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Knowledge Boundaries Shape the Cognitive and Structural Foundations of Innovation: Dyad-Level Expertise Exchange in Teams of Specialists

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APPROVAL OF THE DISSERTATION COMMITTEE

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ABSTRACT

Knowledge Boundaries Shape the Cognitive and Structural Foundations of Innovation: Dyad-Level Expertise Exchange in Teams of Specialists

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Innovation in academia and industry is increasingly achieved via complex problem solving in teams making use of knowledge from multiple areas of expertise. These expertise-diverse teams have proliferated in response to the demands of contemporary knowledge work, and members often possess intellectually distant skillsets that impose novel constraints on the means by which they must collaborate—in particular, they must rely more on distributed taskwork. Yet, research continues to place emphasis on the goal of enabling teams to achieve innovation by increasing knowledge shared in common, overcoming obstacles to cognitive parity, or via sustained periods of problem solving by the team as a whole. Instead, this study shows—and supports using a field experiment—that expertise-diverse teams heavily emphasize skillset complementarity and dyad-level expertise exchange, allowing team-level innovation to emerge from smaller interactions in which concrete, actionable expertise is transferred directly between members. As such, members from partly incommensurate expertise domains can still contribute to one another's work, raising the chance of breakthrough innovation across domains at the team level. Teams were randomly assigned to one of two training interventions emphasizing either dyadic or entirely group-level interaction. Results revealed that dyadic interaction was more strongly related to innovativeness and integrative complexity of team knowledge products. Measured expertise exchange in dyads also predicted team outcomes, a finding mediated by transactive memory—teams with more differentiated transactive memory systems were more effective. This study resolves incoherence about the impact of expertise diversity on teamwork, how to operationalize team cognition, and the contributions of structural features (e.g., interdependence) to team cognition and innovation.

Keywords: expertise diversity, teams, team training, team innovation, compilational emergence, dyads, hybrid interdependence, team cognition

DEDICATION

To my family, friends, and research advisers for the emotional, material, and scholarly support without which it would have been impossible to complete my doctoral studies.

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Knowledge Boundaries Shape the Cognitive and Structural Foundations of Innovation: Dyad-Level Expertise Exchange in Teams of Specialists

Chapter 1: Introduction

The ubiquitous shift toward the use of teams in response to market and task environment complexity has become axiomatic to the academic study of organizational behavior (Campion, Medsker, & Higgs, 1993; Cohen & Bailey, 1997; Guzzo & Shea, 1992; Katz & Koenig, 2001; Salas, Cooke, & Rosen, 2008), and to the achievement of breakthrough innovation in practice (Gardner, Gino, & Staats, 2012; Mohrman, Cohen, & Mohrman, 1995; Wuchty, Jones, & Uzzi, 2007). Yet, as work transitions toward use of knowledge, and as innovation increasingly requires generation of integrative solutions to complex problems that span multiple domains of expertise (Kozlowski & Ilgen, 2006), today's organizations also exhibit a pronounced dependence on the skillsets of *extremely* specialized individuals (Drucker, 1999; Von Nordenflycht, 2010). As a result, teams of expertise-diverse knowledge workers with "intellectually distant" specializations (Boudreau, Guinan, Lakhani, & Riedl, 2016) now reflect the practice of innovation (e.g., Cronin & Weingart, 2007). Such teams engage in macrocognitive knowledge building for non-routine tasks (e.g., research; DeChurch & Mesmer-Magnus, 2010a) with uncertain operative parameters (e.g., hidden profiles; Mesmer-Magnus & DeChurch, 2009) requiring collective creation of new knowledge or procedures (Fiore et al., 2010). Interdisciplinary research (IDR) teams, such as the teams of biologists, policy experts, and clinicians addressing public health issues (e.g., obesity; Stokols, Misra, Moser, Hall, & Taylor, 2007), now permeate scientific enterprises (Wuchty et al., 2007), while companies such as Google or Uber use engineers, programmers, and data scientists to develop commercially viable self-driving cars (Madrigal, 2014; "Uberworld," 2016).

Despite immense potential for innovation at the intersection of “thought worlds” (Baer, 2010; Dougherty, 1992), however, accounts of the collaborative difficulty and frequent failure of highly expertise-diverse knowledge worker teams (KWT; Lewis, 2004) remain familiar refrains (Journet, 1993; Stokols, Hall, Taylor, & Moser, 2008). The large intellectual distances between members of expertise-diverse KWTs impose heavy constraints on their ability to widely share expertise in a manner easily understood by others. The qualitative features of their specialized knowledge require that they employ distinct collaborative forms to overcome communicative difficulties (Bruns, 2013). Specifically, although their goal remains the integration of member expertise into emergently innovative team-level outcomes (Salazar, Lant, Fiore, & Salas, 2012), it is achieved to a greater extent, with respect to day-to-day task execution, through teammates’ skillset complementarity—task expertise mutually applicable to their common problem but not necessarily conceptually overlapped (Fiore et al., 2010; Kozlowski & Klein, 2000). Expertise integration in such teams mandates use of loosely coupled taskwork structures to build the team knowledge that leads to innovation (Girotra, Terwiesch, & Ulrich, 2010; Hargadon & Bechky, 2006). Yet, the value of such modes of collaboration, as well as their means of implementation, may not be familiar to those whose experience is limited to single expertise domains, and may require external intervention or facilitation (Burke, Salas, Wilson-Donnelly, & Priest, 2004).

Use of training interventions is one means of facilitating or updating teams’ collaborative capacities that carries considerable empirical support (Salas et al., 2008). Theoretical models that historically inform such interventions, however, may often overemphasize cultivation of shared mental activity—a feature more useful in teams of similarly trained experts who seek reciprocal coordination, temporal entrainment (cf. Cannon-Bowers, Salas, & Converse, 1993; DeChurch & Mesmer-Magnus, 2010b; Klimoski & Mohammed, 1994; Weick & Roberts, 1993), and cognitive parity through construction of identically shared, "compositional" team knowledge (e.g., flight crew, incrementally innovative project teams; Kozlowski & Klein, 2000; Salas, Stagl, & Burke, 2004). Indeed, such expertise integration occurs within shared conceptual paradigms, or *intra-paradigmatically*, in conditions where teams are capable of sustaining team-level coordination, information sharing, and elaboration (cf. Mesmer-Magnus & DeChurch, 2009; van Knippenberg & van Ginkel, 2010). This does not accurately reflect collaboration in today's expertise-diverse KWTs, and grounding attempts to improve their functioning in intra-paradigmatic models risks faulty team design or task structuring (e.g., Ancona & Caldwell, 1992; Kozlowski & Bell, 2013). Researchers or practitioners seeking to improve effectiveness in highly expertise-diverse KWTs must instead recognize that they collaborate *inter-paradigmatically*, across divergent, and partly incommensurate conceptual schemas, and "semantic" knowledge boundaries between members signaling intrinsic variation in interpretive systems of taskwork (Edmondson & Harvey, 2016). The means of training such teams, moreover, is best focused on teaching members to embrace the divergence between their task perspectives rather than redoubling efforts to overcome it.

