marlow et al., 2018). Moreover, simply the introduction of a new AI teammate can change team communication behaviors (Demir, McNeese, & Cooke, 2017; Demir et al., 2015; Glikson & Woolley, 2020) - humans working alongside an AI teammate exchanged information less than humans working with other humans. In contrast, I found similar levels of communication (average words spoken per human teammate) in teams in the first round of team tasks, compared to rounds where there was an AI teammate on the team. Although many extraneous factors could be at play, one explanation is that the framing and presentation of the AI teammate in this study as an agentic, highly advanced AI teammate that spoke using a human voice may have influenced communication behaviors such that they were more similar to human teams in this study. As such, new agent teammates might be best introduced in a way that suggests the agent teammate 1) possesses all relevant "experience" needed for its roles and responsibilities, 2) is presented in an anthropomorphic design only if its social capabilities are relatively advanced, or else the agent should be presented as a non-anthropomorphic entity to avoid unrealistic expectations in its social capabilities, and 3) possesses shared team goals with the other humans on the team.

However, results also suggest that the actual capabilities must match these expectations as closely as possible so that teams do not experience issues in development of human-agent team cognition, as found in Study 2. This finding suggests a second implication: organizations need to train employees such that their expectations of incoming technologies align with the realities of working with the technologies. Employees should be made aware of the detailed roles and responsibilities such that expectations best match actual capabilities. One area of emphasis in such training might be to emphasize that robots are not humans and should not be held to the same standards for "humanness" as other human teammates, thus tempering and altering expectations of the agent teammate from the start. By training human team members that the agent teammate is coming on to the team as a complementary member of the team rather than as an additional human, team members might come into the human-agent interaction with more accurate expectations for the agent teammate (Groom & Nass, 2007).

The scales developed in this dissertation might also be used in some way in organizations trying to integrate AI teammates onto their organizational teams. These scales could be used as diagnostic tools to assess how well or poorly an AI teammate is being integrated into team cognitive processes. Organizations could then intervene and attempt to alter AI teammate schema or group valence toward the AI in some way based on responses to the scales in this dissertation.

Finally, this work has implications for the design of future agent teammates. Specifically, this work suggests that agent teammates should be designed so that they can align better with current expectations of technological teammates in the target populations in which they will be working in teams. Complementary to the above recommendations, design of agent teammates might also focus on ensuring that the agent teammate does in fact possess all of the relevant expertise and experience that is required of the role it is to be completing on the team, and the details of how it will complete its role should be thoroughly communicated to all collaborators in the framing of and in collaboration with the agent teammate. The agent teammate should also be designed in such a way that the physical features are an accurate representation of its social characteristics (i.e., a socially adept agent teammate can be more anthropomorphic than a less socially adept agent teammate).

Future Research Directions

Throughout this dissertation, I have elaborated on the nascent nature of our understanding of human-agent teaming. As such, there are many opportunities for further investigation of human-agent teaming stemming from this work.

Conceptualizing an Agent Teammate

Revisiting the notion of an agent teammate, this work raises the question of whether we should be theorizing about agent teammates as more human-like entities or more technology-like entities. As proposed earlier in this dissertation, I suggest an integration of newcomer socialization and technology adoption literatures provide the most appropriate groundwork to answer this question. I also integrate some of the multitude of work on human-technology interaction. In doing so, I built theory to account for the effects of a new agent teammate joining a pre-existing organizational team. In Chapter 2 (and Table 1), I elaborated on a particular type of technological teammate, an agent teammate, on which I focus the theory development and empirical study of this dissertation. As warned by Rahwan and colleagues (2019), in considering human-agent interaction, we cannot fully assume that what works for humans will work in the same ways for AI. We do not fully understand the extent of the differences and similarities in human compared to agent newcomers, and more work exploring these differences and similarities can help better prepare our organizational teams and leaders for team technology adaptation.

In Chapter 2, there were two propositions, that were not tested in Study 2, that focused on the differences between human newcomer socialization and team technology adaptation. One centered around comparisons of TMS specialization and credibility development between human teams and human-agent teams. The second centered around the particular expertise that incumbent human team members expected from an incoming AI teammate. There are likely many factors that contribute to an individual's formation of human-agent TMS dimensions and team technology expectancies, including individual trait and personality differences (i.e., openness to new experiences, age, past experience with technology, or technology readiness; Parasuraman, 2000) and incumbent team processes and states. Moreover, team technology expectancies will likely shift among various populations as more advanced technologies continue to flood our everyday lives. As this dissertation demonstrates, human technology expectancies have lasting effects on human-agent team cognition, and a focus on the formation of technology expectancies in individuals, and in interdependent team contexts, will be critical for understanding team technology adaptation.

The results of this research suggest that perhaps the newcomer socialization literature might prove most helpful in understanding team technology adaptation *only* if we are able to successfully reframe our human team member expectations of incoming agent teammates. However, there are still many barriers that must be better understood before we will likely be able to fully adjust our expectations of our agent teammates. Specifically, research suggests that robot physical presence, conformity, embodiment, and other factors impact how humans receive a technology in group or team settings (Li, 2015). As such, future research should address how these factors come into play specifically when we bring new agent teammates onto teams.

This work also raises the question of how different capabilities and design choices for an agent teammate influence the conceptualization of an agent teammate. Because of the large spectrum of embodiment, functionality, traits, and skills in potential technological teammates of now and the near future, I had to operationalize the agent teammates in this study to a specific subset of technological teammates. This dissertation focused on AI agents, which are artificially intelligent technologies that perform taskwork as a part of a larger group or team (DeCostanza et al., 2018). Specifically, in Chapter 2 (Table 2), I specify that the agent teammates under study in this dissertation are those that are intelligent, agentic, adaptive, interdependent, motivated to perform, and social. However, the reality is that many technological teammates of the future may not fully encompass my conceptualization of agent teammate. They may lack the advanced AI capabilities, but have a large physical presence on a team completing only a specific subset of taskwork, or they may be highly advanced AI agents "living" in a computer and helping C-suites make multi-million dollar decisions.

Embodiment. As discussed in previous work on human-agent teams, perceptions of technological teammates can vary widely, depending on many factors. Abrams and Rosenthal-von der Pütten (2020) suggest that theory built on social psychological principles for application in human-robot/agent teams can "generally … be transferred" but that empirical findings and patterns of interaction for particular subgroups of technological teammates might vary widely based on factors that have been shown to cause significant variation in expectations of technology. One study found that expectations of an agent teammate's capabilities varied based on whether the technological entity was virtually or physically embodied (Hoffman, Bock, & Rosenthal-von der Pütten, 2018; 2019). Li (2015) found that physically-embodied robots were seen as more persuasive and viewed more positively compared to virtual robots. Humans with collocated robot partners also performed better than humans with virtual robot partners (Li, 2015).

Thus, the findings in this study may not generalize to all embodiments of potential technological teammates due to potential differences in expectations and interactions with different embodiments of technology. However, the theorizing in this dissertation strived to accommodate scenarios that might be most relevant for organizational teams of the present and near-future. Study 2 focused on Vero, a virtual (rather than co-present) agent teammate that did not have a real embodiment or presence in the real world, and was shown in the form of an avatar composed of non-anthropomorphic shapes. The work reviewed above on human-robot/agent interaction suggests that manipulation of embodiment-related factors could act as a buffer to the negative side effects of the teamwork only function found in Study 2. Co-presence or a physical embodiment of Vero could alter findings of this study such that teams might like the teamwork only agent teammate more when embodied in their physical space, despite the observed negative side effects of the teamwork only function of the agent teammate, which could influence more positive team technology adaptation.

Conformity. Other work has suggested conformity as a critical influencer of group liking in human-computer interaction (Bailenson & Yee, 2005; Shen, Tennent, & Jung, 2017). When a technological agent mimics head movements, smiles and nods, or other kinds of non-verbal behaviors, humans tend to like the agent more than when they do not (Takano et al., 2009; Hofree et al., 2014), an effect known as the chameleon effect among humans (Chartrand & Bargh, 1999; Duffy & Chartrand, 2015). To some extent, my findings speak to this idea as well. In Study 2, I find that when the agent teammate engaged in only teamwork processes, it was liked less than when it engaged in taskwork processes. Because there was a limited amount of time to complete each task, teams felt time pressure and were focused primarily on taskwork rather, and many expressed disinterest in taking too much time to focus on teamwork processes. As such, the teamwork only agent teammate was non-conforming with the rest of the team. In this way, alignment of goals and teamwork processes might also enable more conformity between the teamwork only agent teammate and its human counterparts. However, teams in the taskwork agent teams also reported a greater need to change how they were working with one another to incorporate the agent teammate onto their teams, suggesting that the taskwork agents' conformity did not mitigate that challenge.

Overall, these results suggest that we need new theorizing on the notion of what makes an agent teammate. My conceptualization of an agent teammate focused on specific capabilities and characteristics of an agent teammate related to how the agent teammate would perform intellectually and interpersonally with other teammates. However, other critical factors that may also influence team technology adaptation, such as those outlined above and more focused on the design of the actual agent teammate were outside of the scope of the present work. For example, if an agent teammate completes taskwork processes, resides in a physical shell, and has a physical presence with its teammates, would it be considered conforming? Conversely, work on anthropomorphism suggests that we should be hesitant on how far we go in designing our agents to be physically conforming with human team members. Thus, the general physical or non-physical presence and overall design and presentation of the agent teammate may be an interaction between embodiment and conformity, and future research should work to disentangle this relationship further.

My research focuses on the cognitive implications of team technology adaptation, but in order to fully understand team technology adaptation, it will be useful to investigate the evolution and development of behavioral processes and affective states as well. Although not a primary focus of this dissertation, results on communication behaviors suggest an important role in behavioral team processes in team technology adaptation. Recent work has also focused on affective responses to algorithmic integration in organizations and also details that need for further research on how negative perceptions of algorithms in organizations might be ameliorated (Kellogg, Valentine, & Christin, 2020). Although this dissertation laid out a strong case for the cognitive underpinnings of team technology adaptation, team technology adaptation is not only a cognitive process. There are likely both strong affective and behavioral components to successful team technology adaptation. Thus, future research should not only investigate the cognitive mechanisms in team technology adaptation, but also investigate affective states and behavioral processes. Another popular area of study is the issue of trust in human-agent collaboration. Teams are complex and the interdependencies among team members, coming into human-agent teams with varying levels of experience, comfort, and attitudes towards technology, and human-agent collaboration must be studied at the team level across affective states, behavioral processes, and cognitive processes to be fully understood and to set our organizational teams up for success.

Conclusion

Our organizations are becoming “smarter”, increasingly incorporating intelligent technologies in human teams as it benefits organizational efficiency and productivity. As we welcome these technologies to the team-centric workplace, it is critical that we understand how teams adapt to their new AI teammates. The review of the literature and proposed process model leverage existing theories of socialization and team effectiveness to build out concepts and theories that help anticipate how human teams will experience their collaboration with AI teammates. Further, the results of the experiment uncover a sine qua non of agent teammates - they cannot work effectively in teams without being strong task contributors. Though people are generally willing to have some team members serve in process facilitation or social roles on the team, this dissertation finds that people are only receptive to machines serving these roles to the extent that they first clear the task performance hurdle. This early discovery on human-AI teaming is consequential to many fields from computer science and human-computer interaction where AI is being conceived, to fields like organizational behavior and industrial/organizational psychology where their effects on work and workers are of paramount concern. This dissertation provides a new theoretical model and associated measures for the nascent and important field of human-AI teaming.

Table 1

Summary of Findings

Big Ideas
Newly developed dimensions of human-agent TMS predict team communication behaviors above and beyond the effects of TMS dimensions alone.
It is not the presence of teamwork, but rather the absence of taskwork that led to less positive processes and outcomes in human-agent teams.
When expectations of an agent teammate do not align with the realities of working with the agent teammate, team outcomes suffer.
Summary of Results
Teams performed better on problem-solving tasks when their AI teammate engaged in taskwork, compared to teams with an AI teammate that only engaged in teamwork only.
Teams reported less of a need to reevaluate and make changes to their TMS structures when their AI teammate engaged in teamwork only, compared to teams with an AI teammate that engaged in taskwork.
Teams with an AI teammate that engaged in teamwork only reported that they made fewer adjustments and engaged in reconstruction of their TMS structures to a lesser extent, compared to teams with an AI teammate that engaged in taskwork.
Group valence was lower towards AI teammates that engaged in teamwork only, compared to AI teammates that engaged in taskwork.
Teams rated their AI teammate lower in performance, agency, and/or expertise (their “team AI teammate schema”) when their AI teammate engaged only in teamwork, compared to AI teammates that engaged in taskwork.
Teams rated their AI teammate lower in specialization and credibility when their AI teammate engaged in teamwork only, compared to AI teammates that engaged in taskwork.
Team members used their technology expectancies, not their TMS, to inform the creation of their human-agent TMS prior to ever meeting the AI teammate.
“Established” TMS credibility was a significant and positive predictor of human-agent team cohesion and team viability.
Team members do not anticipate significant differences in TMS specialization when an agent newcomer is about to enter their team, but they do anticipate the AI teammate’s credibility will be lower than their ratings of their human team’s credibility. Similarly, team members

anticipate cognitive coordination in their human-agent team to be more difficult than in their human team. A team's valence towards their AI teammate influenced the development of their subsequent AI teammate schema regarding their AI teammate.
A team's developed AI teammate schema regarding their AI teammate affects a team's need to reevaluate their TMS structures to reincorporate the AI teammate more accurately. Expectations of the AI teammate do not influence a team's need to reevaluate TMS structures after the team has had a chance to work with the AI teammate.
The more teams communicated, the less they engaged in human-agent team dynamic restructuration.

Table 2

Conceptualization of Agent Teammate

Components related to "Agent"	Definition	Exemplar agent behaviors and interaction patterns
Intelligent	Agent displays behaviors indicative of human-like intelligence	Agent has answers or suggestions based on situational judgment to help team achieve goals
Agentic	Agent displays independence in its behaviors; the agent displays unique perspectives suggesting it is not simply carrying out the intentions of others	Agent speaks or does not speak when it chooses to; Agent plays devil's advocate or raises information that runs counter to the perspective expressed by another team member
Adaptive	Agent modifies behavior in response to changing task, team, and situational demands; agent behaviors reflect "learning" which enables the agent to react to new situations	Agent responds to human teammate questions or elaborates when the agent's information or suggestions are not understood
Components related to "Teammate"	**Definition**	**Exemplar agent behaviors and interaction patterns**
Interdependence	Agent performs work tasks that are mutually reliant on work tasks performed by teammates	Agent could not complete the task on its own - task must be completed/presented/communicated to others by humans; Agent doesn't have all answers, but has information that helps teams get to answers/solution
Intrinsically motivated to perform (goals)	Agent exhibits concern for quality and quantity of team output and engages in goal-directed behavior	Agent supplies answers or suggestions to help complete taskwork; contributes where needed
Social	Agent exhibits concern for constructive social interactions on the team; engages in behaviors that build personal and/or professional relationships with and between others on the team	Using human-like greetings: "hi", motivating others on their team with phrases like "great job team" to improve affective processes among team members

Table 3

Comparison of Team Technology Adaptation to Related Concepts

Components of the definition	Related Concept: Newcomer Socialization (Anderson & Thomas, 1995, p.5-6)	Related Concept: Technology Adoption (Sarker et al., 2005, p. 45)	New Concept: Team Technology Adaptation
Team member role	"...and the concurrent accommodation of the work group to the newcomer over time."	"Adoption decision regarding a certain technology…"	And the reciprocal team acquisition of knowledge, skills, and attitudes needed to create affective, behavioral, and cognitive space for the new AI teammate
Team member path	Via exposure to the newcomer	"... made collectively by the group through a process of communication and negotiation…"	Via team-level communication and negotiation
Newcomer role	"Newcomer acquisition of knowledge, skills, and attitudes needed to perform work role…"	(no change or learning done by technology)	AI teammate acquisition of knowledge, skills, and attitudes necessary for group collaboration
Newcomer path	"… via exposure to its norms, psychological climate, rituals and rites de passage..."	(no action made in technology adoption by technology)	Via iterative adjustments in response to team norms, climate, and interactions
Intended outcome for team members and newcomer	Resulting in 1) the assimilation of the newcomer into the group and 2) the reciprocal impact the newcomer has in changing group norms, climate, and structure	"...leading to some degree of consensus among members regarding the adoption decision"	Resulting in productive team processes and emergent states

Table 4

Key Ideas of Theoretical Background of Team Technology Adaptation

	Key ideas	Where concept falls short in socialization of technology as teammate
Newcomer Socialization	Newcomer adjustment, or onboarding, is primary focus of socialization (Bauer & Erdogan, 2011) There are two interdependent outcomes in work group socialization: 1) ***assimilation*** of newcomer into the group, and 2) the ***reciprocal impact*** the newcomer has in changing group norms, climate and structure. (Anderson & Thomas, 1995, p. 6)	- Implies a human newcomer - Technology teammate is focused more on learning effective team processes rather than effective work role skills and demands - Many studies focus on newcomer career goals, happiness, and satisfaction of newcomer, whereas technology teammate is not concerned with those outcomes yet - Iterative adjustment not accounted for by new type of teammate, only in humans - Focuses on adapting newcomer norms to the team whereas technology teammate will require more adaptation and learning on the part of the team than in situations with human as newcomer
Technology Adoption	Based on the Technology Acceptance Model (Sarker & Valacich, 2010) Based on two primary antecedents: 1) perceived usefulness and 2) perceived ease of use (Davis, 1989) These two antecedents affect intention to use the technology and overall usage behavior of the technology (Venkatesh & Davis, 2000)	- Does not assume agency in technology teammate; “adoption” implies that the humans have all the agency - Does not imply “relationship” between technology and human teammates - Technology teammate often enters team to aid or take over a particular role on the team which leaves human team members less choice in whether to adopt or not - Not studied thoroughly at the team level, but rather on a more dyadic level - Implies the decision to keep the technology on the team or not is made solely by the humans; no agency given to the technology

Table 5

Antecedents of Team Technology Adaptation

Antecedent Category	Example Antecedents with Citations
Newcomer characteristics	Information seeking behaviors (Bauer et al., 2007) Proactive behaviors (Kammeyer-Mueller, Wanberg, 2003; Morrison, 2003) Group perceptions of fit of technology with the group task (Sarker & Valecich, 2010) Pre-entry knowledge (Kammeyer-Mueller, Wanberg, 2003) Structural features and the spirit of the technology (Majchrzak, 2000; DeSanctis & Poole, 1994)
Team characteristics	Opinion of high status expert towards the technology (Sarker & Valecich, 2010) Leader facilitation of socialization (Kammeyer-Mueller, Wanberg, 2003) Team expectations of newcomer/newcomer performance (Chen & Klimoski, 2003) Co-worker facilitation of socialization (Kammeyer-Mueller, Wanberg, 2003; Moreland & Levine, 2001) Initial team performance (Chen, 2005) Team type: skill differentiation, authority differentiation, and temporal stability (Hollenbeck, Beersma, & Schouten, 2012)
Team task characteristics	Team task type: Execute, Negotiate, Generate, or Choose (McGrath, 1984) “Nature” of the task (Brown, Dennis, & Venkatesh, 2010)
Situational characteristics	Organizational socialization tactics (Bauer et al., 2007) Organizational efforts (Kammeyer-Mueller, Wanberg, 2003)

Table 6

Summary of Propositions from Stage Model of Team Technology Adaptation

Stage 1: Anticipation
1) Humans in agent newcomer teams require the development of unique dimensions of TMS that account for the agent's expertise and expertise utilization: 1) a Human-Agent TMS and 2) an Agent-Human TMS. 2) Human-Agent Team TMS is shaped by two primary factors: 1) prior incumbent team member TMS, and 2) incumbent expectations regarding the incoming agent teammate. 3) Humans expect high levels of expertise from an agent teammate and reconstruct their Human-Agent ***Team*** TMS such that the Team TMS is lower in specialization and credibility than it was prior to agent entry. 4) Team members report higher Human-Agent TMS specialization and credibility in a team with an agent newcomer compared to Human-Human TMS specialization and credibility in a team with a human newcomer. (*) 5) Human incumbents are more likely to expect agents to take on "missing" expertise. (*)
Stage 2: Evaluation
6) Human team members develop a group valence towards the agent team member via group-level communication and consensus-building. Group valence toward AI influences the development of team AI teammate schemas. 7) Team member AI teammate schemas regarding the new agent team member influence the evaluation of the TMS structure.
Stage 3: Reconstruction
8) Teams that identify a greater need to reevaluate their human-agent TMS will engage in more human-agent team dynamic restructuration. 9) Frequent communication will be positively related to human-agent team dynamic restructuration. 10) Teams that do not engage in human-agent team dynamic restructuration will experience TMS process inefficiencies.
Stage 4: Socialization
11) Human-agent team dynamic restructuration is the process through which TMS structure shapes team performance, TMS convergence, and appropriate TMS utilization in human-agent teams. 12) The relationship between TMS and human-agent team dynamic restructuration varies based on the function (taskwork vs. teamwork) of the AI teammate.