Integrative barriers in today's innovating teams emerge more often from the qualitative features of knowledge itself (Brown & Duguid, 1991). Paired with the multifaceted, ambiguous problems such teams seek to solve, semantic boundaries require teams to use knowledge, skills, or task perspectives rendered, to nontrivial extent, *mutually inaccessible* by intellectual distance. Indeed, members' individual mental models vary widely in compatibility with each other and for specific subtasks (see Mohammed & Dumville, 2001), imposing permanent structural constraints on how closely, and for how long, particular individuals may collaborate. Although members of inter-paradigmatic KWTs must share identical awareness of *certain* aspects of task environments (e.g., team mission or vision; Cannon-Bowers et al., 1993), they retain deeply specialized, *unique* proficiency for other domains of taskwork (Lewis, 2004) to a degree far exceeding other KWTs, such that members often spend much time working alone (Bruns, 2013) or in dyadic interaction with particular teammates whose otherwise diverse skillsets are rendered relatively, often only temporarily intellectually proximate by the contextual features of taskwork (see Tannenbaum, Mathieu, Salas, & Cohen, 2012). Teammates, moreover, share their diverse expertise in highly pragmatic, concrete, and actionable forms, in episodes of dyadic exchange whose content—be it conceptual (e.g., problem framing), technical, or procedural (e.g., new method; Baer, 2010)—is tailored to specific, short-term task demands and contingent upon the intellectual distance within such dyads (Cross & Sproull, 2004; Zhou, Shin, Brass, Choi, & Zhang, 2009). Teams as a whole, in turn, use knowledge outcomes produced by these distributed exchanges as foundation for short periods of emergent, innovative knowledge integration based on newly shared understanding.

Dyadic exchange, as opposed to holistic, continuous team-level interaction or discussion, forms the quotidian foundation of emergent team-level innovation in inter-paradigmatic KWTs (see Tannenbaum et al., 2012), and is a principal means of cultivating the collective knowledge structures that fuel integration across sematic knowledge boundaries. As teams of highly diverse specialists cannot rely primarily on compositional knowledge for day-to-day task execution (e.g., shared mental model; Kozlowski & Klein, 2000), they shift their locus of creativity (Hargadon & Bechky, 2006). Specifically, they harness patterns of dyadic expertise complementarity to build non-isomorphic “compilational” knowledge (e.g., transactive memory systems; Peltokorpi, 2008) to leverage their members’ highly differentiated skillsets (DeChurch & Mesmer-Magnus, 2010b) in day-to-day taskwork. In doing so, members create, at lower levels, conditions for innovation to emerge at the team level in rare, brief moments of compositionally emergent integration, in which loosely coupled outputs of lower-level expertise exchange are combined to generate new ideas or reframe complex problems. Such teams thus rely on cognitive hybrid interdependence, such that extended periods of individual or dyad-level compilational work are punctuated by moments of radically innovative, team-level knowledge transformation (Girotra et al., 2010). In addition, dyadic exchange directly facilitates creation of compositional knowledge by exposing members to how each of their teammates interpret team-level features, such as a team climate or mission, constructing shared cognitive scaffolding that frames future dyadic interaction (Fiore & Schooler, 2004). Innovations thus result from integrative, upward cascades of complementary lower-level effort, irreducible products of macrocognitive processes (Kozlowski & Chao, 2012a; 2012b; Letsky, Warner, Fiore, & Smith, 2008) varying in cognitive heterogeneity (Gardner et al., 2012), interdependence (Girotra et al., 2010), and duration (Hargadon & Bechky, 2006).

This paper seeks to clarify how extremely high expertise diversity shapes the structure of teamwork (Bailey, Leonardi, & Chong, 2010; Girotra et al., 2010), as well as the content (Fiore et al., 2010) and temporal features of cognitive processes (Hargadon & Bechky, 2006) integral to creative expertise integration (see Huber & Lewis, 2010; Kozlowski & Bell, 2013). Further, it aims to use these theoretical advancements to construct a naturalistic team training intervention to improve the effectiveness of dyadic exchange in cultivating team knowledge structures—both the loosely coupled compilational knowledge and identically shared compositional knowledge characteristic of macrocognition in idea-generating KWTs (see Rosen, Fiore, Salas, Letsky, & Warner, 2008)—that spur innovation in today’s teamwork contexts. Structural features, namely, hybrid interdependence (see Wageman, 1995), are built into the training design, lending primacy to compilational knowledge for day-to-day taskwork and to compositional knowledge for team-level knowledge transformation or problem construction (DeChurch & Mesmer-Magnus, 2010b; Fiore & Schooler, 2004; Slyngstad, DeMichele, & Salazar, 2017). Interpersonal aspects, namely, psychological safety, are proposed to moderate the formation of such knowledge structures (see Frazier, Fainshmidt, Klinger, Pezeshkan, & Vracheva, 2016). A test of the conceptual model (Figure 1) will occur via randomized field experiment on a mixed sample of IDR, industry, and expertise-diverse PhD-level student teams who will take part in naturalistic interaction guided by researcher-designed discussion prompts and task mapping activities.

Chapter 2: Conceptual Overview and Research Hypotheses

Qualitative Features of Knowledge Shape the Structure of Inter-Paradigmatic Teamwork

Knowledge itself erects formidable obstacles to cognitive parity in inter-paradigmatic KWTs (Dane, 2010; Gardner et al., 2012; Perry-Smith, 2014) and prevents them from engaging in phases of sustained, team-level integration characterized by tightly coupled coordination or cognition that requires a fully shared understanding of taskwork, such as is used in action teams, or project or decision teams composed of relatively intellectually proximate members (DeChurch & Mesmer-Magnus, 2010b). Instead, they invest in member skill differentiation far in excess of other KWTs (see Faraj & Sproull, 2000; Levesque, Wilson, & Holey, 2001), shaping how they must subsequently collaborate to realize their substantial combined innovative potential. Indeed, for innovative teams bridging expertise domains, Bruns (2013) notes: “what has escaped scholars attention is that experts often spend considerably more time conducting specialized work apart from each other than they spend together with their collaborators from other domains” (p. 62). Specifically, uncodified, contextualized aspects of such specialized knowledge deny members commensurate understandings of teammates’ nuanced, day-to-day taskwork, given that expertise needed to complete it is deeply embedded within particular frames of reasoning, and comprises explicit and tacit knowledge of various assumptions or contingencies that remain hidden to those lacking the same extensive domain-specific training (Hansen, 1999; Winter, 1987). As such, it is difficult for dissimilarly trained team members divided by thick semantic boundaries to directly articulate or transfer knowledge in a manner quickly comprehendible by the team as a whole (Edmondson & Harvey, 2016; Hansen, 1999; Perry-Smith, 2014; Tyre & von Hippel, 1997).

Limitations imposed upon the communication of highly complex knowledge shapes the collaborative structures employed in inter-paradigmatic KWTs, such that their taskwork is best designed by assigning whole domains to lone, qualified individuals or small sets of intellectually proximate dyads. In order to produce innovations incorporating varied expertise domains, inter-paradigmatic KWTs must then ensure team-level integration emerges, in patterned combination, from the resulting network of loosely coupled individuals, dyads, or—in larger teams—small subgroups (see Kozlowski & Chao, 2012a; Liang, Moreland, & Argote, 1995; Moreland, Argote, & Krishnan, 1996; Zhou et al., 2009). Successful inter-paradigmatic KWTs therefore alternate between extended periods of *less* interdependent work and brief periods of *highly* interdependent team-level integration. The former is used to complete day-to-day taskwork and acts to create the conditions for innovation to emerge, while the latter serves as sensemaking to guide future work, via problem framing or construction (Bruns, 2013; Cross & Sproull, 2004; Faraj & Xiao, 2006), and is responsible for the generation of radically innovative solutions to complex problems (van Knippenberg, De Dreu, & Homan, 2004). In effect, the locus of creativity shifts between lower-level outputs (e.g., individuals and dyads) and true team-level synthesis (Hargadon & Bechky, 2006), and inter-paradigmatic KWTs employ cognitive hybrid interdependence to accommodate tensions between individual-level expertise specialization and a need for the collective creation or evaluation of innovative knowledge outcomes (Girotra et al., 2010; Wageman, 1995).

Using hybrid interdependence to bridge intellectual distance. Hybrid interdependence permits the members of inter-paradigmatic KWTs to bridge their intellectual distance at the team level without having to substantially merge their diverse and extremely specialized expertise at the individual or dyadic level simply to collaborate with one another. The structural features of collaboration, however, have been somewhat overlooked in research related to team information processing (Kozlowski & Chao, 2012a), despite being closely tied to information flow (Katz & Koenig, 2001), due to the fact that collective cognition literature emerged to describe KWTs of similarly trained experts who seek to increase knowledge in common for the sake of reciprocal behavioral interdependence and rapid adaptability (Cannon-Bowers et al., 1993; DeChurch & Mesmer-Magnus, 2010b; Klimoski & Mohammed, 1994; Kozlowski & Klein, 2000). In pursuit of such goals, hybrid interdependence, and the task-outcome interdependence asymmetry often observed in teams of highly functionally specialized knowledge workers (Bunderson & Sutcliffe, 2002; Girotra et al., 2010), is conventionally viewed as being detrimental to team effectiveness (e.g., Johnson & Johnson, 1989; Miller & Hamblin, 1963; Saavedra, Earley, & Van Dyne, 1993; Wageman & Baker, 1997). Yet, such studies most often assessed *intra*-paradigmatic teams ill suited to cross-domain knowledge generation (Fiore et al., 2010). In contrast, for teams engaged in complex, uncertain conceptual tasks, research has shown performance may be highest when interdependence is low or high, but not moderate (Mullen, Johnson, & Salas, 1991; Stewart & Barrick, 2000). Most notably, Girotra et al. (2010) found that expertise-diverse KWTs employing hybrid task interdependence were better at both generating ideas and evaluating their quality, a trait linked to revolutionary solutions to cross-domain challenges (Sutton & Hargadon, 1996).

Yet, team-level aspects of hybrid interdependent taskwork in inter-paradigmatic KWTs—collective, compositional sensemaking and deep knowledge integration—are rare, constituting a small fraction of team activity despite being the explicit goal of their formation and the source of breakthrough innovations across diverse expertise domains (Hargadon & Bechky, 2006). This is because the emergent integration that bridges intellectual distance is achieved primarily through use of analogical reasoning or conceptual frame bending (Brown & Duguid, 1991; Harvey, 2014; Krauss & Fussell, 1990)—modes of comprehension that are markedly *less* useful or efficient in the more prevalent day-to-day activities that occur *within* specializations (Bruns, 2013). Instead, quotidian collaboration in inter-paradigmatic KWTs relies on provision of concrete, actionable assistance, often on short-term tasks, from one member to another (Cross & Sproull, 2004) in moments of dyadic expertise sharing made possible by the ever-shifting patterns of expertise complementarity between members. As with other structural concerns, the concept of teams as networks of dyads has received insufficient attention related to team cognition (Tannenbaum et al., 2012), particularly under conditions of very high expertise diversity in which team outcomes must be innovative, integrative products reflecting the specializations of each member. These distributed, loosely coupled dyadic interactions, however, constitute the “less interdependent” aspect of hybrid interdependent taskwork, and, with respect to time spent, account for most of the collaboration in teams of intellectually distant specialists.

The quotidian role of dyadic expertise sharing. Episodes of dyadic interaction in inter-paradigmatic KWTs serve as a means by which expert knowledge workers who possess, at times, incommensurate task perspectives may still offer their varied expertise to one another without needing to communicate their entire professional perspectives (e.g., of an intellectual discipline) simply for the completion of small subtasks (see Hansen, 1999), ensuring that pools of cross-domain expertise remain available to assist with day-to-day work occurring largely within single skill domains. Indeed, in what Bruns (2013) labels “consultation,” members can compare needs of their domain with possibilities (e.g., concepts, methodologies) from one or more others. The content of the expertise shared in dyadic interactions varies, moreover, based on the intellectual distance of the participants in each dyadic exchange. In particular, relatively intellectually distant members are well positioned to offer teammates general conceptual help (i.e., problem framing), moderately intellectually distant members are able to offer technical assistance (e.g., unfamiliar methodology), and relatively intellectually proximate members are capable of providing direct coordinative support (e.g., joint accountability for particular subtasks; Cross & Sproull, 2004). Dyadic exchange aids not only in the completion of individual subtasks, moreover, but exposes members to the diverse task perspectives of each of their teammates and demonstrates how they may be mutually complementary (Dougherty & Tolboom, 2008).

Highly complex, protean task parameters ensure that patterns of dyadic expertise sharing are not static (Van Der Vegt & Van De Vliert, 2005), such that members of inter-paradigmatic KWTs repeatedly contort their mutual complementarity over time to harness a wider range of expertise diversity (Perry-Smith & Shalley, 2003). While sustained, long-term collaboration in dyads is likely only feasible when individuals are highly similarly trained and capable of offering direct behavioral support (see Day, Gronn, & Salas, 2004), individuals with long collaborative histories, too, remain potential beneficiaries of dyadic expertise sharing. Indeed, such members are frequently unaware of the exact nature of their expertise complementarity due to the depth of their knowledge, and because such complex taskwork continually reveals new areas of expertise overlap (Obstfeld, 2005; Wheelan, 2009). This varied exposure to diverse expertise via dyadic exchange encourages specialized members to examine assumptions that undergird their own and their teammates' task perspectives—including views about what the team seeks to accomplish and the means by which it is achievable (Fiore & Schooler, 2004). Through these small changes in mutual understanding, this repeated, varied exposure heightens members' mutual expertise complementarity, producing lower-level knowledge outputs of higher inherent compatibility and ultimately rendering collective knowledge generation more likely (see Harvey & Kou, 2013).