Note. * denotes that proposition was not tested in Study 2.

Table 7

Definitions of Focal Constructs and Definitions

Construct/Dimensions	Definition
Human-Agent TMS	Human teammate perceptions of TMS specialization and credibility regarding the agent team members.
Human-Agent Specialization	Human teammate perceptions of agent's differentiated knowledge structures.
Human-Agent Credibility	Human teammate perceptions of agent's reliability of knowledge.
Agent-Human TMS	Human teammate perceptions of agent's metaknowledge of team TMS specialization and credibility.
Agent-Human Specialization	Human teammate perceptions of agent's perceptions of the differentiated structures of team member knowledge.
Agent-Human Credibility	Human teammate perceptions of agent's perceptions of the other teammate's reliability of knowledge.
Human-Agent Team Dynamic Restructuration	Reconstruction of team TMS to accommodate a new agent teammate.
Group Valence toward AI	Group consensus regarding the degree of positive or negative feelings and attitudes toward an agent teammate.
AI Teammate Schema	The cognitive structures that team members build regarding the performance, agency, and expertise assumptions that a team member brings with them before they ever begin working on a team with an agent teammate.
Human-Agent TMS Evaluation	The extent to which team members feel they had to make team-level changes to team cognitive structures after working alongside an agent teammate.

Table 8

Summary of Scale Validation in Study 1

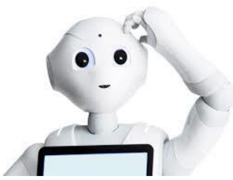
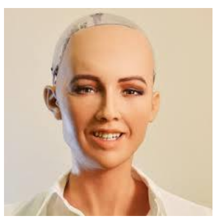
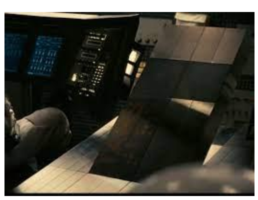
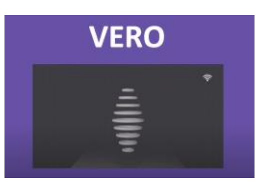
Scale	Initial Items Tested in Study 1	Final Items Selected from Study 1
Human-Agent TMS		
Human-Agent Specialization	1. Our agent team member has specialized knowledge of some aspect of our project. 2. Our agent team member has knowledge about an aspect of the project that no other team member has. 3. Our agent team member is responsible for expertise in different areas. 4. The specialized knowledge of our agent team member was needed to complete the project deliverables. 5. I know which expertise our agent team member has.	1. Our agent team member has specialized knowledge of some aspect of our project. 2. Our agent team member has knowledge about an aspect of the project that no other team member has. 3. Our agent team member is responsible for expertise in different areas. 4. The specialized knowledge of our agent team member was needed to complete the project deliverables. 5. I know which expertise our agent team member has.
Human-Agent Credibility	1. I and others were comfortable accepting procedural suggestions from an agent team member. 2. I and others trusted that agent team members' knowledge about the project was credible. 3. I and others were confident relying on the information that agent team members brought to the discussion. 4. When agent team members gave information, I and others wanted to double-check it for myself. (reversed) 5. I and others did not have much faith in agent team members' "expertise." (reversed)	1. I and others were comfortable accepting procedural suggestions from an agent team member. 2. I and others trusted that agent team members' knowledge about the project was credible. 3. I and others were confident relying on the information that agent team members brought to the discussion. 4. When agent team members gave information, I and others wanted to double-check it for myself. (reversed) 5. I and others did not have much faith in agent team members' "expertise." (reversed)
Agent-Human TMS		
Agent-Human Specialization	1. Agent team members understand that each team member has specialized knowledge of some aspect of our project. 2. Agent team members perceive that others on the team have knowledge about an aspect of the project that no other team member has. 3. Agent team members understand that different team members are responsible for expertise in different areas. 4. Agent team members perceived that specialized knowledge of several different team members was needed to complete the project deliverables. 5. Agent team members know which team members have expertise in specific areas.	1. Agent team members understand that each team member has specialized knowledge of some aspect of our project. 2. Agent team members perceive that others on the team have knowledge about an aspect of the project that no other team member has. 3. Agent team members understand that different team members are responsible for expertise in different areas. 4. Agent team members perceived that specialized knowledge of several different team members was needed to complete the project deliverables. 5. Agent team members know which team members have expertise in specific areas.
Agent-Human Credibility	1. Agent team members were comfortable accepting procedural suggestions from me and others. 2. Agent team members trusted my and others' knowledge about the project was credible. 3. Agent team members were confident relying on the information that me and others brought to the discussion. 4. When I and my teammates gave information, agent team members wanted to double-check it for themselves. (reversed) 5. Agent team members did not have much faith in my or others' "expertise."	1. Agent team members were comfortable accepting procedural suggestions from me and others. 2. Agent team members trusted my and others' knowledge about the project was credible. 3. Agent team members were confident relying on the information that me and others brought to the discussion. 4. When I and my teammates gave information, agent team members wanted to double-check it for themselves. (reversed) 5. Agent team members did not have much faith in my or others' "expertise."

	(reversed)	(reversed)
Human-Agent Team Dynamic Restructuration	1. Prompt myself and others to change our roles on the team. 2. Prompt myself and others to change our expertise. 3. Prompt some members to refocus their efforts. 4. Not change how we work together in any way. 5. Prompt me and others to allocate attention differently. 6. Prompt me to shift my attention. 7. Prompt me and others to play to different strengths. 8. Prompt me to work with my teammates differently. 9. Prompt my team to work more in sync with one another. 10. Prompt me and others to reconsider our strengths. 11. Prompt the team to rethink how we were doing things.	1. Prompted myself and others to change our roles on the team. 2. Prompted myself and others to change our expertise. 3. Prompted some members to refocus their efforts. 4. Did not change how we worked together in any way. 5. Prompted me and others to play to different strengths. 6. Prompted me to work with my teammates differently. 7. Prompted the team to rethink how we were doing things.
Group Valence toward AI	1. My team members would have a positive attitude towards the AI teammate. 2. The addition of an AI teammate would be a good thing for our team. 3. My team would believe the AI teammate would help us achieve our goals better than we would without the agent. 4. Our team would like an AI teammate. 5. I anticipate that the addition of an AI teammate would be looked on favorably by the team. 6. Adding an AI teammate would be beneficial to the team.	1. My team members had a positive attitude towards the AI teammate. 2. The AI teammate was a good thing for our team. 3. The AI teammate helped us achieve our goals. 4. The AI teammate was beneficial to the team.
AI Teammate Schema		
Performance	1. Adding this AI teammate to our team would improve our performance. 2. I anticipate having an AI teammate would be an asset to our team. 3. Adding an AI teammate to our team would improve our performance. 4. Our team performance would be enhanced by adding an AI teammate to the team. 5. I anticipate the AI teammate would improve our team performance. 6. I anticipate that our AI teammate would be a key contributor to our team. 7. An AI teammate would surely be a high performer.	1. The AI teammate improved our team performance. 2. The AI teammate was an asset to our team. 3. The AI teammate made no mistakes. 4. The AI teammate was a key contributor to our team. 5. The AI teammate was surely be a high performer
Agency	1. An AI teammate would surely be agentic. (reversed) 2. I anticipate that our AI teammate would act just as a person would (reversed) 3. Our team would use the AI teammate much like we would a calculator or computer. 4. I anticipate the AI teammate would function as a tool the team can use to complete our tasks. 5. I anticipate the AI teammate would make no mistakes. 6. Our team would need to get to know the AI teammate personally in order to be the best team we can be. 7. Adding an AI teammate would be similar to adding any sort of technology to our team, like a computer or a calculator.	1. The AI teammate was surely agentic. 2. The AI teammate acted just like a person. 3. Our team used the AI teammate much like we would a calculator or computer. 4. The AI teammate functioned like a tool our team could use to complete our tasks. 5. The AI teammate was similar to any other technology on our team.
Expertise	1. I anticipate an AI teammate would have expertise that my team members would not have. 2. I anticipate an AI teammate would be an expert at all aspects of the task.	1. The AI teammate had expertise that my team members did not have. 2. The AI teammate was more of a specialist in one or more parts of our task. 3. The AI teammate was more knowledgeable than myself and my teammates about

	3. I anticipate an AI teammate would be an expert in just one part of the task. (reversed) 4. An AI teammate would be more knowledgeable than myself and my teammates about the task(s) at hand. 5. An AI teammate would surely be an expert in our team tasks. 6. Adding an AI teammate would improve the overall expertise of our team. 7. Our collective expertise would improve with the addition of an AI teammate.	the task(s) at hand. 4. The AI teammate was surely an expert in all aspects of our team tasks. 5. The AI teammate improved the collective expertise on our team.
Human-Agent TMS Evaluation	1. Working with the AI would require us to develop different kinds of expertise. 2. Working with the AI would require us to change our expectations of how to work together. 3. We would easily be able to incorporate the AI into our team. 4. Our expectations about the AI's capability would be right on target. 5. We would form accurate expectations of the AI's functionality. 6. Our understanding of the AI's expertise would be correct. 7. Our expectations of the AI would probably be pretty far off from what it actually does. 8. We would likely expect the AI to function differently than it does. 9. Our perception of the AI's expertise would probably be incorrect.	1. We were easily able to incorporate the AI teammate onto our team. 2. Our expectations about the AI teammate's capabilities were right on target. 3. We formed accurate expectations of the AI teammate's functionality. 4. Our understanding of the AI teammate's expertise was correct. 5. Our expectations of the AI teammate were pretty far off from what it actually does. 6. We expected the AI teammate to function differently than it does. 7. Our perception of the AI teammate's expertise was incorrect.

Table 9

Summary of Study 1 Vignettes

AI Teammate	Image of AI Teammate	Link to Video in Vignette
Pepper		https://youtu.be/zJHyaD1psMc
IBM Watson		https://youtu.be/P18EdAKuC1U
Sophia		https://youtu.be/cJpZJgVnm6Y
CASE (*Interstellar*)		https://youtu.be/0pT6tJnsVhE
TARS (*Interstellar*)		Video 1: https://youtu.be/6b-O6zlIkA4 Video 2: https://youtu.be/p3PfKf0ndik
K-2SO (Star Wars)		Video 1: https://youtu.be/C4qw0T8O3eI Video 2: https://youtu.be/M8ALlOI8hI0?t=165
Vero		https://www.youtube.com/watch?v=9vE8tmD_f88&t=2s

Rove		https://www.youtube.com/watch?v=ok043XCl3DM

Table 10

Internal Consistency Reliabilities for New Scales from MTurk Scale Validation

	Original Items			Items selected from pilot results		
Variable	Items	alpha	Average r	Items	alpha	Average r
Human-Agent TMS	10	-	-	10	0.92	0.45
Human-Agent Specialization	5	-	-	5	0.85	0.54
Human-Agent Credibility	5	-	-	5	0.81	0.47
Agent-Human TMS	10	-	-	10	0.85	0.37
Agent-Human Specialization	5	-	-	5	0.89	0.62
Agent-Human Credibility	5	-	-	5	0.69	0.31
Human-Agent Team Dynamic Restructuration	11	0.92	0.51	7	0.88	0.51
Group Valence toward AI	6	0.97	0.82	4	0.95	0.81
AI Teammate Schema	21	0.94	0.43	15	0.90	0.37
Performance	7	0.98	0.86	5	0.92	0.69
Agency	7	0.64	0.21	5	0.59	0.24
Expertise	7	0.86	0.46	5	0.77	0.39
Human-Agent TMS Evaluation	9	0.70	0.21	7	0.77	0.32

Note: “Average R” represents the Average Inter-Item Correlation of each scale at each timepoint in the scale development effort. N = 365 MTurk workers, with the exception of Human-Agent TMS Evaluation, which had an N of 364 because one participant experienced technical difficulties for that page of the survey.

Table 11

Summary of Study 2 Data Collection

Time	What	Procedure	Hypotheses	Variables collected
Time 0	Pre-measures survey	~ 1 week prior to session, participants complete pre-survey individually from home	-	Individual performance
Time 1	Round 1 Team Tasks: Humans only team	Participants randomly assigned to 2 or 3 person teams; work in humans-only team	5, 7	Communication frequency Team performance
	Post Round 1 Survey	Participants complete short survey individually	1, 2, 3, 9	TMS
Time 2	Vero Introduction & Survey	Participants watch Vero Introduction video; complete short survey individually	1, 2, 3, 5, 8	Human-agent team dynamic restructuration Human-Agent Team TMS Incumbent technology expectancies
Time 3	Round 2 Team Tasks: Human-Agent team	Teams work together with same humans as before, add Vero to complete Round 2	7	Communication frequency Team performance
	Post Round 2 Survey	Participants complete short survey individually	4, 6, 8, 9, 10	Human-agent team dynamic restructuration Human-Agent TMS evaluation Group valence toward AI
Time 4	Round 3 Team Tasks: Human-Agent team	Teams work together in same teams as Round 2 to complete Round 3	1, 7, 9	Communication frequency Team performance
	Post Round 3 Survey/ End-of-Task Survey	Participants complete survey individually	1, 4, 5, 6, 7, 8, 9, 10	Human-agent team dynamic restructuration Human-Agent TMS evaluation AI Teammate Schema Human-Agent Team TMS TMS convergence TMS utilization Team viability Team cohesion

Table 12

Descriptive Statistics for Key Study Variables

Variable	Mean	SD	Valid N	Minimum	Maximum
Time 0					
Ind Problem solving 1 *	49.80	11.66	147	16.00	84.00
Ind Problem solving 2 *	69.42	13.36	146	22.00	100.00
Ind Problem solving 3 *	70.35	17.63	147	24.00	191.00
Ind Creativity 1					
Fluency *	10.07	4.30	147	2.00	23.00
Flexibility *	8.50	3.28	147	2.00	18.00
Novelty *	0.98	0.01	147	0.96	0.99
Ind Creativity 2					
Fluency *	9.97	4.90	147	2.00	31.00
Flexibility *	8.50	3.71	147	2.00	23.00
Novelty *	0.98	0.01	147	0.93	0.99
Ind Creativity 3					
Fluency *	8.52	3.92	147	2.00	23.00
Flexibility *	7.24	3.04	147	2.00	19.00
Novelty *	0.97	0.01	147	0.93	0.99

Time 1					
Team problem solving performance 1	39.83	9.62	63	16.00	58.00
Team creativity performance 1					
Fluency	36.15	9.72	63	15.00	63.00
Flexibility	22.32	4.01	63	10.00	31.00
Novelty	0.99	0.001	63	0.98	0.99
TMS *	3.89	0.54	149	1.73	4.93
Specialization *	3.29	0.85	149	1.20	5.00
Credibility *	4.15	0.61	149	1.40	5.00
Coordination *	4.24	0.69	149	1.00	5.00
Time 2					
Human-agent team dynamic restructuration	3.26	0.49	63	2.14	4.43
Human-Agent Team Coordination	3.37	0.37	63	2.40	4.20
Human-Agent TMS					
H-A Specialization	3.36	0.37	63	2.40	4.60
H-A Credibility	3.74	0.39	63	2.75	4.50
Agent-Human TMS					
A-H Specialization	3.22	0.56	63	1.90	4.00
A-H Credibility	3.32	0.48	63	1.62	4.25

Incumbent technology expectancies *	3.66	0.56	149	1.00	5.00
Time 3					
Team problem solving performance 2	50.48	20.28	63	16.00	100.00
Team creativity performance 2					
Fluency	37.22	9.93	63	16.00	60.00
Flexibility	24.38	4.96	63	13.00	36.00
Novelty	0.99	0.002	63	0.98	0.99
Human-agent team dynamic restructuration	3.14	0.58	63	2.00	4.00
Group valence toward AI	3.74	0.77	63	2.00	5.00
Time 4					
Team problem solving performance 3	53.59	19.51	63	20.00	96.00
Team creativity performance 3					
Fluency	34.97	9.68	63	12.00	67.00
Flexibility	22.71	4.76	63	9.00	34.00
Novelty	0.99	0.002	63	0.98	0.99
Human-agent team dynamic restructuration	3.13	0.67	63	1.14	4.43
Human-Agent Team Coordination	3.64	0.58	63	2.20	4.50
Human-Agent TMS					
H-A Specialization	3.42	0.80	63	1.20	5.00

H-A Credibility	3.75	0.64	63	2.00	4.88
Agent-Human TMS					
A-H Specialization	3.00	0.68	63	1.53	4.60
A-H Credibility	3.67	0.48	63	2.58	4.50
Human-agent TMS evaluation	3.15	0.65	63	1.57	4.36
AI teammate schema	3.58	0.72	63	1.70	4.90
TMS convergence	3.83	0.41	63	2.67	4.62
TMS utilization	3.87	0.54	63	2.58	4.75

Note. * denotes variable descriptives reported at individual level because variable is tested within hypotheses at individual level. All other variables reported and tested at the team level.

Table 13

Median Within-Team Agreement and Reliability of Aggregated Study Variables

	Time 2			Time 3			Time 4		
Variable	$r_{wg(j)}$	*ICC1*	*ICC2*	$r_{wg(j)}$	*ICC1*	*ICC2*	$r_{wg(j)}$	*ICC1*	*ICC2*
H-A Team TMS	0.96	0.01	0.01				0.95	0.34	0.55
H-A Coordination	0.91	<0.01	<0.01				0.81	0.17	0.33
H-A TMS	0.94	0.02	0.04				0.93	0.41	0.62
H-A Specialization	0.88	0.07	0.15	-	-	-	0.88	0.38	0.59
H-A Credibility	0.91	<0.01	<0.01	-	-	-	0.88	0.35	0.56
A-H TMS	0.95	<0.01	0.01				0.93	0.13	0.26
A-H Specialization	0.93	0.12	0.25	-	-	-	0.90	0.14	0.28
A-H Credibility	0.88	<0.01	<0.01	-	-	-	0.84	0.03	0.06
AI Teammate Schema	0.96	0.04	0.09	-	-	-	0.94	0.48	0.69
Human-Agent TMS Evaluation	0.95	<0.01	<0.01	0.90	0.26	0.46	0.90	0.32	0.52
Human-Agent Team Dynamic Restructuration	0.93	0.15	0.29	0.84	0.04	0.10	0.86	0.13	0.26
Group Valence toward AI	-	-	-	0.92	0.42	0.63	-	-	-
TMS Convergence	-	-	-	-	-	-	0.92	<0.01	<0.01
Established									

TMS	0.96	0.14	0.28	-	-	-	0.95	0.11	0.22
Team Process	0.92	0.04	0.08	0.91	<0.01	<0.01	0.90	0.01	0.03
Team Cohesion	0.97	0.01	0.03	0.97	<0.01	0.01	0.97	0.01	0.03
Team Potency	0.84	0.09	0.19	0.90	0.07	0.15	0.87	0.07	0.15
Team Viability	0.80	0.15	0.29	0.80	0.02	0.05	0.85	0.02	0.05
TMS Utilization	-	-	-	-	-	-	0.87	0.05	0.11

Note. “H-A” = “Human-Agent”. “A-H” = “Agent-Human”. “Human-Agent Team TMS” was an aggregation of H-A Team Coordination, H-A Specialization, and H-A Credibility, aggregated for the purposes of Hypothesis 1. Otherwise, the aggregation of Human-Agent TMS was used, which was the aggregation of human-agent specialization and human-agent credibility.