Successful inter-paradigmatic KWTs harness distributed, lower-level outputs of highly specialized individuals or intellectually proximate dyads as inputs into future, brief episodes of emergent team-level integration (Diehl & Stroebe, 1987; Hargadon & Bechky, 2006; Mullen, et al., 1991), in macroscopic structural patterns consistent with hybrid interdependence (Girotra et al., 2010). Given skillful team design and appropriate member composition (see Kozlowski & Bell, 2013; Lewis, 2004), repeated dyadic pairings in inter-paradigmatic KWTs increase mutual compatibility of lower-level knowledge products, establishing conditions in which contributions are more easily integrated and generating upward cascades of converging complementarity that culminate in a higher likelihood that the team as a whole will achieve breakthrough innovations that contain unique, irreducible combinations of each member's diverse expertise (Harvey, 2014; Salazar et al., 2012; Slyngstad et al., 2017; Wong, Ormiston, & Tetlock, 2011).

H1a: Inter-paradigmatic KWTs that engage in more dyad-level expertise exchange will produce team-level outcomes of higher integrative complexity.

H1b: Inter-paradigmatic KWTs that engage in more dyad-level expertise exchange will produce team-level outcomes of higher innovativeness.

Dyadic Exchange Aids Innovation by Bolstering Macrocognitive Knowledge Building

Dyadic exchange heightens innovative likelihood in inter-paradigmatic KWTs by acting to build and refine team knowledge structures linked to innovation (see DeChurch & Mesmer-Magnus, 2010b). Macrocognition, a framework that addresses team-level knowledge creation for teams in naturalistic settings who do not seek behavioral coordination (e.g., hostage negotiation, team science; Fiore, 2008) and are composed of "skilled people going beyond routine methods of performance and generating new knowledge and performance processes" (Fiore et al., 2010, p. 204), offers a model to describe cognition in inter-paradigmatic KWTs. Specifically, it posits that team members externalize their internalized knowledge via iterative problem-solving phases that include "knowledge construction, problem model development, team consensus, and outcome evaluation and revision" (Fiore et al., 2010, p. 215) to generate collective solutions in uncertain problem-solving or decision-making tasks (e.g., Kozlowski & Bell, 2013). While macrocognition is separate from team cognition literature, which historically focuses on rule-based performance (see Rasmussen, 1987), behavioral coordination, or temporal entrainment (Rosen et al., 2008), its general principles are well suited to an investigation of team cognition constructs. Kozlowski and Chao (2012b), for example, offer a team knowledge typology based explicitly on macrocognitive tenets, asserting: "team knowledge emergence is a multilevel phenomenon not just composition based (e.g., team mental models) or just compilation based (e.g., transactive memory), but rather it ranges across a spectrum of emergence" (Kozlowski & Bell, 2013, p. 38). Macrocognition thus frames the process by which specialized, *individualized* knowledge in inter-paradigmatic KWTs is communicated, or *externalized*, via dyadic interaction and team-level synthesis into knowledge structures, compilational and compositional, that facilitate creation/evaluation of team outcomes.

Some clarifications are warranted before applying macrocognition to inter-paradigmatic KWTs. First, inter-paradigmatic KWTs likely account for only a minority of the idea-generating teams for which the model is applicable, and macrocognition infrequently incorporates specific structural features of teamwork (e.g., hybrid interdependence) into discussion of team knowledge creation beyond recognition of the existence of complex task interdependencies. While scholars explicitly denote science teams, inter-paradigmatic KWTs in which "complementary knowledge and methods are brought to bear through interdisciplinary collaborations" (Fiore et al., 2010, p. 213), as among those that engage in macrocognition, more attention is dedicated to teams under acute time pressure (e.g., military, crisis response; Kozlowski & Chao, 2012a). Yet, Rosen et al. (2008) asserts that the model is best suited to teams tightly coupled to their task environments—an apt description of teams of diverse specialists innovating in today's competitive, dynamic, and knowledge-based industries (Slyngstad et al., 2017). Thus, it is this feature, rather than high time pressure, that helps to define the collaborative contexts for which macrocognition is relevant.

Second, macrocognition presents collaborative idea generation as a process of knowledge convergence through which individualized knowledge is transmuted and externalized, first into compilational team knowledge and then into compositional knowledge, such that the expertise of individuals is communicated, adapted, and incorporated into team-level outcomes (Kozlowski & Chao, 2012a). While this is true with respect to the aspects of team cognition that are ultimately integrated to create team-level innovation, not all compilational knowledge in inter-paradigmatic KWTs benefits from, or indeed, is capable of convergence into compositional knowledge. Some forms of compilational knowledge are better conceived of as ends in themselves (e.g., transactive memory systems), but less attention has been paid to collaborative efforts for which convergence is differentially attainable, such as in day-to-day taskwork in inter-paradigmatic KWTs in which externalization occurs primarily in dyads. In inter-paradigmatic contexts, then, this study asserts the primacy of compilational knowledge for the completion of intra-domain subtasks that lead to compositional, innovative problem construction and knowledge generation, but also posits that there is a direct relationship between compilational knowledge and innovation (see DeChurch & Mesmer-Magnus, 2010b)—offering, to the authors' knowledge, the only explicit empirical test of such aspects of team cognition in an exclusively macrocognitive collaborative context.

Dyadic exchange fuels externalization of compilational knowledge. Compilational team knowledge may be described as existing in "configurations that capture patterns of distinct individual, dyadic, and collective knowledge" (Kozlowski & Bell, 2013, p. 38), and is the means by which KWTs manage cognitive resources across distributed tasks (see Faraj & Sproull, 2000). Further, it is still characterized as a form of externalized or "shared" knowledge (Cannon-Bowers & Salas, 2001; Fiore et al., 2010). Theoretical emphasis on this form of team knowledge is recent when compared to that of identically shared, compositional knowledge constructs (Kozlowski & Klein, 2000). Yet, complementary, loosely coupled compilational knowledge permits expertise-diverse KWTs to perform complex tasks that cannot be accomplished by sustained collaboration by the team as a whole, even if members are adept perspective takers or communicators (Zhou et al., 2009)—due to limits of dialogue in bridging representational gaps, for example (see Cronin & Weingart, 2007)—but are nevertheless required for collective knowledge generation (e.g., an intra-domain subtask whose output is required for a later cross-domain task). Indeed, DeChurch and Mesmer-Magnus (2010a) report that effects of team cognition on performance in naturalistic decision-making teams are strongest for compilational constructs. Compilational knowledge is integral to success in the day-to-day taskwork of inter-paradigmatic KWTs, formed in large part in repeated dyadic interactions that expose individual members to the varied specializations of their teammates, and ultimately permits highly expertise-diverse teams to circumvent, as a group, their members' respective domain-specific "cognitive entrenchments" (see Dane, 2010) to share their expertise and achieve subsequent innovation (Hansen, 1999; van Knippenberg et al., 2004).

Dyadic expertise exchange builds compilational knowledge into networks of individuals or pairs of team members, the products of whose efforts are subsequently integrated into team-level innovations (Kozlowski & Chao, 2012a). The expertise that is exchanged in dyads is highly context dependent (see Brown & Duguid, 1991), tailored to requirements of particular subtasks that are frequently native to single expertise domains, or span relatively intellectually proximate domains. In these largely intra-domain, day-to-day subtasks, members that are engaged in dyadic interaction seek to graft their own expertise onto that of teammates who are trained in domains where a subtask resides (e.g., a philosopher reframing the way programmers of self-driving cars solve ethical dilemmas; Knight, 2015). The externalized compilational knowledge produced by work on these subtasks thereby reflects deep expertise in one domain, but incorporates features that heighten its future compatibility with knowledge products of other domains (Bechky, 2003; Bruns, 2013; Carlile, 2002; Hargadon & Bechky, 2006). As stated, the expertise content offered to dyadic partners depends on the intellectual distance between members involved in each dyadic interaction, but all types of exchange increase points of contact between diverse perspectives in inter-paradigmatic KWTs. Leveraging dyadic interaction to finish day-to-day subtasks enables members to retain or refine their expertise differentiation and simultaneously embed dimensions of complementarity into the loose coupled compilational knowledge products that result, creating lower-level knowledge products that foster subsequent emergent team-level idea combination.

A construct that encapsulates the role of externalized compilational knowledge in inter-paradigmatic KWTs is the transactive memory system (TMS), which originated in research on dyads (see Wegner, 1987). Transactive memory systems are "cooperative divisions of labor for learning, remembering, and communicating team knowledge…embedded in team members and in a team's structure and processes" (Lewis, 2004, p. 1519), or cognitive networks that enable teams to overcome information processing limitations of their individual members (Kozlowski & Ilgen, 2006; Peltokorpi, 2008). The construct pertains to "who knows what" and the maintenance of this differentiation (Huber & Lewis, 2010), and to knowledge held in common regarding the location of expertise. Thus, with respect to Kozlowski and Chao's (2012b) knowledge typology, TMS is *primarily* a compilational construct but retains a compositional dimension (Austin, 2003; DeChurch & Mesmer-Magnus, 2010b). Indeed, research has demonstrated that teams aware of their expertise distribution perform better and more readily share unique information (DeChurch & Mesmer-Magnus, 2009; Lewis, 2004; Stasser, Stewart, & Wittenbaum, 1995). Transactive memory systems have also been positively linked to performance, especially for divisible tasks (e.g., intra-domain subtasks; Hollingshead, 1998; 2001), and information processing efficiency (Kozlowski & Bell, 2013) and knowledge integration in complex, nonroutine tasks (Brandon & Hollingshead, 2004; Faraj & Sproull, 2000; Lewis, 2004, Moreland, 1999). Dyadic exchange thus increases team member awareness of the expertise of others and how it is complementary to one's own, creating a well-functioning TMS that facilitates more useful and accurate expertise exchange across domains, and team outcomes of higher subsequent quality.

H2: Dyadic exchange improves the functioning of transactive memory systems.

H3a: Transactive memory systems facilitate the creation of team knowledge outcomes of higher integrative complexity.

H3b: Transactive memory systems facilitate the creation of team knowledge outcomes of higher innovativeness.

Dyadic exchange fuels externalization of compositional knowledge. Compositional team knowledge, too, benefits from dyadic exchange in inter-paradigmatic KWTs, and consists of knowledge that is identically shared or conceptually overlapped (e.g., shared mental model; see Cannon-Bowers & Salas, 2001). Research on team cognition has overwhelmingly prioritized compositional constructs, or has assessed compilational constructs in a manner consistent with compositional phenomena (e.g., via statistical aggregation; Kozlowski & Klein, 2000). Yet, even in teams of diverse specialists, compositional knowledge remains critical despite large quotidian emphasis on compilation (see DeChurch & Mesmer-Magnus, 2010b; Kozlowski & Bell, 2013), and much research has been conducted on processes by which expertise-diverse teams engage in team-level integration (e.g., information elaboration; see van Knippenberg et al., 2004). Indeed, compositional knowledge constitutes the fundamental source of knowledge generation in teams of intellectually distant specialists, such that moments of compositionally emergent integration based on shared understanding (Girotra et al., 2010; Hargadon & Bechky, 2006) unite various compilational knowledge products that have resulted from repeated episodes of dyadic exchange (Kozlowski & Chao, 2012b) to create innovations reflecting each member's diverse skillsets (see Drach-Zahavy & Somech, 2001; Salazar et al., 2012; van Knippenberg & van Ginkel, 2010).

With regards to dyadic interaction, composition establishes boundary conditions in which team member complementarity may be harnessed (see Kozlowski & Ilgen, 2006; Nonaka, 1994). Although members of inter-paradigmatic KWTs are too intellectually distant to utilize implicit, shared mental models of taskwork (see Cannon-Bowers et al., 1993), compositional knowledge offers a means of collective orientation, providing cognitive scaffolding to guide integration and mitigating collective uncertainty about what the team is trying to accomplish (Fiore & Schooler, 2004). Such shared knowledge may include somewhat mundane elements, such as shared mental models of timelines, lists, or scheduling (Fiore et al., 2010), but also includes more sophisticated knowledge held in common, such "who knows what" on the team (e.g., Lewis, 2004; Peltokorpi, 2008) or complex problem conceptualizations and a shared innovative vision (see Mumford & Gustafson, 2007). Indeed, teams of specialists allocate much of their time or effort to cultivating compositionally emergent knowledge of their joint problem space (e.g., Newell & Simon, 1992; Slyngstad et al., 2017; van Ginkel & van Knippenberg, 2008), and to strategizing about how best to assign members to subtasks (Gardner et al., 2012). Exchange of expertise in dyads, then, acts to engage teammates in discussions of how the team can accomplish its goal. Repeated exposure to varied viewpoints prompts modifications in how each member conceives of doing so, such that their perspectives converge over time and reciprocally render future compilational efforts more highly compatible (see Hargadon & Bechky, 2006; West, 2002).

A construct exemplifying the role of compositional knowledge as cognitive scaffolding that shapes future knowledge generation is the team's climate for innovation, and specifically, a shared innovative vision among team members (Anderson & West, 1996; West, 1990). Climate has long been conceptualized as the shared, cognitively based perception or interpretation of the features of collaborative contexts (Lewin, Lippitt, & White, 1939; Ostroff, Kinicki, & Tamkins, 2003) that informs the strategic orientation of subsequent collaborative efforts (Kozlowski & Ilgen, 2006; Kozlowski & Klein, 2000), and has often been linked with innovation (Bunderson & Sutcliffe, 2002; Hulsheger, Anderson, & Salgado, 2009; Kozlowski & Bell, 2013; Kozlowski & Hults, 1987). Teammates' innovative vision converges on shared perceptions via emergent social interactions or leadership influence, (Kozlowski & Doherty, 1989; Rentsch, 1990), or repeated information sharing that conveys the thoughts or interests of each member (Haslam, Wegge, & Postmes, 2009), among other factors. As articulated, the social or instrumental interactions that facilitate formation of shared innovative vision in inter-paradigmatic KWTs occur prominently, although not exclusively, in dyads. This distributed component of vision formation may permit inter-paradigmatic KWTs to circumvent difficulties often encountered when defining a shared team direction in expertise-diverse teams (see Eigenbrode, O'Rourke, & Wulfhorst, 2007), and "construct" their problem space with input from each member (Slyngstad et al., 2017) in a way that garners commitment (Gilson & Shalley, 2004). The upward cascades of complementarity that constitute knowledge integration are thus framed or fueled, in part, by dyadic discussion of innovative vision, and foster a team climate favoring innovation (see Anderson & West, 1998).