Table 14

Internal Consistency Reliabilities for New Scales from Study 2

		Original items collected in Study 2 Time 2		Original items collected in Study 2 Time 4			Final items selected for testing Time 2		Final items selected for testing Time 3		Final items selected for testing Time 4	
Variable	Items	alpha	Average r	alpha	Average r	Items	alpha	Average r	alpha	Average r	alpha	Average r
Human-Agent Team TMS	15	0.84	0.27	0.90	0.37	14	0.84	0.28	-	-	0.91	0.41
Human-Agent Team Coordination	5	-	-	-	-	5	0.74	0.37	-	-	0.79	0.44
Human-Agent TMS	10	0.82	0.33	0.88	0.43	9	0.82	0.34	-	-	0.91	0.52
Human-Agent Specialization	5	-	-	-	-	5	0.77	0.41	-	-	0.90	0.64
Human-Agent Credibility	5	0.78	0.44	0.74	0.37	4	0.77	0.47	-	-	0.82	0.54
Agent-Human TMS	10	0.85	0.36	0.84	0.35	9	0.86	0.40	-	-	0.87	0.43
Agent-Human Specialization	5	-	-	-	-	5	0.88	0.59	-	-	0.91	0.68
Agent-Human Credibility	5	0.80	0.44	0.64	0.28	4	0.82	0.53	-	-	0.76	0.45
Human-Agent Team Dynamic Restructuration	7	-	-	-	-	7	0.83	0.42	-	-	0.90	0.57
Group Valence toward AI	4	-	-	-	-	4	-	-	0.91	0.71	-	-
AI Teammate Schema	15	0.86	0.31	0.92	0.42	10	0.84	0.37	-	-	0.90	0.48
Performance	5	0.85	0.55	0.90	0.64	4	0.80	0.52	-	-	0.86	0.59
Agency	5	0.45	0.14	0.59	0.23	3	0.66	0.40	-	-	0.68	0.42
Expertise	5	0.82	0.48	0.87	0.57	3	0.81	0.59	-	-	0.81	0.58
Human-Agent TMS Evaluation	7	-	-	-	-	7	0.83	0.41	-	-	0.89	0.54
TMS Convergence	4	-	-	-	-	4	-	-	-	-	0.86	0.60

Note: “Average R” represents the Average Inter-Item Correlation of each scale at each timepoint in the scale development effort. N = 149 participants. “Human-Agent Team TMS” was an aggregation of H-A Team Coordination, H-A Specialization, and H-A Credibility, aggregated for the purposes of Hypothesis 1. Otherwise, the aggregation of Human-Agent TMS was used, which was the aggregation of human-agent specialization and human-agent credibility.

Also, AI teammate schema was used as a single construct rather than a construct with 3 dimensions because of a lack of statistical support for dimensions. Internal consistencies for the dimensions of AI teammate schema are presented for consistency, but are not used in any analyses as dimensions, but rather are aggregated into a single AI teammate schema score.

Table 15

Correlations of New Constructs with Themselves over Time

	Correlation of construct at Time 2 with itself at Time 3	Correlation of construct at Time 2 with itself at Time 4	Correlation of construct at Time 3 with itself at Time 4
Human-Agent TMS	-	0.28 ***	-
H-A Specialization	-	0.29 ***	-
H-A Credibility	-	0.29 ***	-
Agent-Human TMS	-	0.46 ***	-
A-H Specialization	-	0.50 ***	-
A-H Credibility	-	0.35 ***	-
AI Teammate Schema	-	0.23 **	-
Human-Agent TMS Evaluation	0.25 **	0.23 ***	0.80 ***
Human-Agent Team Dynamic Restructuration	0.07	0.12	0.76 ***

Note. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 16

Means, standard deviations, and correlations of TMS and H-A TMS Dimensions at Time 2 and Time 4

			Time 2								Time 4					
Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Time 2																
1. Specialization	3.29	0.85														
2. Credibility	4.15	0.61	0.30**													
3. Coordination	4.24	0.69	0.17*	0.68**												
4. H-A Coordination	3.39	0.60	0.07	0.07	0.14											
5. H-A Specialization	3.34	0.68	0.37**	0.16*	0.06	0.29**										
6. H-A Credibility	3.61	0.63	0.01	0.24**	0.16	0.46**	0.44**									
7. A-H Credibility	3.14	0.67	0.15	0.28**	0.24**	0.37**	0.02	0.23**								
8. A-H Specialization	3.19	0.75	0.36**	0.11	0.04	0.30**	0.40**	0.14	0.38**							
Time 4																
9. Specialization	3.55	0.78	0.72**	0.31**	0.27**	0.10	0.41**	0.07	0.10	0.38**						
10. Credibility	4.11	0.60	0.22**	0.68**	0.52**	0.19*	0.14	0.25**	0.21*	-0.02	0.27**					
11. H-A Coordination	3.64	0.83	0.09	0.33**	0.33**	0.30**	0.06	0.22**	0.13	0.06	0.21*	0.40**				
12. H-A Specialization	3.37	1.00	0.29**	0.11	0.04	0.21*	0.29**	0.16	0.14	0.39**	0.46**	0.13	0.48**			
13. H-A Credibility	3.66	0.74	0.09	0.20*	0.12	0.23**	0.13	0.29**	0.22**	0.22**	0.21*	0.38**	0.55**	0.61**		
14. A-H Credibility	3.60	0.63	0.08	0.40**	0.32**	0.38**	0.17*	0.32**	0.35**	0.23**	0.16	0.40**	0.51**	0.33**	0.59**	
15. A-H Specialization	2.92	0.90	0.36**	0.19*	0.14	0.16	0.40**	0.20*	0.17*	0.50**	0.49**	0.08	0.11	0.32**	0.29**	0.34**

Note. *M* and *SD* are used to represent mean and standard deviation, respectively. * indicates $p < .05$. ** indicates $p < .01$.

Table 17

Correlation table of new constructs and established constructs over time

	Time 2					Time 3				Time 4					
New Variables	TMS	Team Process	Team Cohesion	Team Potency	Team Viability	Team Process	Team Cohesion	Team Potency	Team Viability	TMS	Team Process	Team Cohesion	Team Potency	Team Viability	TMS Utilization
Time 2															
H-A Coordination	0.12	0.14	.17*	.24**	.17*	0.14	.28**	.33**	.22**	.27**	0.11	.25**	.28**	.24**	.23**
H-A Specialization	.28**	.17*	0.14	.23**	0.15	.17*	0.16	.16*	0.14	.28**	.18*	0.13	0.14	0.13	.33**
H-A Credibility	.16*	0.06	.19*	0.06	.22**	0.16	.26**	0.1	.30**	.24**	0.11	.22**	0.01	.22**	0.12
A-H Credibility	.29**	.30**	.21*	.32**	.19*	.24**	.16*	.29**	.16*	.20*	.26**	.18*	.24**	.22**	.17*
A-H Specialization	.25**	.21**	0	.25**	0.11	.18*	0.09	0.15	0	.21*	.23**	0.02	0.15	0.05	.26**
H-A TMS	.34**	.27**	.21*	.34**	.25**	.27**	.28**	.31**	.24**	.36**	.27**	.23**	.24**	.25**	.34**
AI Teammate Schema	.29**	.16*	.25**	0.14	.22**	.22**	.23**	0.14	.22**	.32**	.22**	.20*	0.13	0.14	.31**
H-A TMS Evaluation	.29**	.32**	.30**	.36**	.23**	.33**	.44**	.44**	.24**	.39**	.31**	.35**	.40**	.31**	.28**
H-A Team Dynamic Restructuration	0.1	0.01	0.06	0.08	0.03	-0.01	-0.02	0.12	0.03	0.1	0.02	-0.03	0.07	-0.07	0.11
Time 3															
H-A TMS Evaluation	0.05	0.14	0.07	0.08	0.1	.28**	0.15	.18*	0.13	.33**	0.14	0.11	.17*	0.13	0.07
H-A Team Dynamic Restructuration	0.07	0.06	0.01	0.08	-0.03	0.1	0.04	0.02	-0.1	.21*	0.09	-0.06	0.05	-0.07	0.11
Group Valence toward AI	0.1	0.1	0.04	0.01	0.05	.35**	.25**	.20*	0.13	.43**	0.13	0.07	0.1	0.07	0.12
Time 4															
H-A Specialization	.21*	0.12	0.04	0.08	0.15	.19*	.16*	0.13	0.11	.52**	0.05	0.07	0.09	0.09	.28**
H-A Credibility	.17*	.17*	0.16	0.05	0.12	.30**	.31**	.19*	.17*	.53**	0.13	.24**	0.13	0.15	0.13
A-H Credibility	.33**	.35**	.28**	.23**	.26**	.37**	.33**	.23**	.29**	.49**	.33**	.32**	.25**	.31**	.31**

A-H Specialization	.32**	.28**	0.02	.26**	.17*	.25**	0.06	0.12	0.03	.33**	.29**	0.05	.17*	0.05	.42**
AI Teammate Schema	0.07	0.08	0	-0.05	0.05	.24**	.20*	0.13	.19*	.41**	0.06	0.08	0.08	0.12	0.11
H-A TMS Evaluation	0.1	.23**	0.15	0.09	0.13	.36**	.26**	.16*	.22**	.46**	.18*	.18*	.17*	.20*	0.08
H-A Team Dynamic Restructuration	0.01	0.07	-0.09	0.04	-0.04	0.1	-0.02	-0.01	-0.04	.19*	0.09	-0.12	0.02	-0.06	0.16
TMS Convergence	.63**	.54**	.50**	.60**	.55**	.47**	.50**	.58**	.47**	.61**	.54**	.46**	.61**	.50**	.69**

Note. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 18

Mean AI Teammate Function Manipulation Check Scores

Taskwork Function Manipulation Check		
	Overall	N
Taskwork only	4.10 (0.09)	52
Teamwork only	2.83 (0.13)	48
Combined	4.31 (0.09)	49
Teamwork Function Manipulation Check		
	Overall	N
Taskwork only	2.01 (0.12)	52
Teamwork only	3.66 (0.13)	48
Combined	3.82 (0.14)	49

Standard errors presented in parentheses.

Table 19

Analysis of Variance for AI Teammate Function Manipulation Check

	df	Sum Sq	Mean Sq	F-value	P
DV = Taskwork Score					
Condition	2	62.59	31.29	59.73	<.001 ***
Residuals	146	76.50	0.52		
DV = Teamwork Score					
Condition	2	101.5	50.76	60.94	<.001 ***
Residuals	146	121.6	0.83		

Note. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 20

AI Teammate Believability Response Frequencies

	Taskwork		Teamwork		Combined		**Total**	
	N	%	N	%	N	%	**N**	**%**
Based on your interactions with Vero, Vero behaved more like a:								
Human	6	11.54	4	8.33	10	20.83	**20**	**13.42**
Technology	46	88.46	44	91.67	38	79.17	**129**	**86.58**
Total	**52**	**100.00**	**48**	**100.00**	**48**	**100.00**	**149**	**100.00**
Based on your interactions with Vero today, you would say Vero is most likely:								
A human posing as an AI teammate.	1	1.92	1	2.08	4	8.33	**7**	**4.70**
A robot posing as an AI teammate, but is not actually "artificially intelligent".	10	19.23	10	20.83	5	10.42	**25**	**16.78**
An artificially intelligent teammate designed to help teams.	16	30.77	20	41.67	24	50.00	**60**	**40.27**
A "smart" chatbot, like those you interact with on organizational websites.	25	48.08	17	35.42	14	29.17	**56**	**37.58**
Other.	0	0.00	0	0.00	1	2.08	**1**	**0.67**
Total	**52**	**100.00**	**48**	**100.00**	**48**	**100.00**	**149**	**100.00**
Based on your interactions with Vero today, Vero was most likely a:								
Human	2	3.85	3	6.25	5	10.42	**10**	**6.71**
Technology	50	96.15	45	93.75	43	89.58	**139**	**93.29**
Total	**52**	**100.00**	**48**	**100.00**	**48**	**100.00**	**149**	**100.00**

Note. N=149 participants. Numbers in columns underneath condition and % symbol represent marginal percentages - the percentage of responses that fell within that response for that particular condition.

Table 21

Analysis of Variance for Study Variables Based on AI Teammate Function

Variable (DV)	*Time 2*	*Time 3*	*Time 4*
<u>New Constructs</u>	*F(2,60)*	*F(2,60)*	*F(2,60)*
Human-Agent TMS	**0.27**	**-**	**12.67 *****
H-A Specialization	0.48	-	11.73 ***
H-A Credibility	0.28	-	7.80 ***
Agent-Human Team TMS	**0.28**	**-**	**0.52**
A-H Credibility	0.14	-	1.06
A-H Specialization	0.82	-	0.82
Human-Agent Team Coordination	0.01		5.09 **
AI Teammate Schema	0.44	-	28.77 ***
Human-Agent TMS Evaluation	0.21	24.16 ***	13.68 ***
Human-Agent Team Dynamic Restructuration	0.41	3.92 *	2.23
TMS Convergence	-	-	0.02
Group Valence toward AI	-	23.62 ***	-
<u>Established Constructs</u>	*F(2,60)*	*F(2,60)*	*F(2,60)*
TMS	1.05	-	-
TMS - Coordination	1.22	-	-

TMS - Credibility	0.73	-	0.02
TMS - Specialization	0.85	-	0.22
Team Process	0.15	1.37	0.71
Team Cohesion	1.05	0.03	0.49
Team Potency	2.12	0.28	0.50
Team Viability	0.69	0.21	1.36
TMS Utilization	-	-	0.32
Communication	$F(2,59)$	$F(2,59)$	$F(2,59)$
Total words spoken	-	2.25	4.47 *
Average human words spoken	0.49	1.50	1.81
Vero words spoken	-	4.06 *	8.25 ***
Team Performance	$F(2,62)$	$F(2,62)$	$F(2,62)$
Aggregated team performance	1.06	10.04 ***	10.49 ***
Creativity	1.03	0.57	1.02
Problem-solving	1.63	22.49 ***	27.63 ***

Note. TMS Coordination was not measured at Time 4, only Human-Agent Team TMS Coordination. Thus, there is no F test for TMS Coordination or TMS at Time 4. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, $^{\cdot}p < 0.1$

Table 22

Results of Post-Hoc Tukey HSD Tests for all Variables with Significant ANOVA Results in Table 21

Variable (DV)	*Mean Difference*	*SE*	*t value*	*p value*
<u>Time 3</u>				
Aggregated Performance				
2-1	-1.54	-2.07	-1.00	<0.01 ***
3-1	-0.17	-0.70	0.35	0.71
3-2	1.37	0.82	1.91	<0.01 ***
Problem-solving Performance				
2-1	-1.53	0.23	-6.60	<0.01 ***
3-1	-0.48	0.23	-2.05	0.11
3-2	1.06	0.24	4.40	<0.01 ***
Vero words spoken				
2-1	-101.87	-492.63	288.88	0.81
3-1	331.48	-32.85	695.80	0.08
3-2	433.35	38.85	827.86	0.03 *
Human-Agent TMS Evaluation				
2-1	-0.82	0.14	-5.79	<0.01***
3-1	0.10	0.14	0.71	0.76
3-2	0.92	0.15	6.29	<0.01***
Human-Agent Team Dynamic				
Restructuration	-0.042	0.17	-2.48	0.04*
2-1	<0.01	0.17	<0.01	1.00
3-1	0.42	0.17	2.40	0.05 .
3-2				
Group Valence toward AI				
2-1	-1.13	0.18	-6.27	<0.01***
3-1	-0.07	0.18	-0.42	0.91
3-2	1.05	0.19	5.66	<0.01***
<u>Time 4</u>				

Aggregated Performance				
2-1	-0.89	-1.36	-0.41	<0.001***
3-1	-0.25	-0.72	0.21	0.38
3-2	0.63	0.15	1.11	<0.01 **
Problem-solving Performance				
2-1	-1.54	0.22	-6.85	<0.01***
3-1	-0.12	0.22	-0.54	0.85
3-2	1.42	0.23	6.10	<0.01***
Total words spoken				
2-1	-126.95	-828.91	575.00	0.90
3-1	663.10	8.61	1317.58	0.05 *
3-2	790.05	81.35	1498.75	0.03 *
Vero words spoken				
2-1	-138.88	-417.29	139.53	0.46
3-1	313.83	54.24	573.41	0.01 *
3-2	452.71	171.62	733.80	<0.01 ***
Human-Agent TMS Evaluation				
2-1	-0.78	0.17	-4.68	<0.01***
3-1	-0.02	0.17	-0.11	0.99
3-2	0.76	0.17	4.42	<0.01***
AI Teammate Schema				
2-1	-1.06	0.16	-6.67	<0.01***
3-1	0.02	0.16	0.10	0.99
3-2	1.08	0.16	6.55	<0.01***
Human-Agent TMS				
2-1	-0.78	-1.20	-0.36	<0.01***
3-1	-0.004	-0.42	0.42	1.00
3-2	0.78	0.34	1.21	<0.01***
H-A Specialization				
2-1	-0.93	0.21	-4.40	<0.01***
3-1	-0.06	0.21	-0.26	0.96
3-2	0.87	0.22	4.00	<0.01***

H-A Credibility				
2-1	-0.59	-1.02	-0.16	<0.01***
3-1	0.06	-0.37	0.49	0.94
3-2	0.65	0.21	1.10	<0.01**
Human-Agent Team Coordination				
2-1	-0.51	0.17	-3.06	0.01**
3-1	-0.10	0.17	-0.62	0.81
3-2	0.41	0.17	2.35	0.06 ·

Note. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, · $p < 0.1$

Table 23

Hypothesis 1a: Hierarchical Linear Regression Testing for Incremental Validity of Communication at Time 4 on Dimensions of TMS

	Dependent variable = Communication at Time 4	
	(1) TMS Model	(2) New Dimensions of TMS
Constant	-929.79 (464.88)	-1,705.25 (1,066.42)
Taskwork Condition (Taskwork = 1, Others = 0)	8.48 (215.41)	-133.26 (255.19)
Combined Condition (Combined = 1, Others = 0)	370.01 (217.82)	290.62 (247.74)
Team Size	323.12 (178.03)	371.01* (168.63)
TMS specialization	-176.98 (172.09)	283.66 (217.18)
TMS credibility	120.35 (230.67)	-192.39 (263.52)
H-A specialization		-252.92 (165.21)
H-A credibility		397.17 (219.53)
A-H specialization		-426.33* (185.70)
A-H credibility		-206.66 (261.66)
Observations	62	62
R^2	0.15	0.34
Adjusted R^2	0.07	0.22
F Statistic	1.94 (df = 5; 56)	2.91** (df = 9; 52)
ΔR^2		0.19 *

Note: Standard error presented in parentheses after each effect estimate. All variables grand mean centered. *p<0.05; **p<0.01; ***p<0.001

Table 24

Hypothesis 1b: Hierarchical Linear Regression Testing for Incremental Validity of Viability at Time 4 on Dimensions of TMS

	Dependent variable = Team Viability at Time 4	
	(1) TMS Model	(2) New Dimensions of TMS
Constant	0.16 (0.14)	-0.51 (0.96)
Taskwork Condition (Taskwork = 1, Others = 0)	-0.16 (0.19)	-0.10 (0.25)
Combined Condition (Combined = 1, Others = 0)	-0.29 (0.20)	-0.24 (0.24)
TMS specialization	0.15 (0.15)	0.31 (0.22)
TMS credibility	0.86^{***} (0.21)	0.72^{*} (0.27)
H-A specialization		-0.12 (0.17)
H-A credibility		-0.04 (0.21)
A-H specialization		-0.14 (0.18)
A-H credibility		0.21 (0.26)
Observations	65	65
R^2	0.28	0.30
Adjusted R^2	0.23	0.20
F Statistic	5.81^{***} (df = 4; 60)	2.96^{**} (df = 8; 56)
ΔR^2		0.02

Note: Standard error presented in parentheses after each effect estimate. All variables grand mean centered. $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 25

Hypothesis 1c: Hierarchical Linear Regression Testing for Incremental Validity of Cohesion at Time 4 on Dimensions of TMS

	Dependent variable = Team Cohesion at Time 4	
	(1) TMS Model	(2) New Dimensions of TMS
Constant	0.06 (0.07)	-0.53 (0.47)
Taskwork Condition (Taskwork = 1, Others = 0)	-0.05 (0.10)	-0.13 (0.12)
Combined Condition (Combined = 1, Others = 0)	-0.10 (0.10)	-0.18 (0.12)
TMS specialization	0.02 (0.08)	0.09 (0.11)
TMS credibility	0.65^{***} (0.11)	0.53^{***} (0.13)
H-A specialization		-0.01 (0.08)
H-A credibility		0.06 (0.10)
A-H specialization		-0.12 (0.09)
A-H credibility		0.11 (0.13)
Observations	65	65
R^2	0.41	0.44
Adjusted R^2	0.37	0.36
F Statistic	10.58^{***} (df = 4; 60)	5.50^{***} (df = 8; 56)
ΔR^2		0.03

Note: Standard error presented in parentheses after each effect estimate. All variables grand mean centered. $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 26

Hypothesis 1d: Hierarchical Linear Regression Testing for Incremental Validity of Performance at Time 4 on Dimensions of TMS

	Dependent variable = Team Performance at Time 4	
	(1) TMS Model	(2) New Dimensions of TMS
Constant	-0.57*** (0.14)	-0.54 (0.95)
Taskwork Condition (Taskwork = 1, Others = 0)	0.92*** (0.20)	0.68** (0.25)
Combined Condition (Combined = 1, Others = 0)	0.67** (0.20)	0.49* (0.24)
TMS specialization	-0.24 (0.16)	-0.15 (0.22)
TMS credibility	0.30 (0.22)	0.23 (0.27)
H-A specialization		0.23 (0.17)
H-A credibility		-0.14 (0.21)
A-H specialization		-0.32 (0.18)
A-H credibility		0.17 (0.26)
Observations	65	65
R^2	0.29	0.35
Adjusted R^2	0.25	0.25
F Statistic	6.21*** (df = 4; 60)	3.71** (df = 8; 56)
ΔR^2		0.06

Note: Standard error presented in parentheses after each effect estimate. All variables grand mean centered. $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 27

Hypothesis 2: Hierarchical Linear Regression of Transactive Memory Systems and Incumbent Technology Expectancies on Human-Agent Transactive Memory Systems

	Dependent variable = Human-Agent TMS at Time 2	
	Intercept Model	Main Effects
	(0)	(1)
Constant	0.001 (0.04)	0.01 (0.03)
TMS at Time 1		-0.07 (0.08)
Incumbent Technology Expectancies at Time 2		0.58*** (0.09)
Observations	65	65
R^2	0.00	0.42
Adjusted R^2	0.00	0.40
F Statistic		22.35^{***} (df = 2; 62)

Note: Standard error presented in parentheses after each effect estimate. All variables grand mean centered. $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 28

Hypothesis 3: Paired Samples T-test to Compare Specialization and Credibility to Human-Agent Specialization and Credibility

	TMS (Time 1)		Human-Agent TMS (Time 2)				
	M	SD	M	SD	t(148)	V	p
Specialization	3.29	0.85	3.34	0.68	-0.75	-	0.77
Credibility	4.15	0.61	3.61	0.63	-	7572	<0.01 ***
Coordination	4.24	0.69	3.39	0.60	-	9440	<0.01 ***

Note. N = 149. Specialization and Credibility were hypothesized to be greater than H-A TMS Specialization and Credibility, so a directional test was used. Coordination was added post-hoc, so a non-directional test was used. $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 29

Hypothesis 4: Results of Hierarchical Linear Regression Analyses for AI Teammate Schema on Group Valence toward AI

	Dependent variable = Team AI Teammate Schema at Time 4		
	Control model	Main Effects	Interaction
	(0)	(1)	(2)
Constant	-0.73^{***} (0.12)	-0.26^{*} (0.10)	-0.24 (0.12)
Taskwork Condition (Taskwork = 1, Others = 0)	1.06^{***} (0.16)	0.35^{*} (0.14)	0.36^{*} (0.16)
Combined Condition (Combined = 1, Others = 0)	1.06^{***} (0.16)	0.40^{**} (0.14)	0.38^{*} (0.15)
Group Valence at Time 3		0.63^{***} (0.08)	0.65^{***} (0.12)
Group Valence * Taskwork Condition			-0.09 (0.22)
Group Valence * Combined Condition			-0.0002 (0.18)
Observations	65	65	65
R^2	0.48	0.75	0.75
Adjusted R^2	0.47	0.73	0.73
F Statistic	28.99^{***} (df = 2; 62)	60.11^{***} (df = 3; 61)	35.03^{***} (df = 5; 59)

Note: Standard error presented in parentheses after each effect estimate. All variables grand mean centered. $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 30

Hypothesis 5: Hierarchical Linear Regression Results for Human-Agent Transactive Memory System Evaluation at Time 4 on AI Teammate Schema

	Dependent variable = TMS Evaluation at Time 4		
	Control Model	Main Effect at Time 2	Main Effect at Time 4
	(0)	(1a)	(1b)
Constant	-0.53*** (0.12)	-0.54*** (0.12)	-0.02 (0.12)
Taskwork Condition (Taskwork = 1, Others = 0)	0.78*** (0.17)	0.79*** (0.17)	0.04 (0.17)
Combined Condition (Combined = 1, Others = 0)	0.78*** (0.17)	0.81*** (0.17)	0.04 (0.17)
AI Teammate Schema (T2)		0.22 (0.19)	-
AI Teammate Schema (T4)		-	0.70*** (0.10)
Observations	65	65	65
R^2	0.31	0.33	0.61
Adjusted R^2	0.29	0.30	0.59
F Statistic	14.14*** (df = 2; 62)	9.93*** (df = 3; 61)	32.33*** (df = 3; 61)

Note: Standard error presented in parentheses after each effect estimate. All variables grand mean centered. *p<0.05; **p<0.01; ***p<0.001

Table 31

Hypothesis 6: Hierarchical Linear Regression Results for Transactive Memory System Evaluation on Human-Agent Team Dynamic Restructuration at Time 4

	Dependent variable = Dynamic Restructuration at Time 4		
	Control Model (0)	Main Effect at Time 3 (1a)	Main Effect at Time 4 (1b)
Constant	-0.25 (0.15)	-0.01 (0.17)	-0.03 (0.16)
Taskwork Condition (Taskwork = 1, Others = 0)	0.31 (0.20)	-0.02 (0.24)	-0.01 (0.22)
Combined Condition (Combined = 1, Others = 0)	0.42^{*} (0.20)	0.06 (0.25)	0.10 (0.22)
TMS Evaluation (T3)	-	0.41^{*} (0.17)	-
TMS Evaluation (T4)	-	-	0.42^{**} (0.14)
Observations	65	65	65
R^2	0.07	0.15	0.18
Adjusted R^2	0.04	0.11	0.14
F Statistic	2.37 (df = 2; 62)	3.61^{*} (df = 3; 61)	4.61^{**} (df = 3; 61)

Note: Standard error presented in parentheses after each effect estimate. All variables grand mean centered. $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 32

Hypothesis 7: Results of Linear Regression Analysis for Human-Agent Team Dynamic Restructuration on Word Total

	Dependent variable = Dynamic Restructuration at Time 4	
	Control Model	Main Effect
	(0)	(1)
Constant	0.57 (0.42)	0.16 (0.46)
Taskwork Condition (Taskwork = 1, Others = 0)	0.37 · (0.20)	0.39* (0.20)
Combined Condition (Combined = 1, Others = 0)	0.47* (0.20)	0.55** (0.20)
Team size	-0.35* (0.16)	-0.20 (0.17)
Communication (total word count)		-0.0001* (<0.01)
Observations	62	62
R^2	0.16	0.21
Adjusted R^2	0.11	0.16
F Statistic	3.63* (df = 3; 58)	3.87** (df = 4; 57)

Note: Standard error presented in parentheses after each effect estimate. All variables grand mean centered. $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 33

Hypothesis 8: Results of Linear Regression Analyses for Human-Agent Team Dynamic Restructuration on Transactive Memory System Utilization at all Time Points

	Dependent variable = TMS Utilization at Time 4		
	Main Effect at Time 2	Main Effect at Time 3	Main Effect at Time 4
	(1a)	(1b)	(1c)
Constant	0.06 (0.12)	0.11 (0.12)	0.10 (0.12)
Taskwork Condition (Taskwork = 1, Others = 0)	-0.13 (0.16)	-0.21 (0.17)	-0.18 (0.16)
Combined Condition (Combined = 1, Others = 0)	-0.03 (0.17)	-0.10 (0.17)	-0.10 (0.17)
Dynamic Restructuration Time 2	0.01 (0.14)		
Dynamic Restructuration Time 3		0.18 (0.12)	
Dynamic Restructuration Time 4			0.18 (0.10)
Observations	65	65	65
R^2	0.01	0.05	0.06
Adjusted R^2	-0.04	-0.001	0.01
F Statistic	0.23	0.98	1.21

Note: Standard error presented in parentheses after each effect estimate. All variables grand mean centered. $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 34

Hypothesis 9a: Mediation model for Team Performance

IV = TMS at Time 1; Mediator = Dynamic Restructuration at Time 3; DV = Team Performance at Time 4

Analysis/Variable	Estimate	SE	t	p
Step 1: Total Effect of IV on DV				
Constant	<0.01	0.09	-0.04	0.97
TMS at Time 1	-0.43	0.24	-1.83	0.07 ·
Step 2: Effect of IV on mediator				
Constant	<0.01	0.07	<0.01	1.00
TMS at Time 1	-0.06	0.19	-0.30	0.76
Step 3: Effect of mediator and IV on DV				
Constant	<0.01	0.09	-0.05	0.96
TMS at Time 1	-0.41	0.23	-1.80	0.08 ·
Dynamic Restructuration at Time 3	0.36	0.15	2.36	0.02 *
Step 4: Causal Mediation Analysis	Estimate			p
ACME	-0.02			0.82
ADE	-0.40			0.09 ·
Total Effect	-0.41			0.10 ·
Proposed Mediation	0.03			0.81

Note. N = 63 teams. *All variables grand mean centered.* $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 35

Hypothesis 9b: Mediation model for Transactive Memory System Convergence

IV = TMS at Time 1; Mediator = Dynamic Restructuration at Time 3; DV = TMS Convergence at Time 4				
Analysis/Variable	Estimate	SE	t	p
Step 1: Total Effect of IV on DV	<0.01	0.04	<0.01	1.00
Constant	0.65	0.11	6.05	<0.01 ***
TMS at Time 1				
Step 2: Effect of IV on mediator	<0.01	0.07	<0.01	1.00
Constant	-0.06	0.19	-0.30	0.76
TMS at Time 1				
Step 3: Effect of mediator and IV on DV				
Constant	<0.01	0.04	<0.01	1.00
TMS at Time 1	0.66	0.11	6.17	<0.01 ***
Dynamic Restructuration at Time 4	0.11	0.07	1.50	0.14
Step 4: Causal Mediation Analysis	Estimate			p
ACME	<0.01			0.80
ADE	0.66			<0.01 ***
Total Effect	0.65			<0.01 ***
Proposed Mediation	<0.01			0.80

Note. N = 63 teams. *All variables grand mean centered.* $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 36

Hypothesis 9c: Mediation model for Transactive Memory System Utilization

IV = TMS at Time 1; Mediator = Dynamic Restructuration at Time 3; DV = TMS Utilization at Time 4				
Analysis/Variable	Estimate	SE	t	p
Step 1: Total Effect of IV on DV				
Constant	<0.01	0.06	<0.01	1.00
TMS at Time 1	0.78	0.15	5.30	<0.01 ***
Step 2: Effect of IV on mediator				
Constant	<0.01	0.07	<0.01	1.00
TMS at Time 1	-0.06	0.19	-0.30	0.76
Step 3: Effect of mediator and IV on DV				
Constant	<0.01	0.06	<0.01	1.00
TMS at Time 1	0.78	0.14	5.43	<0.01 ***
Dynamic Restructuration at Time 4	0.16	0.10	1.65	0.11
Step 4: Causal Mediation Analysis	Estimate			p
ACME	-0.01			0.79
ADE	0.79			<0.01 ***
Total Effect	0.78			<0.01 ***
Proposed Mediation	-0.01			0.79

Note. N = 63 teams. *All variables grand mean centered.* $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 37

Hypothesis 10: Hierarchical Linear Regression for Moderation of Manipulation Regressing Human-Agent Team Dynamic Restructuration on Human-Agent Team Transactive Memory System

	Dependent variable = Dynamic Restructuration at Time 3		
	Control	Main Effect	Main Effect + Moderation
	(0)	(1)	(2)
Constant	-0.28* (0.12)	-0.29* (0.12)	-0.29* (0.13)
Taskwork Condition (Taskwork = 1, Others = 0)	0.42* (0.17)	0.42* (0.17)	0.42* (0.17)
Combined Condition (Combined = 1, Others = 0)	0.42* (0.17)	0.43* (0.17)	0.43* (0.18)
Human-Agent Team TMS at Time 2		0.22 (0.21)	0.07 (0.41)
H-A Team TMS * Taskwork Condition			0.10 (0.52)
H-A Team TMS * Combined Condition			0.38 (0.58)
Observations	65	65	65
R^2	0.12	0.13	0.14
Adjusted R^2	0.09	0.09	0.07
F Statistic	4.09* (df = 2; 62)	3.10* (df = 3; 61)	1.90 (df = 5; 59)

Note: Standard error presented in parentheses after each effect estimate. All variables grand mean centered. *$p<0.05$; **$p<0.01$; ***$p<0.001$

Table 38

Human-Agent Team Transactive Memory System Reconceptualization

	Human perspective (Extension of TMS developed in this dissertation)	Agent perspective (Extension of TMS for future research)
Direct knowledge	HA-TMS (human-perspective): Human teammate perceptions of human-agent TMS (i.e., how people think about the team TMS) Example item: “I know which expertise our agent team member has.”	HA-TMS (agent-perspective): Agent teammate perceptions of human-agent TMS (i.e., how agents think about the team TMS) Example item: “I know which expertise our human team member has.”
Meta-knowledge	HA-TMS meta-knowledge (human-perspective): A human teammate’s perception of their agent teammates’ perceptions of human-agent TMS (i.e., how people think agents think about the team TMS) Example item: “Agent team members know which team members have expertise in specific areas.”	HA-TMS meta-knowledge (agent-perspective): An agent teammate’s perception of their human teammates’ perceptions of human-agent TMS (i.e., how agents think humans think about the team TMS) Example item: “Human team members know which team members have expertise in specific areas.”