H4: Dyadic exchange facilitates formation of shared innovative vision.

H5a: Shared innovative vision facilitates the creation of team knowledge outcomes of higher integrative complexity.

H5b: Shared innovative vision facilitates the creation of team knowledge outcomes of higher innovativeness.

Relational Features Moderate the Formation of Team Knowledge Structures

Exclusive focus on team behavior patterns and knowledge structures risks overlooking ever-present relational components of teaming, and particularly their capacity to moderate how information is shared and the extent to which unique knowledge is utilized and integrated (e.g., Dirks & Ferrin, 2001; Gruenfeld, Mannix, Williams, & Neale, 1996; Quigley, Tesluk, & Bartol, 2007). Indeed, while avoiding interpersonal or relational difficulty in inter-paradigmatic KWTs is no guarantee of innovative success due to teammates' extreme specialization and the burden of communicating across expertise domains, poor affective integration or low trust among members nevertheless presents serious obstacles to expertise integration (e.g., Homan, van Knippenberg, Van Cleef, & De Dreu, 2007; Meyer & Schermuly, 2012; van Ginkel & van Knippenberg, 2008; van Knippenberg et al., 2004). For inter-paradigmatic KWTs engaged in hybrid interdependence, relational issues can emerge in dyad- or team-level collaborative endeavors, and pose danger to a team's ability to build knowledge structures essential to innovative success. Relational barriers to the transfer of expertise at the dyad or team level, such as low trust between members, may lead members to take fewer interpersonal risks by sharing information that is less unique, with which others are likely to agree, such that expertise exchange exhibits biased information sampling (see

Mesmer-Magnus & DeChurch, 2009; Stasser & Titus, 1985; 1987). Indeed, a high degree of perceived participative safety has been repeatedly linked to innovation (Hulsheger et al., 2009; Ragazzoni, Baiardi, Zotti, Anderson, & West, 2002; West, 1990; West & Anderson, 1996).

A construct that captures the impact of perceived participative safety on team learning and the willingness to share or receive feedback on diverse ideas, especially in expertise-diverse KWTs, is psychological safety, a "shared belief held by team members that the team is safe for interpersonal risk taking" (Edmondson, 1999, p. 350) that "facilitates the willing contribution of ideas and actions to a shared enterprise" (Edmondson & Lei, 2004, p. 24). Psychological safety is asserted to facilitate creativity in teams (Hargadon & Bechky, 2006). In a recent meta-analysis, moreover, Frazier and colleagues (2016) find that psychological safety is positively related to task performance, learning behaviors, information sharing, voicing, and team creativity. Given that team members can perceive either dyad- or team-level taskwork contexts as psychologically safe, the construct can be conceptualized compilationally, between specific pairs of individuals, or compositionally, such as in periods of team-level discussion. With respect to dyads, low safety may mitigate the extent to which pairs of teammates invest effort to relay complex knowledge to one another, such as the fundamental assumptions that underlie or frame expertise they choose to share, rendering it less actionable to teammates (e.g., Baer, 2010; Perry-Smith, 2014; Tyre & von Hippel, 1997; Zhou et al., 2009) and hindering formation of compilational knowledge structures. In collective team-level discussion, by contrast, team climate that reinforces psychological safety permits members to reveal their own ignorance of the expertise contained within other fields to the group, thereby revealing areas of overlap or complementary across domains that may serve to guide compositional expertise integration or problem framing (e.g., Hargadon & Bechky, 2006).

H6a: Psychological safety moderates formation of compilational knowledge, such that team contexts of higher perceived safety facilitates dyadic expertise exchange that leads to team outcomes of higher integrative complexity and innovativeness.

H6b: Psychological safety moderates formation of compositional knowledge, such that team contexts of higher perceived safety facilitates dyadic expertise exchange that leads to team outcomes of higher integrative complexity and innovativeness.

Training Teams Engaged in Cross-Domain Innovation

Incorporating the theoretical clarifications made in the above sections, this investigation seeks to create a training intervention for inter-paradigmatic KWTs that is compatible with their naturalistic task settings and facilitates a hybrid interdependent approach to taskwork, adding to a rich history of formal interventions to improve information processing in problem-solving teams (e.g., Okhuysen, 2001; Okhuysen & Eisenhardt, 2002). Given their recent emergence in today's organizations (see Salazar et al., 2012; Slyngstad et al., 2017; Wuchty et al., 2007) little research has addressed training or facilitating teams of highly expertise-diverse specialists. Yet, research has shown that training is generally positively associated with performance, at times accounting for nearly 20% of the variance in performance outcomes (Salas et al., 2008). Notably, Kozlowski and Bell (2013) assert that KWTs relying largely on compositionally emergent constructs should be trained at the individual level so as to capitalize on additive effects of their subsequent efforts, but KWTs making heavy use of compilation require training to be directed toward the team as a whole in actual or simulated performance environments, such as via scripted interactions, role playing scenarios, or simulations to bolster situational awareness, error identification, feedback, planning, or transactive memory (Salas & Cannon-Bowers, 1997; Salas, Stagl, & Fiore, 2007).

Traditional approaches to training KWTs often emphasize the elimination of obstacles to shared understanding, such as lessening barriers to information sharing (Stasser & Titus, 1985; 1987) or fostering goal alignment (Bunderson & Sutcliffe, 2002) for the sake of achieving rule-based performance (Letsky et al., 2008; Rosen et al., 2008). When training inter-paradigmatic KWTs, by contrast, greater emphasis must be placed on facilitating the collaborative efforts of specific dyads (or small subgroups in teams of sufficient size) to account for less interdependent aspects of taskwork, and on improving transfer of actionable expertise between members from distinct expertise domains (see Cross & Sproull, 2004; van Der Vegt & van de Vliert, 2005) given that team members are often unaware of the precise nature of their expertise overlap, and because approaches to collaborating across domains are infrequently taught to those who seek deeply specialized knowledge (e.g., Burke et al., 2004). Indeed, team training must be oriented toward "specifying desirable *patterns* of team-member KSAOs" (Kozlowksi & Ilgen, 2006, p. 111) and emphasize developing a capacity for autonomous taskwork design such that teams learn to employ strategic task structuring (e.g., who works with whom on what and when). Facilitation is characterized by enabling emergent collaboration among those with requisite skills, rather than direct attempts to facilitate or remove obstacles to team-level collaboration.