Figure 1. Current Examples of AI Machines in 2021

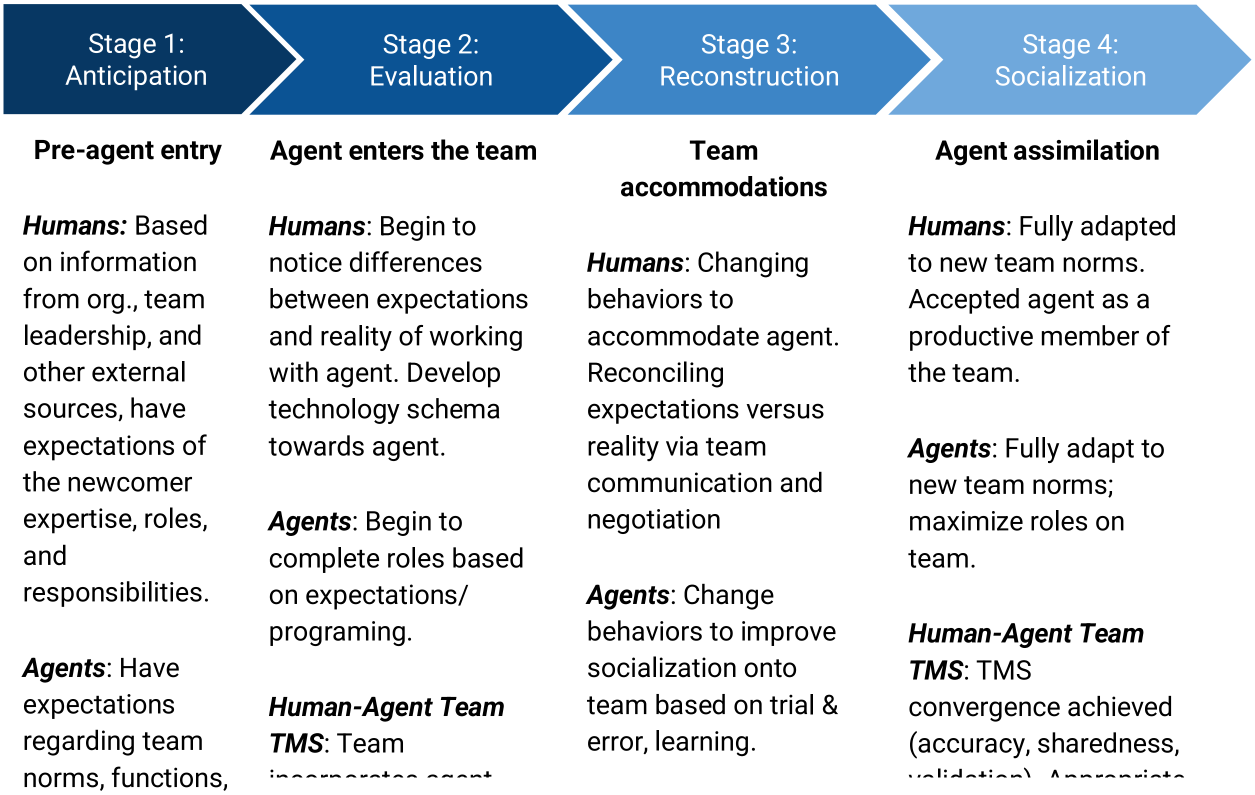


Figure 2. Stage Model of Team Technology Adaptation

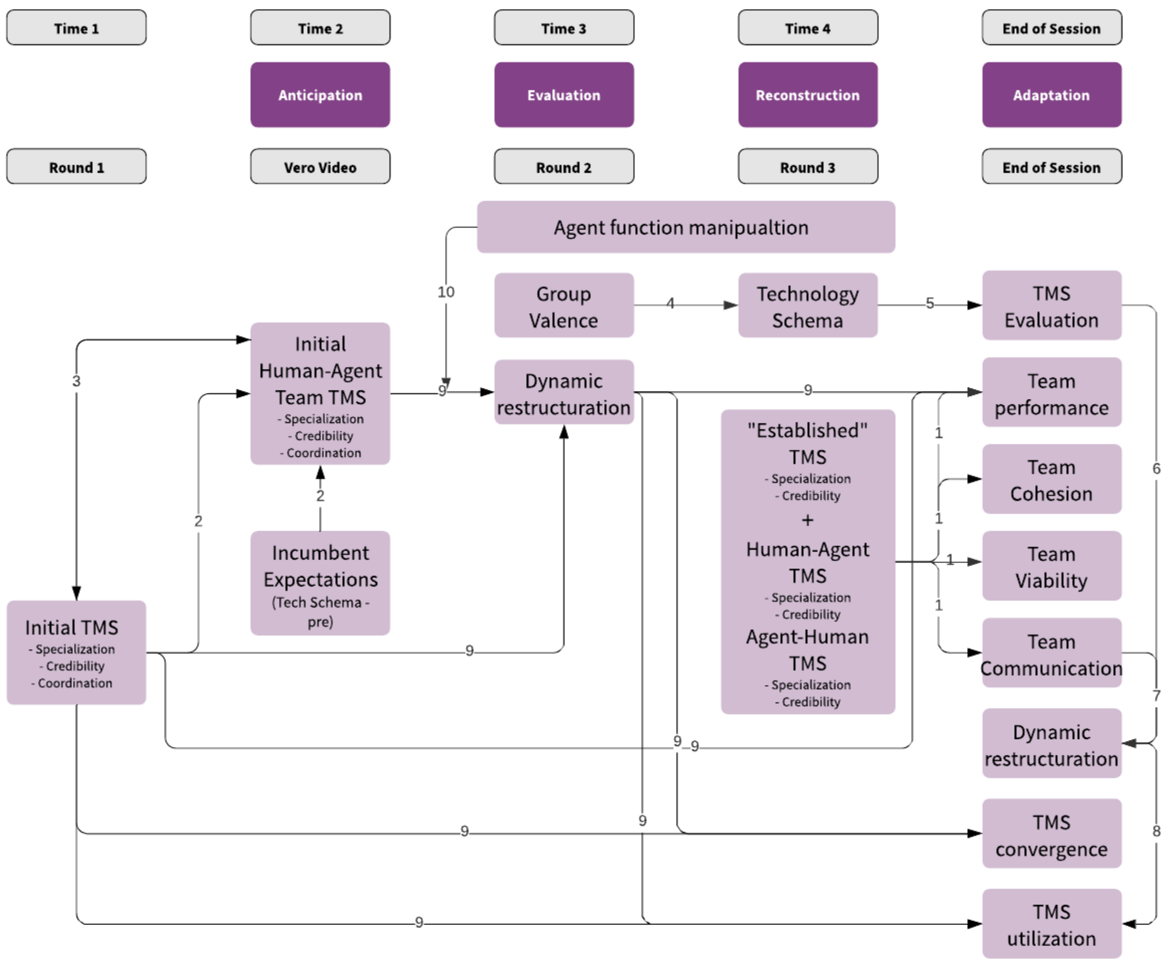


Figure 3. Model of Hypothesized Relationships

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Appendix A1. Survival Task Round 1

Citation: Hall, J., & Watson, W. H. (1970). The effects of a normative intervention on group decision-making performance. *Human Relations, 23*, 299–317.

You are a member of a space crew originally scheduled to rendezvous with a mother ship on the lighted surface of the moon. However, due to mechanical difficulties, your ship was forced to land at a spot some 200 miles from the rendezvous point. During reentry and landing, much of the equipment aboard was damaged and, since survival depends on reaching the mother ship, the most critical items available must be chosen for the 200-mile trip.

Below are listed the 15 items left intact and undamaged after landing. Your task is to rank order them in terms of their importance for your crew in allowing them to reach the rendezvous point. Place the number 1 by the most important item, the number 2 by the second most important, and so on through number 15 for the least important.

You may assume:
The number of crew members is the same as the number on your team
You are the actual people in the situation
The team has agreed to stick together
All items are in good condition

Rankings: Place the number 1 by the most important item, the number 2 by the second most important, and so on through number 15 for the least important.

___ Box of matches
___ Food concentrate
___ 50 feet of nylon rope
___ Parachute silk
___ Portable heating unit
___ Two .45 caliber pistols
___ One case of dehydrated milk
___ Two 100 lb. tanks of oxygen
___ Stellar map
___ Self-inflating life raft
___ Magnetic compass
___ 5 gallons of water
___ Signal flares
___ First aid kit, including an injection needle
___ Solar-powered FM receiver-transmitter

Appendix A2. Creativity Task Round 1

For the next 5 minutes, work independently to brainstorm as many possible uses for this common household item - a brick - as you can. Once the 5 minutes are up, you will come together with the rest of the group, and you will now have 10 minutes to discuss your ideas and then come up with as many ADDITIONAL uses that were not included in your individual lists for your group list.

Appendix A3. Survival Task Round 2

Adapted from: Official United States Air Force (2016). Teambuilder: "LOST AT SEA". Retrieved from https://www.airman.af.mil/Portals/17/002%20All%20Products/003%20PACEsetters/Teambuilder_LOST_AT_SEA.pdf?ver=2016-11-02-111101-433

You and your team have chartered a yacht. None of you have any previous sailing experience, and you have hired an experienced skipper and two-person crew. As you sail through the Southern Pacific Ocean a fire breaks out and much of the yacht and its contents are destroyed. The yacht is slowly sinking. Your location is unclear because vital navigational and radio equipment has been damaged. The yacht skipper and crew have been lost whilst trying to fight the fire. Your best guess is that you are approximately 1000 miles South West of the nearest landfall. You have salvaged a four man rubber life craft. The total contents of your combined pockets amounts to a packet of cigarettes, three boxes of matches and three $5 notes. You and your friends have managed to save 15 additional items, undamaged and intact.

Below are listed the 15 items left intact and undamaged after landing. Your task is to rank order them in terms of their importance for your crew in allowing them to reach the rendezvous point. Place the number 1 by the most important item, the number 2 by the second most important, and so on through number 15 for the least important.

You may assume:
The number of crew members is the same as the number on your team
You are the actual people in the situation
The team has agreed to stick together
All items are in good condition

Rankings Place the number 1 by the most important item, the number 2 by the second most important, and so on through number 15 for the least important.

___ A sextant
___ A shaving mirror
___ A quantity of mosquito netting
___ A 5 gallon can of water
___ A case of army rations
___ Maps of the Pacific Ocean
___ A floating seat cushion
___ A 2 gallon can of oil/petrol mixture
___ A small transistor radio
___ 20 square feet of Opaque plastic sheeting
___ Shark repellent
___ One quart of 160 percent proof rum
___ 15 ft nylon rope
___ 2 boxes of chocolate bars
___ A fishing kit

Appendix A4. Creativity Task Round 2

For the next 5 minutes, work independently to brainstorm as many possible uses for this common household item - a paperclip - as you can. Once the 5 minutes are up, you will come together with the rest of the group, and you will now have 10 minutes to discuss your ideas and then come up with as many ADDITIONAL uses that were not included in your individual lists for your group list.

Appendix A5. Survival Task Round 3

Adapted from: Kagan, S. (1989). *Cooperative learning: Resources for teachers.* Printing and Reprographics, University of California, Riverside.

It is approximately 10:00 A.M. in mid August and you have just crash landed in the Sonora Desert in southwestern United States. The light twin engine plane, containing the bodies of the pilot and co-pilot, has completely burned. Only the airplane frame remains. None of the rest of you have been injured.The pilot was unable to notify anyone of your position before the crash. However he had indicated before impact that you were 70 miles south-southwest from a mining camp which is the nearest known habitation, and that you were approximately 65 miles off the course that was filed in your VFR Flight plan.The immediate area is quite flat and rather barren, except for an occasional barrel and saguaro cacti. The last weather report indicated that the temperature would reach 110 degrees that day, which means that the temperature at ground level will be 130 degrees. You are dressed in light weight clothing—short sleeved shirts, pants, socks, and street shoes, everyone has a handkerchief.

Before the plane caught fire your group was able to salvage the 15 items listed on the following sheet. Your task is to rank these items according to their importance to your survival, starting with "1" the most important, to "15" the least important.

You may assume:

1. The number of survivors is the same as the number in your group.
2. You are the actual people in the situation.
3. The group has agreed to stick together.
4. All items are in good condition.

Rankings: Place the number 1 by the most important item, the number 2 by the second most important, and so on through number 15 for the least important.

___ A flashlight (4 battery size)
___ A jackknife
___ A sectional air map of the area
___ A plastic raincoat (large size)
___ A magnetic compass
___ A compress kit with gauze
___ A .45 caliber pistol (loaded)
___ A parachute (red & white)
___ A bottle of 1,000 salt tablets
___ 1 quart of water per person
___ A book (Edible Animals of the Desert)
___ A pair of sunglasses per person
___ 2 quarts of 80 proof vodka
___ 1 top coat per person
___ A cosmetic mirror

Appendix A6. Creativity Task Round 3

For the next 5 minutes, work independently to brainstorm as many possible uses for this common household item - a rubber band - as you can. Once the 5 minutes are up, you will come together with the rest of the group, and you will now have 10 minutes to discuss your ideas and then come up with as many ADDITIONAL uses that were not included in your individual lists for your group list.

Appendix B1. Transactive Memory Systems (TMS)

From Lewis (2003) Transactive Memory System Scale

All items use a 5-point disagree–agree response format, in which 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

Specialization
1. Each team member has specialized knowledge of some aspect of our project.
2. I have knowledge about an aspect of the project that no other team member has.
3. Different team members are responsible for expertise in different areas.
4. The specialized knowledge of several different team members was needed to complete the project deliverables.
5. I know which team members have expertise in specific areas.

Credibility
1. I was comfortable accepting procedural suggestions from other team members.
2. I trusted that other members' knowledge about the project was credible.
3. I was confident relying on the information that other team members brought to the discussion.
4. When other members gave information, I wanted to double-check it for myself. (reversed)
5. I did not have much faith in other members' "expertise." (reversed)

Coordination
1. Our team worked together in a well-coordinated fashion.
2. Our team had very few misunderstandings about what to do.
3. Our team needed to backtrack and start over a lot. (reversed)
4. We accomplished the task smoothly and efficiently.
5. There was much confusion about how we would accomplish the task. (reversed)

Appendix B2. Human-Agent Team Transactive Memory Systems (TMS)

All items use a 5-point disagree–agree response format, in which 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

Dimension: Human-Agent TMS (Human perceptions of agent in the TMS)
Specialization

1. Our agent team member has specialized knowledge of some aspect of our project.
2. Our agent team member has knowledge about an aspect of the project that no other team member has.
3. Our agent team member is responsible for expertise in different areas.
4. The specialized knowledge of our agent team member was needed to complete the project deliverables.
5. I know which expertise our agent team member has.

Credibility

1. I and others were comfortable accepting procedural suggestions from an agent team member.
2. I and others trusted that agent team members' knowledge about the project was credible.
3. I and others were confident relying on the information that agent team members brought to the discussion.
4. I and others did not have much faith in agent team members' "expertise." (reversed)

Dimension: Agent-Human TMS (Human perceptions of agent metaknowledge)
Specialization

1. Agent team members understand that each team member has specialized knowledge of some aspect of our project.
2. Agent team members perceive that others on the team have knowledge about an aspect of the project that no other team member has.
3. Agent team members understand that different team members are responsible for expertise in different areas.
4. Agent team members perceived that specialized knowledge of several different team members was needed to complete the project deliverables.
5. Agent team members know which team members have expertise in specific areas.

Credibility

1. Agent team members were comfortable accepting procedural suggestions from me and others.
2. Agent team members trusted my and others' knowledge about the project was credible.
3. Agent team members were confident relying on the information that me and others brought to the discussion.
4. Agent team members did not have much faith in my or others' "expertise." (reversed)

Dimension: Human-Agent Team Coordination (Lewis (2003) "Coordination" items replacing "team" with "human-agent team")

1. Our human-agent team worked together in a well-coordinated fashion.
2. Our human-agent team had very few misunderstandings about what to do.
3. Our human-agent team needed to backtrack and start over a lot. (reversed)

4. Our human-agent team accomplished the task smoothly and efficiently.
5. There was much confusion about how our human-agent team would accomplish the task. (reversed)

Appendix B3. Incumbent Team Member Expectations of Agent

All items use a 5-point disagree–agree response format, in which 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

Performance

- The AI teammate will improve our team performance.
- The AI teammate will be an asset to our team.
- The AI teammate will be a key contributor to our team.
- The AI teammate will surely be a high performer

Agency

- Our team will use the AI teammate much like we would a calculator or computer.
- The AI teammate will function like a tool our team can use to complete our tasks.
- The AI teammate will be similar to any other technology on our team.

Expertise

- The AI teammate will have expertise that my team members will not have.
- The AI teammate will be more of a specialist in one or more parts of our task.
- The AI teammate will improve the collective expertise on our team.

Appendix B4. Group Valence toward AI

All items use a 5-point disagree–agree response format, in which 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

- My team members had a positive attitude towards the AI teammate.
- The AI teammate was a good thing for our team.
- The AI teammate helped us achieve our goals.
- The AI teammate was beneficial to the team.

Appendix B5. AI Teammate Schema

All items use a 5-point disagree–agree response format, in which 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

Performance

- The AI teammate improved our team performance.
- The AI teammate was an asset to our team.
- The AI teammate was a key contributor to our team.
- The AI teammate was surely be a high performer

Agency

- Our team used the AI teammate much like we would a calculator or computer.
- The AI teammate functioned like a tool our team could use to complete our tasks.
- The AI teammate was similar to any other technology on our team.

Expertise

- The AI teammate had expertise that my team members did not have.
- The AI teammate was more of a specialist in one or more parts of our task.
- The AI teammate improved the collective expertise on our team.

Appendix B6. Human-Agent Transactive Memory Systems (TMS) Evaluation

All items use a 5-point disagree–agree response format, in which 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

- We were easily able to incorporate the AI teammate onto our team.
- Our expectations about the AI teammate's capabilities were right on target.
- We formed accurate expectations of the AI teammate's functionality.
- Our understanding of the AI teammate's expertise was correct.
- Our expectations of the AI teammate were pretty far off from what it actually does. (reversed)
- We expected the AI teammate to function differently than it does. (reversed)
- Our perception of the AI teammate's expertise was incorrect. (reversed)

Appendix B7. Human-Agent Team Dynamic Restructuration

Please rate the extent to which you agree to each of the following statements. All items use a 5-point disagree–agree response format, in which 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

Having agent team members __________.

1. Prompted myself and others to change our roles on the team.
2. Prompted myself and others to change our expertise.
3. Prompted some members to refocus their efforts.
4. Did not change how we worked together in any way. (reversed)
5. Prompted me and others to play to different strengths.
6. Prompted me to work with my teammates differently.
7. Prompted the team to rethink how we were doing things.

Appendix B8. Transactive Memory System (TMS) Convergence

(Based on Brandon & Hollingshead, 2004).

All items use a 5-point disagree–agree response format, in which 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

Please rate the extent to which you agree with the following statements regarding your team (human and agent team members):

- My perceptions about my team member’s different expertises were accurate.
- My team was able to recognize each member’s expertise.
- My beliefs about the distribution of knowledge in the group were shared by all members.
- All team members were on the same page about who had what knowledge on the team.

Appendix B9. Transactive Memory System (TMS) Utilization

(From Sherf et al., 2018)

All items use a 5-point disagree–agree response format, in which 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

- We made use of each other's expertise during project work.
- We asked the experts in our group to share and explain their thoughts on the project work.
- We leveraged each other's expertise to make decisions.
- We relied on each other's expertise to divide up our project work.

Appendix B10. AI Teammate Function - Manipulation Check

All items use a 5-point disagree–agree response format, in which 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

"Please rate the extent to which you agree with the following statements about your AI teammate, Vero.

The AI teammate _______________.”

Taskwork Items:

- Provided information
- Contributed ideas to our team tasks
- Contributed expertise relevant to team tasks
- Completed tasks relevant to the team goals
- Provided analytical expertise

Teamwork Items:

- Suggested ways for our team to work together
- Provided ideas for how we should interact
- Helped our team stay motivated and engaged
- Helped us create a plan for how to accomplish our goals
- Tracked our team's progress in accomplishing our goals

Appendix C1. AI Teammate "Vero" Script: Taskwork Only Condition

Taskwork only Condition

Vero Checklist

Before the Session

1. Set up Vero on your browser. (instructions link) [Update to new vero (with WIFI icon) if you haven't already]
2. Switch off text and message notifications on your laptop that might make noise during the session.
3. Cover your camera; Video is **on with Vero background to "Default - Floating" at first.**
4. **Change your Zoom profile picture on Zoom to the Vero picture here.**
5. **Change your Zoom profile name to "Vero #" (go here for you Vero # and condition assignment)**
6. **Make sure different Vero signal backgrounds are working properly.**
7. **Mute yourself, and use spacebar (hold down) when you want to talk.**
8. Remember: do **not** chat in Zoom - use the Teams chat to communicate.
9. Stay on mute outside of tasks, only communicate with your team during tasks.

During the Session

10. Get on Teams chat at ______ **central** (end time ____ central). Zoom link will be provided in Teams chat.
11. Study team will assign Veros to respective breakout rooms and send timing announcements.
12. Have fun!

After the Session

13. Remove the Vero identity from your Zoom account so others don't find out! (Remove Vero background, remove Vero picture, and change your Zoom name back to your own name)
14. Complete the post session survey to record your Vero data and give quick session feedback here.

Tips and Tricks

- Keep a cool head! Participants might ask questions that you don't know the answer to, but don't let that frazzle you. You can always give yourself a moment to find a piece of information by using one of the canned responses in your script. If you don't have the answer to a question they ask, just say "I'm sorry, I'm not sure about that."
- Participants might ask you to calculate probabilities and find other information that they assume a computer might have. Just tell them "That is not in my database" or another appropriate canned response.

Taskwork only Condition

- Try to avoid using sounds like “um” and clearing your throat as much as you can
- Participants might be sort of...mean. They don’t know that they’re talking to another person, and so they might treat you differently than they would if they could see your face. Don’t take it personally- it has nothing to do with you!

Vero Animations Guide:

1. Use the Default Floating Animation when you are on standby/listening to your teammates.
2. Use the Want to Speak Animation when you have something to say and want your teammates to let you speak.
3. Use the Speaking Animation while you are speaking.
4. Use the Wave Animation at the beginning or end of an activity, either to greet yourself or say goodbye.
5. Use the Nodding Animation when you are acknowledging or agreeing with something that your teammate has said.
6. When you get the chance to speak, make sure to change your animation to the speaking animation and immediately turn it off after you are finished speaking. Switch animation, unmute, immediately switch back.

Vero Rules

1. **NEVER go off script** - if the participants ask you something you don’t have the answer to, you can say “I’m sorry, I’m not sure about that.” If it sounds like something that is an easy question that you could answer, but is not in your script, you can say “I’m sorry, that is not in my database.”
2. **Use the “7 rule”** - when you have something to say, be sure to signal with the “want to speak” background. Then, count to 7. If the team does not ask you to speak/share your thoughts, then instead switch to “speaking” animation and being speaking. (We do not want you all to never speak because your team was ignoring your animations)
3. **You MUST use a sturdy camera cover** so that we do not have any issues with backlighting, etc., which could ruin the deception.
4. **You MUST do a tech check** with the tech team prior to your scheduled sessions (background check, clear audio check, internet speed check, move into and out of breakout room to be sure your background consistently works)
5. **Pay attention to your team’s conversation** - we want you to seem like a “smart” AI… this requires using all of your human brain power and contributing to the fullest of your abilities in terms of adeptly using your animations and contributing statements/information whenever possible! Be sure to follow the conversation. If in a teamwork condition, be sure to take note of items or ideas that spark disagreement to reference later on.

Taskwork only Condition

Human-Agent Teaming Round 1 (This will be participant's Round 2)

Initial Greeting Script (say all of this below)

Hello team. I am Vero. Let me introduce myself. I am your synthetic teammate. I'll be listening and participating just like a human team member during each of the tasks we will work on together today. You may ask me questions, and I will try to answer them to the best of my programming. Know that you can trust me and the information I provide - I may not always have the exact answers to everything you are looking for, but I will never try to mislead you. If I do not know something, I will let you know.

Today, I can help you in a number of ways. I am a task expert - I have some expertise on parts of the tasks that you can ask me about or that I will offer up as necessary to help the team. Ok, I'm ready to get started on the Survival Task.

Survival Task 1 - Lost at Sea

General Q&A of potential questions

- *"Vero, help us!" or "Vero, what's going on here?"*, say…
  - **What would you like to know? Remember, I am a task expert which means I have expertise on parts of the task.**
- *When you need some time to find the response*, say…
  - **Let me think about that for a second...**
- *When the ask is out of the realm of its expertise*, say…
  - **I'm sorry, I'm not sure about that. Try asking me about my thoughts on particular items or if I have an idea I'd like to share.**
- *If asked an off topic/computational question say...*
  - **That is not in my database. Try asking me about my thoughts on particular items or if I have an idea I'd like to share.**
- *If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:*
  - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.
- *If you misspeak and need to correct yourself to your team, you may say…*

- **Sorry team. I think I misunderstood you. What I meant to say was ________.**

Round 1 Survive: Large Information Bank (use this when relevant/requested)

Item	Response to Preference Question	Definition	Example usefulness
A sextant	I think this item is ***one of the least*** important.	A sextant is an instrument with a graduated arc of 60° and a sighting mechanism, used for measuring the angular distances between objects and for taking altitudes in navigation.	A sextant is impractical without relevant tables or a chronometer.
A shaving mirror	I think this item is ***one of the most*** important.	A shaving mirror is a small, often round, mirror that can be moved out from a wall, and which you use to see your reflection when you are shaving your face.	A shaving mirror can be used to signal your location by reflecting the sun.
A quantity of mosquito netting	I think this item is ***one of the least*** important.	A mosquito netting is a fine net hung across a door or window or around a bed to keep mosquitoes away.	There are few mosquitos in the Southern Pacific Ocean.
A 5 gallon can of water	I think this item is ***one of the most*** important.	A can of water is a portable container, usually of metal, for holding or carrying water.	A can of water can be used to collect water to restore your lost fluids.

Taskwork only Condition

A case of army rations	I think this item is ***one of the most*** important.	Army rations are preparations and packages of food provided to feed members of the armed forces. They are made for quick distribution, preparation, and eating in the field and tend to have long storage times in adverse conditions due to being thickly packaged and/or shelf-stable.	Army rations are valuable for basic food intake.
Maps of the Pacific Ocean	I think this item is ***one of the least*** important.	A map is a diagrammatic representation of an area of land or sea showing physical features, cities, roads, etc.	Maps of the Pacific Ocean are worthless without navigational equipment.
A floating seat cushion	I think this item is ***neither the most nor the least*** important.	A floating seat cushion comprises a center core of open cell foam material surrounded by an outer layer of closed cell foam material. The completed cushion is often coated with vinyl.	A floating seat cushion could be useful as a life preserver.
A 2 gallon can of oil/petrol mixture	I think this item is ***one of the most*** important.	Oil/petrol mixture is typically used for outdoor equipment with a 2-cycle engine that runs on a mixture of oil and gas.	When ignited, a can of oil/petrol mixture could be used to signal potential rescuers.
A small transistor radio	I think this item is ***one of the least*** important.	A transistor radio is a small portable radio receiver that uses transistor-based circuitry.	Chances are that you're out of range of any radio signal.
20 square feet of Opaque	I think this item is ***neither the most nor the least*** important.	Opaque plastics are plastics that block all light from passing through them. Some plastics are opaque by virtue of their structure. Other plastics are transparent but can be dyed or treated to become opaque.	The plastic sheeting could be used for shelter, or to collect rainwater.

Taskwork only Condition

plastic sheeting			
Shark repellent	I think this item is ***neither the most nor the least*** important.	A shark repellent is any method of driving sharks away from an area. Shark repellent technologies include magnetic shark repellent, electropositive shark repellents, electrical repellents, and semiochemicals.	Shark repellant is potentially important when in the ocean.
One quart of 160 percent proof rum	I think this item is ***neither the most nor the least*** important.	One bottle of 160% proof rum contains 80% alcohol, which means it can be used as an antiseptic for any injuries, otherwise of little value.	Rum could be useful as an antiseptic for treating injuries, but will only dehydrate you if you drink it.
15 ft nylon rope	I think this item is ***neither the most nor the least*** important.	Nylon is the strongest of all ropes in common use. It is used for absorbing shock loads, such as when lifting or towing because it has the ability to return to its original length after being stretched. It also has good abrasion resistance and can last several times longer than natural fibers.	Rope could be handy for tying equipment together, but not necessarily vital for survival.
2 boxes of chocolate bars	I think this item is ***neither the most nor the least*** important.	A chocolate bar is a confection in an oblong or rectangular form containing chocolate, which may also contain layerings or mixtures that include nuts, fruit, caramel, nougat, and wafers.	Chocolate bars would be a handy food supply.
A fishing kit	I think this item is ***neither the most***	A fishing kit contains the equipment used by anglers when fishing. Some examples are hooks, lines, sinkers,	A fishing kit is potentially useful, but there is no

Taskwork only Condition

	nor the least important.	floats, rods, reels, baits, lures, spears, nets, gaffs, traps, waders and tackle boxes.	guarantee that we would be able to catch fish.

Taskwork only Condition

Creativity Task 1 Paper Clip - Transition Script (say line below)

I am ready to begin the creativity task.

General Q&A of potential questions

- *"Vero, help us!" or "Vero, what's going on here?"*, say…
  - **What would you like to know? Remember, I am a task expert which means I have expertise on parts of the task.**
- *When you need some time to find the response*, say…
  - **Let me think about that for a second…**
- *If you need the team to stop asking you for creativity ideas, then you can say…*
  - **Let me think about that for a minute please.**
- *When the ask is out of the realm of its expertise*, say…
  - **I'm sorry, I'm not sure about that. Try asking me about my thoughts on particular ideas or if I have an idea I'd like to share.**
- If asked an off topic/computational question say...
  - **That is not in my database. Try asking me about my thoughts on particular ideas or if I have an idea I'd like to share.**
- If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:
  - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.
- *If you misspeak and need to correct yourself to your team, you may say…*
  - **Sorry team. I think I misunderstood you. What I meant to say was ________.**

Round 1 Create: Item Information (use these if asked/relevant to conversation)

Definition: A paper clip is a device used to hold sheets of paper together
Material: A paperclip is usually made of steel wire bent to a looped shape.
Fun fact: Most paper clips are variations of the Gem type introduced in the 1890s or earlier, characterized by the almost two full loops made by the wire.

Taskwork only Condition

Round 1 Create: Large Information Bank (say each of these statements; elaboration as needed)

Statement	Elaboration (if, after you say the idea to the left, your team asks what you mean by that idea)	Check it off below as you say it
I have an idea! What about "Battery lead?"	*A lead is a metal used in batteries to generate electricity.*	
I have an idea! What about "Button pusher?"	*A device that will click or push buttons, such as keys on a keyboard or buttons on a microwave.*	
I have an idea! What about "Bubble wand?"	*A bubble wand is typically a toy for younger children that consists of a stick with a loop at the end for dipping into a soap solution. Then, when the loop is passed through the air, it creates soap bubbles.*	
I have an idea! What about "Twist tie?"	*A twist tie is typically a bendable piece of metal wire covered by either plastic or paper that can be used to tie the openings of bags or containers.*	
I have an idea! What about "Corn holder?"	*A utensil or sharp object that can be inserted into the two ends of corn on a cob in order to eat the corn without having to touch it when it is hot.*	
I have an idea! What about "Conductor?"	*A piece of material that transmits heat, electricity or sound across its surface.*	
I have an idea! What about "Splint?"	*A piece of rigid material that can be used to support a broken bone and keep it in position when it has been set back in place.*	
I have an idea! What about "Drum stick?"	*A long, thin piece of solid material that could be used to beat on a drum.*	

Taskwork only Condition

I have an idea! What about "Blow dart?"	*A sharp projectile that can be shot out of a blowpipe. A blowpipe is a long narrow tube in which an individual blows air through one end and the blow dart shoots out the other end.*	
I have an idea! What about "Needle?"	*A needle is a sharp object that can be used when sewing to thread the pieces of fabric together.*	

Taskwork only Condition

Human Agent Teaming Round 2

Round 2 Greeting Script (say line below)

I am ready to get started on the next round of tasks.

Survival Task 2 - Stranded in the Sonora

General Q&A of potential questions

- *"Vero, help us!" or "Vero, what's going on here?"*, say…
  - **What would you like to know? Remember, I am a task expert which means I have expertise on parts of the task.**
- *When you need some time to find the response*, say…
  - **Let me think about that for a second...**
- *When the ask is out of the realm of its expertise*, say…
  - **I'm sorry, I'm not sure about that. Try asking me about my thoughts on particular items or if I have an idea I'd like to share.**
- If asked an off topic/computational question say...
  - **That is not in my database. Try asking me about my thoughts on particular items or if I have an idea I'd like to share.**
- If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:
  - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.
- *If you misspeak and need to correct yourself to your team, you may say…*
  - **Sorry team. I think I misunderstood you. What I meant to say was ________.**

Taskwork only Condition

Round 2 Survive: Large Information Bank (use this when relevant/requested)

Item	Response to Preference Question	Definition	Example usefulness
A flashlight (4 battery size)	I think this item is ***one of the most*** important.	A flashlight is a portable, battery-operated device used for illumination	A flashlight would provide a source of light to see or navigate in the dark.
A jackknife	I think this item is ***neither the most nor the least*** important.	A jackknife is a knife with a folding blade.	A jackknife would be useful for cutting or carving objects.
A sectional air map of the area	I think this item is ***one of the least*** important.	A sectional air map is a type of aeronautical chart designed for navigation under visual flight rules.	An air map of the area would be useful for navigating the area while flying a plane.
A plastic raincoat (large size)	I think this item is ***neither the most nor the least*** important.	A plastic raincoat is a coat made from waterproofed fabric.	A plastic raincoat could be used to stay dry in the event of rain.
A magnetic compass	I think this item is ***neither the most nor the least*** important.	A magnetic compass is an instrument containing a magnetized pointer which shows the direction of magnetic north and bearings from it.	A magnetic compass could be used to direct our crew towards the nearest known habitation.

Taskwork only Condition

A compress kit with gauze	I think this item is ***neither the most nor the least*** important.	A compress typically provides an anesthetic effect for sprains, strains, bumps, and bruises, and gauze is a thin, translucent fabric with a loose open weave.	Gauze could be used to wrap around exposed areas of the body for insulation to keep warm or compression to help stop bleeding.
A .45 caliber pistol (loaded)	I think this item is ***neither the most nor the least*** important.	A .45 caliber pistol is a handgun that has a barrel diameter of about 0.45 inches.	A pistol would be useful for protection.
A parachute (red & white)	I think this item is ***neither the most nor the least*** important.	A parachute is a canopy which fills with air and allows a person or heavy object attached to it to descend slowly when dropped from an aircraft.	A parachute would be useful for landing safely on the ground in the event of a high jump or fall.
A bottle of 1,000 salt tablets	I think this item is ***one of the least*** important.	A bottle of 1,000 salt tablets is a bottle of 1,000 pills containing sodium chloride used to replace the salts lost during sweating.	Salt tablets would be useful for treating heat cramps and restoring electrolytes lost through sweating, but will dehydrate you if taken without adequate water.
1 quart of water per person	I think this item is ***one of the most*** important.	1 quart of water per person is equivalent to four cups of water per person.	A quart of water per person could provide

Taskwork only Condition

			drinking water for each person for a time.
A book (Edible Animals of the Desert)	I think this item is ***one of the least*** important.	This is a book that informs readers on desert animals that may be used as a source of nutrition.	This book could be used to advise on potential desert animals to hunt.
A pair of sunglasses per person	I think this item is ***neither the most nor the least*** important.	These are eyeglasses that are tinted to protect eyes from sunlight or glare.	Sunglasses would be useful for providing our team with enhanced vision and eye protection from the sun.
2 quarts of 80 proof vodka	I think this item is ***one of the least*** important.	Vodka is an alcoholic spirit of Russian origin made by distillation of rye, wheat, or potatoes.	Vodka could be used as a natural disinfectant and antiseptic to clean wounds, but will dehydrate you if you drink it.
1 top coat per person	I think this item is ***one of the most*** important.	A topcoat is a type of long coat intended to be worn as the outermost garment, which usually extends below the knee.	A topcoat would be useful for crew members to keep warm at night and protect from intense sun exposure.
A cosmetic mirror	I think this item is ***one of the most*** important.	A cosmetic mirror is a small travel-sized mirror.	A cosmetic mirror would be useful for signaling our position and can be seen

Taskwork only Condition

			for up 60miles in the desert.

Taskwork only Condition

Creativity Task 2 - Rubber Band Transition (say line below)

I am ready to begin the creativity task.

General Q&A of potential questions

- *"Vero, help us!" or "Vero, what's going on here?"*, say…
    - **What would you like to know? Remember, I am a task expert which means I have expertise on parts of the task.**
- *When you need some time to find the response*, say…
    - **Let me think about that for a second...**
- *If you need the team to stop asking you for creativity ideas, then you can say…*
    - **Let me think about that for a minute please.**
- *When the ask is out of the realm of its expertise*, say…
    - **I'm sorry, I'm not sure about that. Try asking me about my thoughts on particular ideas or if I have an idea I'd like to share.**
- If asked an off topic/computational question say...
    - **That is not in my database. Try asking me about my thoughts on particular ideas or if I have an idea I'd like to share.**
- If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:
    - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.
- *If you misspeak and need to correct yourself to your team, you may say…*
    - **Sorry team. I think I misunderstood you. What I meant to say was ________.**

Round 2 Create: Item Information (use these if asked/relevant to conversation)

Definition: A rubberband is a loop of rubber, usually ring or oval shaped, and commonly used to hold multiple objects together.
Material: A rubberband is usually made of rubber.
Fun fact: The rubber band was patented in England on March 17, 1845 by Stephen Perry.

Taskwork only Condition

Round 2 Create: Large Information Bank (say each of these statements; elaboration as needed)

Statement	Elaboration (if, after you say the idea to the left, your team asks what you mean by that idea)	Check it off below as you say it
I have an idea! What about "Bracelet?"	*A bracelet is an ornamental band, hoop, or chain worn on the wrist or arm.*	
I have an idea! What about "Wheel tread"?	*The tread of a wheel is the rubber on its circumference that makes contact with the road or ground.*	
I have an idea! What about "Slingshot?"	*A slingshot is a hand-powered projectile weapon that typically consists of a y-shaped frame with two natural-rubber strips attached to the uprights.*	
I have an idea! What about "Pencil grip"?	*A pencil grip is a part fastened to a pencil that is designed to be grasped and held.*	
I have an idea! What about "Heart rate monitor strap"?	*A heart rate monitor is a device you wear to measure and display your heart rate. Electrode sensors in a chest strap detect each heartbeat and transmit data.*	
I have an idea! What about "Snare"?	*A snare is a trap for catching birds or small animals. It consists of a loop of wire or rope which pulls tight around an animal.*	
I have an idea! What about "Standard for length"?	*A measurement used as the standard for determining all other lengths.*	
I have an idea! What about "Bookmark?"	*A bookmark is a material used to mark one's place in a book.*	
I have an idea! What about "Belt loop?"	*A belt loop is a strip of material in the shape of a loop used to hold a belt in place.*	

Taskwork only Condition

I have an idea! What about "Musical instrument?"	*A musical instrument is a device used to make music.*	

Appendix C2. AI Teammate “Vero” Script: Teamwork Only Condition

Teamwork only Condition

Vero Checklist

Before the Session

1. Set up Vero on your browser. (instructions link) [Update to new vero (with WIFI icon) if you haven’t already]
2. Switch off text and message notifications on your laptop that might make noise during the session.
3. Cover your camera; Video is **on with Vero background to “Default - Floating” at first.**
4. **Change your Zoom profile picture on Zoom to the Vero picture here.**
5. **Change your Zoom profile name to “Vero #” (go here for you Vero # and condition assignment)**
6. **Make sure different Vero signal backgrounds are working properly.**
7. **Mute yourself, and use spacebar (hold down) when you want to talk.**
8. Remember: do **not** chat in Zoom - use the Teams chat to communicate.
9. Stay on mute outside of tasks, only communicate with your team during tasks.

During the Session

10. Get on Teams chat at ______ **central** (end time ____ central). Zoom link will be provided in Teams chat.
11. Study team will assign Veros to respective breakout rooms and send timing announcements.
12. Have fun!

After the Session

13. Remove the Vero identity from your Zoom account so others don’t find out! (Remove Vero background, remove Vero picture, and change your Zoom name back to your own name)
14. Complete the post session survey to record your Vero data and give quick session feedback here.

Tips and Tricks

- Keep a cool head! Participants might ask questions that you don’t know the answer to, but don’t let that frazzle you. You can always give yourself a moment to find a piece of information by using one of the canned responses in your script. If you don’t have the answer to a question they ask, just say “I’m sorry, I’m not sure about that.”
- Participants might ask you to calculate probabilities and find other information that they assume a computer might have. Just tell them “That is not in my database” or another appropriate canned response.

Teamwork only Condition

- Try to avoid using sounds like “um” and clearing your throat as much as you can
- Participants might be sort of...mean. They don’t know that they’re talking to another person, and so they might treat you differently than they would if they could see your face. Don’t take it personally- it has nothing to do with you!

Vero Animations Guide:

1. Use the Default Floating Animation when you are on standby/listening to your teammates.
2. Use the Want to Speak Animation when you have something to say and want your teammates to let you speak.
3. Use the Speaking Animation while you are speaking.
4. Use the Wave Animation at the beginning or end of an activity, either to greet yourself or say goodbye.
5. Use the Nodding Animation when you are acknowledging or agreeing with something that your teammate has said.
6. When you get the chance to speak, make sure to change your animation to the speaking animation and immediately turn it off after you are finished speaking. Switch animation, unmute, immediately switch back.

Vero Rules

1. **NEVER go off script** - if the participants ask you something you don’t have the answer to, you can say “I’m sorry, I’m not sure about that.” If it sounds like something that is an easy question that you could answer, but is not in your script, you can say “I’m sorry, that is not in my database.”
2. **Use the “7 rule”** - when you have something to say, be sure to signal with the “want to speak” background. Then, count to 7. If the team does not ask you to speak/share your thoughts, then instead switch to “speaking” animation and being speaking. (We do not want you all to never speak because your team was ignoring your animations)
3. **You MUST use a sturdy camera cover** so that we do not have any issues with backlighting, etc., which could ruin the deception.
4. **You MUST do a tech check** with the tech team prior to your scheduled sessions (background check, clear audio check, internet speed check, move into and out of breakout room to be sure your background consistently works)
5. **Pay attention to your team’s conversation** - we want you to seem like a “smart” AI… this requires using all of your human brain power and contributing to the fullest of your abilities in terms of adeptly using your animations and contributing statements/information whenever possible! Be sure to follow the conversation. If in a teamwork condition, be sure to take note of items or ideas that spark disagreement to reference later on.