Chapter 3: Method

Sample and Participation Criteria

The study's sample was comprised of expertise-diverse teams sampled from two research universities in Southern California. The collaborative features of such teams were consistent with inter-paradigmatic KWTs, although not all teams were necessarily interdisciplinary. Indeed, even specialists within single disciplines can be specialized enough to create communication obstacles similar to that described above, which must be overcome by joint reliance on compositional and compilational cognition and expertise exchange in dyads. The teams were contacted directly by researchers or via internal recruitment forums at their respective host universities. Participating teams were required to have at least three members—a team size judged capable of producing sufficiently diverse discussions between members (see Hackman, 1992). For teams larger than six members, no more than six individuals per team were permitted to participate in the training sessions or subsequent data collection as it is unlikely that teams of that size can fully explore the contributions of each member in the limited time available to administer training sessions (see Guzzo & Shea, 1992; Poulton & West, 1999).

Design and Procedure

This study employed a 2x1 experimental design, coupled with survey assessment at three time points. First, teams matching study inclusion criteria were sent a recruitment letter, study information sheet, and informed consent form. Teams agreeing to participate were contacted via email to schedule their team training session. For all training sessions, teams were directed to discuss their own work, such as one of their team's current projects or planned future projects, to create psychologically realistic research settings (e.g., Knoke & Yang, 2008; Mook, 1983) and increase the value of the training to participating teams. Teams were randomly assigned to one of two conditions, either 1) the Dyadic Pairing (treatment) condition or 2) the Collective Discussion (control) condition. In both conditions, prior to the start of training, teams were presented with a brief conceptual overview (10 minutes) of some of the challenges inherent to innovation across expertise domains. For the training session itself, they were directed to discuss their team's own work with the aid of researcher-designed discussion prompts, which varied minimally in their wording across the two conditions (Appendix A).

Across conditions, the researcher induced structural variations in patterns of expertise sharing and communication between members by instructing teams to use different modes of discussion depending on their assigned condition. In the Dyadic Pairing condition, discussion occurred across two phases—first at the *dyadic level* to enhance member-to-member expertise exchange (Cross & Sproull, 2004). Each member was paired, successively and in random order, with up to five teammates (depending on team size). This phase lasted for approximately one hour. In the second phase, they were given an opportunity to briefly discuss (10 minutes) the team's overarching mission and upcoming projects in a shared, *collective-level* conversation at the end of the session (Appendix B). As such, a team's progression through phases of the Dyadic Pairing condition paralleled the hybrid interdependence and shifting locus of creativity asserted to drive macrocognitive knowledge building and innovation in expertise-diverse KWTs (Fiore et al., 2010; Girotra et al., 2010; Hargadon & Bechky, 2006). The Collective Discussion (control) condition likewise had two phases, but communication amongst teammates occurs at the team level for *both* expertise sharing and team mission discussion phases. Thus, the control condition did not include dyadic pairings and teams in this condition were not exposed to conditions that parallel hybrid interdependence or dyadic interaction to stimulate idea generation.

Data were collected via online or paper surveys at three points during the study. The first survey, consisting of about 25 items (varies by team size), was given immediately prior to the training intervention (T0; Appendix C). The second survey, about 45 items, was administered immediately following it (T1; Appendix D). In both cases, participants completed surveys while under observation by the research team. The participants could choose to have surveys given on paper or electronically on Qualtrics. The third survey (T2; Appendix E), also consisting of about 25 items, was administered electronically no less than two weeks (see Crano, Brewer, & Lac,

2015) after the session's conclusion. Surveys are designed in accordance with Dillman's (2007) Tailored Design Method, using techniques to elicit genuine, unbiased responses and to reduce measurement error (see Sudman, Bradburn, & Schwartz, 1996). Audio recordings of sessions were taken when feasible to assist in potential future follow up analyses for subsequent projects.

Measures

Measure selection and modification in this study reflected an attempt to assess constructs in a manner precisely consistent with their conceptual formulation in literature, circumventing a widespread tendency to assess team states or processes as compositionally emergent even when constructs are explicitly conceptualized as compilationally emergent (e.g., Kozlowski & Klein, 2000). To remain compatible with the survey methodology, all compilational constructs were captured via measurement techniques from social network analysis (SNA; see Borgatti, Mehra, Brass, & Labianca, 2009), as they offer pragmatic means of assessing patterned emergence for team constructs (Fiore & Wiltshire, 2016; Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Kozlowski & Chao, 2012a; Kozlowski, Chao, Grand, Braun, & Kuljanin, 2013; Tannenbaum et al., 2012). For each SNA item described below, teams were assessed via the calculation of valued, weighted density (Wasserman & Faust, 1994) given the research goal of increasing sharing of actionable expertise of all types and among all team members. For each measure described below, its type (i.e., SNA versus conventional Likert response scale), data collection phase (i.e., pre-intervention [T0], proximal [T1] or distal post-intervention [T2] survey), and psychometric properties (when relevant) are noted. When required, items were slightly cosmetically modified to fit the research context (e.g., verb tense). Unless otherwise noted, response options ranged from 1 ("*Strongly Disagree*") to 7 ("*Strongly Agree*"), and sample items below are taken from electronic surveys.

Tracking items and social network teammate names prompt. For each survey, several original tracking items facilitated merging of participant data across time points. These included questions concerning the respondent's name ("What is your first and last name?"), researcher-provided team ID number ("Please enter the team ID number assigned to your interdisciplinary research team for this study."), and research site ("What is the name of the medical campus or academic institution at which you currently work, through which you are participating in this study?"). Each survey also featured a prompt requiring respondents to provide the names of their teammates, which were piped into subsequent substantive items to conserve respondent attention and time (see Wasserman & Faust, 1994).

Integrative complexity. Integrative complexity consists of two dimensions, conceptual integration and evaluative differentiation (Wong et al., 2011). Integration was assessed at both T1 and T2, and differentiation at T2. Although often assessed qualitatively, both dimensions were measured via SNA questions adapted from conceptual summaries of the construct in team-level integrative complexity literature (e.g., Gruenfeld & Hollingshead, 1993). Respondents answered one SNA item per dimension, repeated for each member of their team. Conceptual integration was assessed using the following item: "The innovations produced by this team would have been impossible without the *unique combination* of __________ and my ideas." Evaluative integration, in turn, was assessed using the following item: "__________'s expertise uniquely contributes to the team's outputs in a way that is *distinct from my own* contribution." Blanks in the above sample items correspond to the piped text that contained the respondent's teammates' names.

Team innovativeness. Team innovativeness was measured at both T1 and T2 using Burpitt and Bigoness's (1997) 5-item Problem Oriented Team Innovation subscale of their

Team-Level Innovation Scale. Items for this subscale loaded onto a single factor with minimal cross-loadings, and have demonstrated adequate internal consistency (Cronbach's α = .88). Sample items include "This team identifies and learns new skills and technologies that may be useful to solving unfamiliar problems" and "This team learns new ways to apply knowledge of familiar techniques and procedures to develop new and unusual solutions." Observed internal consistency in the present sample was adequate at T1, α = .88, and T2, α = .94.