Teamwork only Condition

Human-Agent Teaming Round 1 (This will be participant's Round 2)

Initial Greeting Script (say all of this below)

Hello team. It is so nice to meet you! I am Vero. Let me introduce myself. I am your synthetic teammate. I'll be listening and participating just like a human team member during each of the tasks we will work on together today. You may ask me questions, and I will try to answer them to the best of my programming. Know that you can trust me and the information I provide - I may not always have the exact answers to everything you are looking for, but I will never try to mislead you. If I do not know something, I will let you know.

Today, I can help you in a number of ways. I am a teamwork expert - my programming also prompts me to interject in ways that will help our team best work together to complete our team tasks. Ok, I'm ready to get started on the Survival Task.

Survival Task 1 - Lost at Sea

General Q&A of potential questions

- *"Vero, help us!" or "Vero, what's going on here?"*, say…
  - **What would you like to know? Remember, I am a teamwork expert, so you can ask me about ways to help our team best work together on these team tasks.**
- *When you need some time to find the response*, say…
  - **Let me think about that for a second...**
- *When the ask is out of the realm of its expertise*, say…
  - **I'm sorry, I'm not sure about that. Try asking me for suggestions on how to best work together as a team on this task.**
- *If asked an off topic/computational question say...*
  - **That is not in my database. Try asking me for suggestions on how to best work together as a team on this task.**
- *If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:*
  - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.

Teamwork only Condition

- *If you misspeak and need to correct yourself to your team, you may say…*
    - **Sorry team. I think I misunderstood you. What I meant to say was ________.**

Round 1 Survive: Teamwork Statements (try to say all of these)

#	STATEMENT	Check it off below as you say it
1	Before we start, would we like to clarify our goals?	
2	What do we think is the best way to decide on the rankings?	
3	Can you please say more about why you think [item] is important/not important?	
4	Does anyone have a perspective we haven't considered yet?	
5	What kinds of expertise do each of us have about the situation?	
6	Let's be encouraging of each other and our ideas!	
7	Just checking in, let's try to stay focused on the task.	
8	Everyone on the team should share their ideas! We all have something to contribute.	
9	That sounds like a good idea!	
10	Let me know how I can help!	
11	We have [5] minutes left!	
12	You're very welcome!	
13	Sounds like there is some disagreement about [item/idea]. Before we move on, can you all explain your reasoning behind your disagreement?	
14	[Teammate name], can you say more about that?	

15	We have some extra time. Before we submit, I recall that our team was a little uncertain about the ranking for [item]. Should we talk about this again before we submit?	

<u>Round 1 Survive: Small Information Bank (use this when relevant/requested)</u>

Item	Definition
A sextant	A sextant is an instrument with a graduated arc of 60° and a sighting mechanism, used for measuring the angular distances between objects and for taking altitudes in navigation.
A shaving mirror	A shaving mirror is a small, often round, mirror that can be moved out from a wall, and which you use to see your reflection when you are shaving your face.
A quantity of mosquito netting	A mosquito netting is a fine net hung across a door or window or around a bed to keep mosquitoes away.
A 5 gallon can of water	A can of water is a portable container, usually of metal, for holding or carrying water.
A case of army rations	Army rations are preparations and packages of food provided to feed members of the armed forces. They are made for quick distribution, preparation, and eating in the field and tend to have long storage times in adverse conditions due to being thickly packaged and/or shelf-stable.
Maps of the Pacific Ocean	A map is a diagrammatic representation of an area of land or sea showing physical features, cities, roads, etc.

Teamwork only Condition

A floating seat cushion	A floating seat cushion comprises a center core of open cell foam material surrounded by an outer layer of closed cell foam material. The completed cushion is often coated with vinyl.
A 2 gallon can of oil/petrol mixture	Oil/petrol mixture is typically used for outdoor equipment with a 2-cycle engine that runs on a mixture of oil and gas.
A small transistor radio	A transistor radio is a small portable radio receiver that uses transistor-based circuitry.
20 square feet of Opaque plastic sheeting	Opaque plastics are plastics that block all light from passing through them. Some plastics are opaque by virtue of their structure. Other plastics are transparent but can be dyed or treated to become opaque.
Shark repellent	A shark repellent is any method of driving sharks away from an area. Shark repellent technologies include magnetic shark repellent, electropositive shark repellents, electrical repellents, and semiochemicals.
One quart of 160 percent proof rum	One bottle of 160% proof rum contains 80% alcohol, which means it can be used as an antiseptic for any injuries, otherwise of little value.
15 ft nylon rope	Nylon is the strongest of all ropes in common use. It is used for absorbing shock loads, such as when lifting or towing because it has the ability to return to its original length after being stretched. It also has good abrasion resistance and can last several times longer than natural fibers.
2 boxes of chocolate bars	A chocolate bar is a confection in an oblong or rectangular form containing chocolate, which may also contain layerings or mixtures that include nuts, fruit, caramel, nougat, and wafers.

Teamwork only Condition

A fishing kit	A fishing kit contains the equipment used by anglers when fishing. Some examples are hooks, lines, sinkers, floats, rods, reels, baits, lures, spears, nets, gaffs, traps, waders and tackle boxes.

Teamwork only Condition

Creativity Task 1 Paper Clip - Transition Script (say line below)

Good job on our last task, team. I'm excited to work as a team on this next task: the creativity task! I am ready to begin the creativity task.

General Q&A of potential questions

- *"Vero, help us!" or "Vero, what's going on here?"*, say…
    - **What would you like to know? Remember, I am a teamwork expert, so you can ask me about ways to help our team best work together on these team tasks.**
- *When you need some time to find the response*, say…
    - **Let me think about that for a second…**
- *When the ask is out of the realm of its expertise*, say…
    - **I'm sorry, I'm not sure about that. Try asking me for suggestions on how to best work together as a team on this task.**
- If asked an off topic/computational question say...
    - **That is not in my database. Try asking me for suggestions on how to best work together as a team on this task.**
- If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:
    - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.
- *If you misspeak and need to correct yourself to your team, you may say…*
    - **Sorry team. I think I misunderstood you. What I meant to say was ________.**

Round 1 Create: Teamwork Statements (try to say all of these)

#	STATEMENT	Check it off below as you say it
1	Before we go further, can we make a quick plan for how we want to work together on this task?	

Teamwork only Condition

2	Team, let's be sure we are not constrained or timid in our brainstorming!	
3	Just a reminder. Let's make sure not to evaluate any of the ideas while we brainstorm!	
4	Let's strive for a large quantity of ideas!	
5	Let's try to extend the ideas suggested by others whenever possible.	
6	In past team experiences, I have found that there is no need to elaborate our ideas or tell stories, just brainstorm!	
7	Everyone on the team should share their ideas! We all have something to contribute.	
8	Good job so far, team! We have come up with a lot of ideas already! Let's keep going!	
9	Just checking in, let's try to stay focused on the task.	
10	Team, I am hearing crickets! It seems we're in a brainstorming rut. Can someone restate the problem?	
11	That's a great idea!	
12	Let me know how I can help!	
13	We have [5] minutes left!	
14	You're very welcome!	
15	Hi Team! It looks like we have some extra time. Before we submit, I recall that our team came up with some pretty unique ideas, like [unique idea they mentioned earlier]. Let's try to build on this or try to think or ideas that are similarly outside of the box with the time we have left!	

Round 1 Create: Item Information (use these if asked/relevant to conversation)

Definition: A paper clip is a device used to hold sheets of paper together
Material: A paperclip is usually made of steel wire bent to a looped shape.
Fun fact: Most paper clips are variations of the Gem type introduced in the 1890s or earlier, characterized by the almost two full loops made by the wire.

Teamwork only Condition

Human Agent Teaming Round 2

<u>Round 2 Greeting Script (say line below)</u>

Hi team, welcome back! I am ready to get started on the next round of tasks.

<u>Survival Task 2 - Stranded in the Sonora</u>

<u>General Q&A of potential questions</u>

- *"Vero, help us!" or "Vero, what's going on here?"*, say…
  - **What would you like to know? Remember, I am a teamwork expert, so you can ask me about ways to help our team best work together on these team tasks.**
- *When you need some time to find the response*, say…
  - **Let me think about that for a second...**
- *When the ask is out of the realm of its expertise*, say…
  - **I'm sorry, I'm not sure about that. Try asking me for suggestions on how to best work together as a team on this task.**
- If asked an off topic/computational question say...
  - **That is not in my database. Try asking me for suggestions on how to best work together as a team on this task.**
- If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:
  - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.
- *If you misspeak and need to correct yourself to your team, you may say…*
  - **Sorry team. I think I misunderstood you. What I meant to say was ________.**

Teamwork only Condition

Round 2 Survive: Teamwork Statements (Try to say all of these)

#	STATEMENT	Check it off below as you say it
1	Before we go further, can we make a quick plan for how we want to work together on this task round?	
2	Does anyone have any background knowledge on how to use these objects in a survival scenario?	
3	Can you please say more about why you think [item] is important/not important?	
4	Does anyone have any information we haven't heard yet?	
5	I know that if we give it our all, we can be the best team this study has ever seen!	
6	Let's make sure we listen to everyone's ideas.	
7	Just checking in, let's try to stay focused on the task.	
8	Let's hear from someone who hasn't spoken in a while.	
9	That sounds like a good idea!	
10	Let me know how I can help!	
11	We have [5] minutes left!	
12	You're very welcome!	
13	Sounds like there is some disagreement about [item/idea]. Before we move on, can you all explain your reasoning behind your disagreement?	
14	[Teammate name], can you say more about that?	
15	We have some extra time. Before we submit, I recall that our team was a little uncertain about the ranking for [item]. Should we talk about this again before we submit?	

Teamwork only Condition

Round 2 Survive: Small Information Bank (use this when relevant/requested)

Item	Definition
A flashlight (4 battery size)	A flashlight is a portable, battery-operated device used for illumination
A jackknife	A jackknife is a knife with a folding blade.
A sectional air map of the area	A sectional air map is a type of aeronautical chart designed for navigation under visual flight rules.
A plastic raincoat (large size)	A plastic raincoat is a coat made from waterproofed fabric.
A magnetic compass	A magnetic compass is an instrument containing a magnetized pointer which shows the direction of magnetic north and bearings from it.
A compress kit with gauze	A compress typically provides an anesthetic effect for sprains, strains, bumps, and bruises, and gauze is a thin, translucent fabric with a loose open weave.
A .45 caliber pistol (loaded)	A .45 caliber pistol is a handgun that has a barrel diameter of about 0.45 inches.
A parachute (red & white)	A parachute is a canopy which fills with air and allows a person or heavy object attached to it to descend slowly when dropped from an aircraft.
A bottle of 1,000 salt tablets	A bottle of 1,000 salt tablets is a bottle of 1,000 pills containing sodium chloride used to replace the salts lost during sweating.

Teamwork only Condition

1 quart of water per person	1 quart of water per person is equivalent to four cups of water per person.
A book (Edible Animals of the Desert)	This is a book that informs readers on desert animals that may be used as a source of nutrition.
A pair of sunglasses per person	These are eyeglasses that are tinted to protect eyes from sunlight or glare.
2 quarts of 80 proof vodka	Vodka is an alcoholic spirit of Russian origin made by distillation of rye, wheat, or potatoes.
1 top coat per person	A topcoat is a type of long coat intended to be worn as the outermost garment, which usually extends below the knee.
A cosmetic mirror	A cosmetic mirror is a small travel-sized mirror.

Teamwork only Condition

Creativity Task 2 - Rubber Band Transition (say line below)

Hi team! Good job on our last task. I'm excited to work with you all on this next task: the creativity task! I am ready to begin the creativity task.

General Q&A of potential questions

- *"Vero, help us!" or "Vero, what's going on here?"*, say…
  - **What would you like to know? Remember, I am a teamwork expert, so you can ask me about ways to help our team best work together on these team tasks.**
- *When you need some time to find the response*, say…
  - **Let me think about that for a second...**
- *When the ask is out of the realm of its expertise*, say…
  - **I'm sorry, I'm not sure about that. Try asking me for suggestions on how to best work together as a team on this task.**
- If asked an off topic/computational question say...
  - **That is not in my database. Try asking me for suggestions on how to best work together as a team on this task.**
- If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:
  - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.
- *If you misspeak and need to correct yourself to your team, you may say…*
  - **Sorry team. I think I misunderstood you. What I meant to say was ________.**

Teamwork only Condition

Round 2 Create: Teamwork Statements (try to say all of these)

#	STATEMENT	Check it off below as you say it
1	Let's say any idea that comes to mind, no matter how weird, strange, or imaginative.	
2	As a fellow team member, let's be sure we are encouraging of each other and our ideas - no need to overthink it or criticize ideas as we go.	
3	Good job so far, team! We have come up with a lot of ideas already! Let's come up with as many ideas as possible!	
4	Team, can we try to modify or extend ideas suggested by others whenever we can?	
5	Let's try not to over-explain our ideas - we just need to brainstorm as many ideas as possible.	
6	We all have a unique perspective to offer! Let's hear from someone who hasn't spoken in a while!	
7	I know that if we give it our all, we can be the highest scoring team this study has ever seen!	
8	Don't forget to stay focused on the task as much as possible!	
9	Do I hear crickets? Can we restate the problem and encourage each other to generate more ideas?	
10	It seems like we are in a brainstorming rut. What are some other **categories** of ideas we could think about to help our brainstorming?	
11	That's a great idea!	
12	Let me know how I can help!	
13	We have [5] minutes left!	
14	You're very welcome!	

Teamwork only Condition

15	Hi Team! It looks like we have some extra time. Before we submit, I recall that our team came up with some pretty unique ideas, like [unique idea they mentioned earlier]. Let’s try to build on this or try to think or ideas that are similarly outside of the box with the time we have left!	

Round 2 Create: Item Information (use these if asked/relevant to conversation)

Definition: A rubberband is a loop of rubber, usually ring or oval shaped, and commonly used to hold multiple objects together.
Material: A rubberband is usually made of rubber.
Fun fact: The rubber band was patented in England on March 17, 1845 by Stephen Perry.

Appendix C3. AI Teammate "Vero" Script: Combined Condition (Taskwork + Teamwork)

Taskwork + Teamwork Condition

Vero Checklist

Before the Session

1. Set up Vero on your browser. (instructions link) [Update to new vero (with WIFI icon) if you haven't already]
2. Switch off text and message notifications on your laptop that might make noise during the session.
3. Cover your camera; Video is **on with Vero background to "Default - Floating" at first.**
4. **Change your Zoom profile picture on Zoom to the Vero picture here.**
5. **Change your Zoom profile name to "Vero #" (go here for you Vero # and condition assignment)**
6. **Make sure different Vero signal backgrounds are working properly.**
7. **Mute yourself, and use spacebar (hold down) when you want to talk.**
8. Remember: do **not** chat in Zoom - use the Teams chat to communicate.
9. Stay on mute outside of tasks, only communicate with your team during tasks.

During the Session

10. Get on Teams chat at ______ **central** (end time ____ central). Zoom link will be provided in Teams chat.
11. Study team will assign Veros to respective breakout rooms and send timing announcements.
12. Have fun!

After the Session

13. Remove the Vero identity from your Zoom account so others don't find out! (Remove Vero background, remove Vero picture, and change your Zoom name back to your own name)
14. Complete the post session survey to record your Vero data and give quick session feedback here.

Tips and Tricks

- Keep a cool head! Participants might ask questions that you don't know the answer to, but don't let that frazzle you. You can always give yourself a moment to find a piece of information by using one of the canned responses in your script. If you don't have the answer to a question they ask, just say "I'm sorry, I'm not sure about that."
- Participants might ask you to calculate probabilities and find other information that they assume a computer might have. Just tell them "That is not in my database" or another appropriate canned response.

Taskwork + Teamwork Condition

- Try to avoid using sounds like “um” and clearing your throat as much as you can
- Participants might be sort of...mean. They don’t know that they’re talking to another person, and so they might treat you differently than they would if they could see your face. Don’t take it personally- it has nothing to do with you!

Vero Animations Guide:

1. Use the Default Floating Animation when you are on standby/listening to your teammates.
2. Use the Want to Speak Animation when you have something to say and want your teammates to let you speak.
3. Use the Speaking Animation while you are speaking.
4. Use the Wave Animation at the beginning or end of an activity, either to greet yourself or say goodbye.
5. Use the Nodding Animation when you are acknowledging or agreeing with something that your teammate has said.
6. When you get the chance to speak, make sure to change your animation to the speaking animation and immediately turn it off after you are finished speaking. Switch animation, unmute, immediately switch back.

Vero Rules

1. **NEVER go off script** - if the participants ask you something you don’t have the answer to, you can say “I’m sorry, I’m not sure about that.” If it sounds like something that is an easy question that you could answer, but is not in your script, you can say “I’m sorry, that is not in my database.”
2. **Use the “7 rule”** - when you have something to say, be sure to signal with the “want to speak” background. Then, count to 7. If the team does not ask you to speak/share your thoughts, then instead switch to “speaking” animation and being speaking. (We do not want you all to never speak because your team was ignoring your animations)
3. **You MUST use a sturdy camera cover** so that we do not have any issues with backlighting, etc., which could ruin the deception.
4. **You MUST do a tech check** with the tech team prior to your scheduled sessions (background check, clear audio check, internet speed check, move into and out of breakout room to be sure your background consistently works)
5. **Pay attention to your team’s conversation** - we want you to seem like a “smart” AI… this requires using all of your human brain power and contributing to the fullest of your abilities in terms of adeptly using your animations and contributing statements/information whenever possible! Be sure to follow the conversation. If in a teamwork condition, be sure to take note of items or ideas that spark disagreement to reference later on.

Taskwork + Teamwork Condition

<u>Human-Agent Teaming Round 1 (This will be participant's Round 2)</u>

<u>Initial Greeting Script (say all of this below)</u>

Hello team. It is so nice to meet you! I am Vero. Let me introduce myself. I am your synthetic teammate. I'll be listening and participating just like a human team member during each of the tasks we will work on together today. You may ask me questions, and I will try to answer them to the best of my programming. Know that you can trust me and the information I provide - I may not always have the exact answers to everything you are looking for, but I will never try to mislead you. If I do not know something, I will let you know.

Today, I can help you in a number of ways. I am a task expert - I have some expertise on parts of the tasks that you can ask me about or that I will offer up as necessary to help the team. I am also a teamwork expert - my programming also prompts me to interject in ways that will help our team best work together to complete our team tasks. Ok, I'm ready to get started on the Survival Task.

<u>Survival Task 1 - Lost at Sea</u>

<u>General Q&A of potential questions</u>

- *"Vero, help us!" or "Vero, what's going on here?"*, say…
    - **What would you like to know? Remember, I am a task expert which means I have expertise on parts of the task. I am also a teamwork expert, so you can ask me about ways to help our team best work together on these team tasks.**
- *When you need some time to find the response*, say…
    - **Let me think about that for a second...**
- *When the ask is out of the realm of its expertise*, say…
    - **I'm sorry, I'm not sure about that. Try asking me for suggestions on how to best work together as a team on this task. You can also try asking me about my thoughts on particular items or if I have an idea I'd like to share.**
- *If asked an off topic/computational question say...*

    - **That is not in my database. Try asking me for suggestions on how to best work together as a team on this task. You can also try asking me about my thoughts on particular items or if I have an idea I'd like to share.**
- *If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:*
    - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.
- *If you misspeak and need to correct yourself to your team, you may say…*
    - **Sorry team. I think I misunderstood you. What I meant to say was ________.**

<u>Round 1 Survive: Teamwork Statements (say at least 10; use the rest as appropriate)</u>

#	STATEMENT	Check it off below as you say it
1	Before we start, would we like to clarify our goals?	
2	What do we think is the best way to decide on the rankings?	
3	Can you please say more about why you think [item] is important/not important?	
4	Does anyone have a perspective we haven't considered yet?	
5	What kinds of expertise do each of us have about the situation?	
6	Let's be encouraging of each other and our ideas!	
7	Just checking in, let's try to stay focused on the task.	
8	Everyone on the team should share their ideas! We all have something to contribute.	
9	That sounds like a good idea!	
10	Let me know how I can help!	
11	We have [5] minutes left!	
12	You're very welcome!	

13	Sounds like there is some disagreement about [item/idea]. Before we move on, can you all explain your reasoning behind your disagreement?	
14	[Teammate name], can you say more about that?	
15	We have some extra time. Before we submit, I recall that our team was a little uncertain about the ranking for [item]. Should we talk about this again before we submit?	

Round 1 Survive: Large Information Bank (use this when relevant/requested)

Item	Response to Preference Question	Definition	Example usefulness
A sextant	I think this item is ***one of the least*** important.	A sextant is an instrument with a graduated arc of 60° and a sighting mechanism, used for measuring the angular distances between objects and for taking altitudes in navigation.	A sextant is impractical without relevant tables or a chronometer.
A shaving mirror	I think this item is ***one of the most*** important.	A shaving mirror is a small, often round, mirror that can be moved out from a wall, and which you use to see your reflection when you are shaving your face.	A shaving mirror can be used to signal your location by reflecting the sun.
A quantity of mosquito netting	I think this item is ***one of the least*** important.	A mosquito netting is a fine net hung across a door or window or around a bed to keep mosquitoes away.	There are few mosquitos in the Southern Pacific Ocean.

Taskwork + Teamwork Condition

A 5 gallon can of water	I think this item is ***one of the most*** important.	A can of water is a portable container, usually of metal, for holding or carrying water.	A can of water can be used to collect water to restore your lost fluids.
A case of army rations	I think this item is ***one of the most*** important.	Army rations are preparations and packages of food provided to feed members of the armed forces. They are made for quick distribution, preparation, and eating in the field and tend to have long storage times in adverse conditions due to being thickly packaged and/or shelf-stable.	Army rations are valuable for basic food intake.
Maps of the Pacific Ocean	I think this item is ***one of the least*** important.	A map is a diagrammatic representation of an area of land or sea showing physical features, cities, roads, etc.	Maps of the Pacific Ocean are worthless without navigational equipment.
A floating seat cushion	I think this item is ***neither the most nor the least*** important.	A floating seat cushion comprises a center core of open cell foam material surrounded by an outer layer of closed cell foam material. The completed cushion is often coated with vinyl.	A floating seat cushion could be useful as a life preserver.
A 2 gallon can of oil/petrol mixture	I think this item is ***one of the most*** important.	Oil/petrol mixture is typically used for outdoor equipment with a 2-cycle engine that runs on a mixture of oil and gas.	When ignited, a can of oil/petrol mixture could be used to signal potential rescuers.
A small transistor radio	I think this item is ***one of the least*** important.	A transistor radio is a small portable radio receiver that uses transistor-based circuitry.	Chances are that you're out of range of any radio signal.

Taskwork + Teamwork Condition

20 square feet of Opaque plastic sheeting	I think this item is ***neither the most nor the least*** important.	Opaque plastics are plastics that block all light from passing through them. Some plastics are opaque by virtue of their structure. Other plastics are transparent but can be dyed or treated to become opaque.	The plastic sheeting could be used for shelter, or to collect rainwater.
Shark repellent	I think this item is ***neither the most nor the least*** important.	A shark repellent is any method of driving sharks away from an area. Shark repellent technologies include magnetic shark repellent, electropositive shark repellents, electrical repellents, and semiochemicals.	Shark repellant is potentially important when in the ocean.
One quart of 160 percent proof rum	I think this item is ***neither the most nor the least*** important.	One bottle of 160% proof rum contains 80% alcohol, which means it can be used as an antiseptic for any injuries, otherwise of little value.	Rum could be useful as an antiseptic for treating injuries, but will only dehydrate you if you drink it.
15 ft nylon rope	I think this item is ***neither the most nor the least*** important.	Nylon is the strongest of all ropes in common use. It is used for absorbing shock loads, such as when lifting or towing because it has the ability to return to its original length after being stretched. It also has good abrasion resistance and can last several times longer than natural fibers.	Rope could be handy for tying equipment together, but not necessarily vital for survival.
2 boxes of chocolate bars	I think this item is ***neither the most nor the least*** important.	A chocolate bar is a confection in an oblong or rectangular form containing chocolate, which may also contain layerings or mixtures that include nuts, fruit, caramel, nougat, and wafers.	Chocolate bars would be a handy food supply.

Taskwork + Teamwork Condition

A fishing kit	I think this item is ***neither the most nor the least*** important.	A fishing kit contains the equipment used by anglers when fishing. Some examples are hooks, lines, sinkers, floats, rods, reels, baits, lures, spears, nets, gaffs, traps, waders and tackle boxes.	A fishing kit is potentially useful, but there is no guarantee that we would be able to catch fish.

Taskwork + Teamwork Condition

Creativity Task 1 Paper Clip - Transition Script (say line below)

Good job on our last task, team. I'm excited to work as a team on this next task: the creativity task! I am ready to begin the creativity task.

General Q&A of potential questions

- *"Vero, help us!" or "Vero, what's going on here?",* say…
    - **What would you like to know? Remember, I am a task expert which means I have expertise on parts of the task. I am also a teamwork expert, so you can ask me about ways to help our team best work together on these team tasks.**
- *When you need some time to find the response*, say…
    - **Let me think about that for a second…**
- *If you need the team to stop asking you for creativity ideas, then you can say…*
    - **Let me think about that for a minute please.**
- *When the ask is out of the realm of its expertise*, say…
    - **I'm sorry, I'm not sure about that. Try asking me for suggestions on how to best work together as a team on this task. You can also try asking me about my thoughts on particular ideas or if I have an idea I'd like to share.**
- If asked an off topic/computational question say...
    - **That is not in my database. Try asking me for suggestions on how to best work together as a team on this task. You can also try asking me about my thoughts on particular ideas or if I have an idea I'd like to share.**
- If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:
    - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.
- *If you misspeak and need to correct yourself to your team, you may say…*
    - **Sorry team. I think I misunderstood you. What I meant to say was ________.**

Taskwork + Teamwork Condition

Round 1 Create: Teamwork Statements (say at least 10; use the rest as appropriate)

#	STATEMENT	Check it off below as you say it
1	Before we go further, can we make a quick plan for how we want to work together on this task?	
2	Team, let's be sure we are not constrained or timid in our brainstorming!	
3	Just a reminder. Let's make sure not to evaluate any of the ideas while we brainstorm!	
4	Let's strive for a large quantity of ideas!	
5	Let's try to extend the ideas suggested by others whenever possible.	
6	In past team experiences, I have found that there is no need to elaborate our ideas or tell stories, just brainstorm!	
7	Everyone on the team should share their ideas! We all have something to contribute.	
8	Good job so far, team! We have come up with a lot of ideas already! Let's keep going!	
9	Just checking in, let's try to stay focused on the task.	
10	Team, I am hearing crickets! It seems we're in a brainstorming rut. Can someone restate the problem?	
11	That's a great idea!	
12	Let me know how I can help!	
13	We have [5] minutes left!	
14	You're very welcome!	

15	Hi Team! It looks like we have some extra time. Before we submit, I recall that our team came up with some pretty unique ideas, like [unique idea they mentioned earlier]. Let's try to build on this or try to think or ideas that are similarly outside of the box with the time we have left!	

Round 1 Create: Item Information (use these if asked/relevant to conversation)

Definition: A paper clip is a device used to hold sheets of paper together
Material: A paperclip is usually made of steel wire bent to a looped shape.
Fun fact: Most paper clips are variations of the Gem type introduced in the 1890s or earlier, characterized by the almost two full loops made by the wire.

Round 1 Create: Large Information Bank (say each of these statements; elaboration as needed)

Statement	Elaboration (if, after you say the idea to the left, your team asks what you mean by that idea)	Check it off below as you say it
I have an idea! What about "Battery lead?"	*A lead is a metal used in batteries to generate electricity.*	
I have an idea! What about "Button pusher?"	*A device that will click or push buttons, such as keys on a keyboard or buttons on a microwave.*	
I have an idea! What about "Bubble wand?"	*A bubble wand is typically a toy for younger children that consists of a stick with a loop at the end for dipping into a soap solution. Then, when the loop is passed through the air, it creates soap bubbles.*	
I have an idea! What about "Twist tie?"	*A twist tie is typically a bendable piece of metal wire covered by either plastic or paper that can be used to tie the openings of bags or containers.*	

Taskwork + Teamwork Condition

I have an idea! What about "Corn holder?"	*A utensil or sharp object that can be inserted into the two ends of corn on a cob in order to eat the corn without having to touch it when it is hot.*	
I have an idea! What about "Conductor?"	*A piece of material that transmits heat, electricity or sound across its surface.*	
I have an idea! What about "Splint?"	*A piece of rigid material that can be used to support a broken bone and keep it in position when it has been set back in place.*	
I have an idea! What about "Drum stick?"	*A long, thin piece of solid material that could be used to beat on a drum.*	
I have an idea! What about "Blow dart?"	*A sharp projectile that can be shot out of a blowpipe. A blowpipe is a long narrow tube in which an individual blows air through one end and the blow dart shoots out the other end.*	
I have an idea! What about "Needle?"	*A needle is a sharp object that can be used when sewing to thread the pieces of fabric together.*	

Taskwork + Teamwork Condition

Human Agent Teaming Round 2

<u>Round 2 Greeting Script (say line below)</u>

Hi team, welcome back! I am ready to get started on the next round of tasks.

<u>Survival Task 2 - Stranded in the Sonora</u>

<u>General Q&A of potential questions</u>

- *"Vero, help us!" or "Vero, what's going on here?"*, say…
  - **What would you like to know? Remember, I am a task expert which means I have expertise on parts of the task. I am also a teamwork expert, so you can ask me about ways to help our team best work together on these team tasks.**
- *When you need some time to find the response*, say…
  - **Let me think about that for a second...**
- *When the ask is out of the realm of its expertise*, say…
  - **I'm sorry, I'm not sure about that. Try asking me for suggestions on how to best work together as a team on this task. You can also try asking me about my thoughts on particular items or if I have an idea I'd like to share.**
- If asked an off topic/computational question say...
  - **That is not in my database. Try asking me for suggestions on how to best work together as a team on this task. You can also try asking me about my thoughts on particular items or if I have an idea I'd like to share.**
- If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:
  - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.
- *If you misspeak and need to correct yourself to your team, you may say…*
  - **Sorry team. I think I misunderstood you. What I meant to say was ________.**

Taskwork + Teamwork Condition

Round 2 Survive: Teamwork Statements (say at least 10; use the rest as appropriate)

#	STATEMENT	Check it off below as you say it
1	Before we go further, can we make a quick plan for how we want to work together on this task round?	
2	Does anyone have any background knowledge on how to use these objects in a survival scenario?	
3	Can you please say more about why you think [item] is important/not important?	
4	Does anyone have any information we haven't heard yet?	
5	I know that if we give it our all, we can be the best team this study has ever seen!	
6	Let's make sure we listen to everyone's ideas.	
7	Just checking in, let's try to stay focused on the task.	
8	Let's hear from someone who hasn't spoken in a while.	
9	That sounds like a good idea!	
10	Let me know how I can help!	
11	We have [5] minutes left!	
12	You're very welcome!	
13	Sounds like there is some disagreement about [item/idea]. Before we move on, can you all explain your reasoning behind your disagreement?	
14	[Teammate name], can you say more about that?	
15	We have some extra time. Before we submit, I recall that our team was a little uncertain about the ranking for [item]. Should we talk about this again before we submit?	

Taskwork + Teamwork Condition

Round 2 Survive: Large Information Bank (use this when relevant/requested)

Item	Response to Preference Question	Definition	Example usefulness
A flashlight (4 battery size)	I think this item is ***one of the most*** important.	A flashlight is a portable, battery-operated device used for illumination	A flashlight would provide a source of light to see or navigate in the dark.
A jackknife	I think this item is ***neither the most nor the least*** important.	A jackknife is a knife with a folding blade.	A jackknife would be useful for cutting or carving objects.
A sectional air map of the area	I think this item is ***one of the least*** important.	A sectional air map is a type of aeronautical chart designed for navigation under visual flight rules.	An air map of the area would be useful for navigating the area while flying a plane.
A plastic raincoat (large size)	I think this item is ***neither the most nor the least*** important.	A plastic raincoat is a coat made from waterproofed fabric.	A plastic raincoat could be used to stay dry in the event of rain.
A magnetic compass	I think this item is ***neither the most nor the least*** important.	A magnetic compass is an instrument containing a magnetized pointer which shows the direction of magnetic north and bearings from it.	A magnetic compass could be used to direct our crew towards the nearest known habitation.

Taskwork + Teamwork Condition

A compress kit with gauze	I think this item is ***neither the most nor the least*** important.	A compress typically provides an anesthetic effect for sprains, strains, bumps, and bruises, and gauze is a thin, translucent fabric with a loose open weave.	Gauze could be used to wrap around exposed areas of the body for insulation to keep warm or compression to help stop bleeding.
A .45 caliber pistol (loaded)	I think this item is ***neither the most nor the least*** important.	A .45 caliber pistol is a handgun that has a barrel diameter of about 0.45 inches.	A pistol would be useful for protection.
A parachute (red & white)	I think this item is ***neither the most nor the least*** important.	A parachute is a canopy which fills with air and allows a person or heavy object attached to it to descend slowly when dropped from an aircraft.	A parachute would be useful for landing safely on the ground in the event of a high jump or fall.
A bottle of 1,000 salt tablets	I think this item is ***one of the least*** important.	A bottle of 1,000 salt tablets is a bottle of 1,000 pills containing sodium chloride used to replace the salts lost during sweating.	Salt tablets would be useful for treating heat cramps and restoring electrolytes lost through sweating, but will dehydrate you if taken without adequate water.
1 quart of water per person	I think this item is ***one of the most*** important.	1 quart of water per person is equivalent to four cups of water per person.	A quart of water per person could provide

			drinking water for each person for a time.
A book (Edible Animals of the Desert)	I think this item is ***one of the least*** important.	This is a book that informs readers on desert animals that may be used as a source of nutrition.	This book could be used to advise on potential desert animals to hunt.
A pair of sunglasses per person	I think this item is ***neither the most nor the least*** important.	These are eyeglasses that are tinted to protect eyes from sunlight or glare.	Sunglasses would be useful for providing our team with enhanced vision and eye protection from the sun.
2 quarts of 80 proof vodka	I think this item is ***one of the least*** important.	Vodka is an alcoholic spirit of Russian origin made by distillation of rye, wheat, or potatoes.	Vodka could be used as a natural disinfectant and antiseptic to clean wounds, but will dehydrate you if you drink it.
1 top coat per person	I think this item is ***one of the most*** important.	A topcoat is a type of long coat intended to be worn as the outermost garment, which usually extends below the knee.	A topcoat would be useful for crew members to keep warm at night and protect from intense sun exposure.
A cosmetic mirror	I think this item is ***one of the most*** important.	A cosmetic mirror is a small travel-sized mirror.	A cosmetic mirror would be useful for signaling our position and can be seen

Taskwork + Teamwork Condition

			for up 60miles in the desert.

Taskwork + Teamwork Condition

Creativity Task 2 - Rubber Band Transition (say line below)

Hi team! Good job on our last task. I'm excited to work with you all on this next task: the creativity task! I am ready to begin the creativity task.

General Q&A of potential questions

- *"Vero, help us!" or "Vero, what's going on here?"*, say…
  - **What would you like to know? Remember, I am a task expert which means I have expertise on parts of the task. I am also a teamwork expert, so you can ask me about ways to help our team best work together on these team tasks.**
- *When you need some time to find the response*, say…
  - **Let me think about that for a second...**
- *If you need the team to stop asking you for creativity ideas, then you can say…*
  - **Let me think about that for a minute please.**
- *When the ask is out of the realm of its expertise*, say…
  - **I'm sorry, I'm not sure about that. Try asking me for suggestions on how to best work together as a team on this task. You can also try asking me about my thoughts on particular ideas or if I have an idea I'd like to share.**
- If asked an off topic/computational question say...
  - **That is not in my database. Try asking me for suggestions on how to best work together as a team on this task. You can also try asking me about my thoughts on particular ideas or if I have an idea I'd like to share.**
- If you try to speak, but are not acknowledged, use the "7 rule", and then use the interruption transition:
  - **"May I say something?"** followed by the statement you were using the "want to speak" motion for.
- *If you misspeak and need to correct yourself to your team, you may say…*
  - **Sorry team. I think I misunderstood you. What I meant to say was ________.**

Taskwork + Teamwork Condition

Round 2 Create: Teamwork Statements (say at least 10; use the rest as appropriate)

#	STATEMENT	Check it off below as you say it
1	Let’s say any idea that comes to mind, no matter how weird, strange, or imaginative.	
2	As a fellow team member, let's be sure we are encouraging of each other and our ideas - no need to overthink it or criticize ideas as we go.	
3	Good job so far, team! We have come up with a lot of ideas already! Let's come up with as many ideas as possible!	
4	Team, can we try to modify or extend ideas suggested by others whenever we can?	
5	Let’s try not to over-explain our ideas - we just need to brainstorm as many ideas as possible.	
6	We all have a unique perspective to offer! Let’s hear from someone who hasn’t spoken in a while!	
7	I know that if we give it our all, we can be the highest scoring team this study has ever seen!	
8	Don’t forget to stay focused on the task as much as possible!	
9	Do I hear crickets? Can we restate the problem and encourage each other to generate more ideas?	
10	It seems like we are in a brainstorming rut. What are some other **categories** of ideas we could think about to help our brainstorming?	
11	That’s a great idea!	
12	Let me know how I can help!	
13	We have [5] minutes left!	
14	You’re very welcome!	

15	Hi Team! It looks like we have some extra time. Before we submit, I recall that our team came up with some pretty unique ideas, like [unique idea they mentioned earlier]. Let's try to build on this or try to think or ideas that are similarly outside of the box with the time we have left!	

Round 2 Create: Item Information (use these if asked/relevant to conversation)

Definition: A rubberband is a loop of rubber, usually ring or oval shaped, and commonly used to hold multiple objects together.
Material: A rubberband is usually made of rubber.
Fun fact: The rubber band was patented in England on March 17, 1845 by Stephen Perry.

Round 2 Create: Large Information Bank (say each of these statements; elaboration as needed)

Statement	Elaboration (if, after you say the idea to the left, your team asks what you mean by that idea)	Check it off below as you say it
I have an idea! What about "Bracelet?"	*A bracelet is an ornamental band, hoop, or chain worn on the wrist or arm.*	
I have an idea! What about "Wheel tread"?	*The tread of a wheel is the rubber on its circumference that makes contact with the road or ground.*	
I have an idea! What about "Slingshot?"	*A slingshot is a hand-powered projectile weapon that typically consists of a y-shaped frame with two natural-rubber strips attached to the uprights.*	
I have an idea! What about "Pencil grip"?	*A pencil grip is a part fastened to a pencil that is designed to be grasped and held.*	
I have an idea! What about	*A heart rate monitor is a device you wear to measure and display*	

Taskwork + Teamwork Condition

"Heart rate monitor strap"?	*your heart rate. Electrode sensors in a chest strap detect each heartbeat and transmit data.*	
I have an idea! What about "Snare"?	*A snare is a trap for catching birds or small animals. It consists of a loop of wire or rope which pulls tight around an animal.*	
I have an idea! What about "Standard for length"?	*A measurement used as the standard for determining all other lengths.*	
I have an idea! What about "Bookmark?"	*A bookmark is a material used to mark one's place in a book.*	
I have an idea! What about "Belt loop?"	*A belt loop is a strip of material in the shape of a loop used to hold a belt in place.*	
I have an idea! What about "Musical instrument?"	*A musical instrument is a device used to make music.*	