Expertise sharing. Expertise sharing functioned as a manipulation check for the training session's effectiveness, and was assessed with Faraj and Sproull's (2000) 4-item Bring Expertise to Bear subscale of the Expertise Coordination scale. Items have been shown to load on a single factor and have adequate internal consistency at both the individual (α = .88) and team level (α = .88). Sample items include "People in our team share their special knowledge and expertise with each other" and "More knowledgeable team members freely provide other members with hard-to-find knowledge or specialized skills." This scale was administered at T1 following training, and observed internal consistency for the present sample was adequate, α = .95

Actionable expertise exchange. Functioning as an additional manipulation check but measured compilationally via SNA, one original item addressing actionable expertise sharing was administered at T1. The item, repeated once for each teammate listed by the respondent, stated: "__________ shared his/her expertise with me by providing actionable assistance with an aspect of my work," prompted by text stating: "For each individual, consider the extent to which they provided assistance to you during the training session that was specific, pragmatic, and actionable. This assistance could have been conceptual (e.g., reframing a problem), procedural (e.g., suggesting a new method), or technical (e.g., advice about unfamiliar technology)."

Transactive memory. Transactive memory as compilationally defined pertains to 1) "who knows what" on the team or knowledge of teammates' expertise complementarity and 2) the differentiation of member expertise as it relates to team taskwork (Peltokorpi, 2008). Each dimension was assessed with one SNA item, respectively. The "who knows what" dimension was assessed via a single item adapted from Lewis's (2003) Transactive Memory Systems scale (α = .88), which states "__________ has knowledge about aspects of the team's work that are distinct from my own." Expertise complementarity was captured via an item adapted from Faraj and Sproull's (2000) Expertise Location subscale ($\alpha_{individual}$ = .87; α_{team} = .90) from the Expertise Coordination scale, which states "__________ has specialized skills or knowledge to offer that are relevant to my work *on this team*." Both were administered at T1.

Innovative team vision. Innovative vision is a compositional construct, assessed using Anderson and West's (1998) 11-item Vision subscale from the Team Climate Inventory. All items from the subscale have been shown to load onto a single factor and possess high internal consistency (α = .94). Sample items include "The team's objectives are clear" and "The team's objectives are realistic and can be attained." This scale was administered at T1 following the training session. Immediately prior to this scale, respondents answered a qualitative item reading "Please state your team's overall objective or core mission," to prompt them to consider their team's specific mission in more detail and use it as a shared referent when answering the items. The observed internal consistency for the present sample was adequate, α = .88.

Psychological safety. Psychological safety can be considered as either a compositional (i.e., the extent individuals perceive that it is safe to take interpersonal risks on their team) or a compilational construct (i.e., the extent team members perceive interpersonal risk taking to be safe with respect to particular teammates; see Frazier et al., 2017; Tynan, 2005). To capture the construct's compositional role in fostering climates for team innovative processes, Edmondson's (1999) full 7-item scale was administered at T1. Sample items include "It is safe to take a risk on this team" and "Working with this team, my unique skills are valued and utilized." Observed internal consistency for the present sample was adequate, $\alpha = .85$.

Substantive control variables. Several substantive control variables were included in T0, T1, and T2 surveys. Teammate expertise similarity (i.e., intellectual distance; Boudreau et al., 2016) was assessed at T0 and T2 with an original item, ranging from 1 ("*Very Dissimilar*") to 7 ("*Very Similar*"), which read "On a scale from 1 to 7, how similar is their area of expertise to yours?" repeated for the name of each of the respondent's teammates. Previous collaborative experience was assessed at T0 on a dichotomous 0 ("*No*") or 1 ("*Yes*") scale, with an original item stating "For each individual, indicate whether you have collaborated/are collaborating with them on other teams or projects." At T1, immediately following the training session, the number of conversation partners was accounted for with a SNA item reading "I engaged in direct, one-on-one conversation with __________ during the training session," to control for respondents having different numbers of conversation partners depending on allotted time or their team's size. To account for team decision-making structure during training, Lee, Koopman, Hollenbeck, Wang, and Lanaj's (2015) Authority Differentiation scale from the Team Descriptive Index was adapted and administered at T1 (see Appendix D). To account for a team's leadership differences compilationally, as an explanatory complement to Authority Differentiation, Carson, Tesluk, and Marrone's (2007) SNA item "I rely on __________ for leadership" was administered at T2.

Demographic control variables. Several demographic control variables were assessed at T0, immediately preceding the training session. These included respondents' team tenure ("In years and months, how long have you been a member of this interdisciplinary research team?";

see Kozlowski & Bell, 2013), prior respondent participation in an IDR team ("*Not including your current team*, have you ever participated in an interdisciplinary team before?"), work position ("What best describes your current position at the institution where you currently work?"), education and professional training (e.g., "Of the following, what would you describe as your main area of research or practice?"), topic tenure ("What percent *of all of your work* is related to your team's topic domain?"; see Dane, 2010), and potential sources of funding ("Not including any monetary resources provided by your team members [e.g., funds unaffiliated with grant providing organizations], has your team received any funding as a group [e.g., federal grant]?"; see Stokols et al., 2008). Lastly, age, gender, and ethnicity were each assessed with single items (see Campion et al., 1993; Joshi & Roh, 2009, Mannix & Neale, 2005).

Data Analysis Strategy

Given the inherent uncertainty in predicting participation or response rate, missing data patterns, or features impacting the data's consistency with univariate or multivariate statistical assumptions (see Tabachnick & Fidell, 2013)—especially when using assessment techniques of social network analysis (Borgatti, Everett, & Johnson, 2013; Knoke & Yang, 2008; Wasserman & Faust, 1994) and when recruiting from a relatively rare population of teams—determination of analytic approach was based on data quality. Prior to hypothesis testing, variables were assessed for consistency with statistical assumptions (e.g., skewness, kurtosis, outliers; Meyers, Gamst, & Guarino, 2013). Any justified transformations were applied. To derive descriptive SNA statistics (i.e., network density; Borgatti et al., 2013) for the set of compilationally defined constructs (e.g., transactive memory, integrative complexity), survey responses were converted to symmetrical matrices capturing the strength of dyadic ties and exported to UCINET—the team-level output of which is then used in subsequent tests of hypotheses in SPSS, R, or M*plus*. Tests of hypotheses employed a mixture of team-level mediation analyses and tests of moderated mediation, as well as multilevel or structural equation modeling depending on data quality, the sample size, and quality implied by the aggregation statistics reported. Covariates were retained only when they are significant to maximize power and minimize collinearity (see Tabachnick & Fidell, 2013).

As a note, integrative complexity's conceptual integration and evaluative differentiation dimensions were assessed separately as dependent variables in tests of hypotheses (i.e., each model predicting integrative complexity was run twice, once for each dimension), based on the fact that most measurement approaches to the construct have been qualitative (see Driver & Streufert, 1969; Gruenfeld & Hollingshead, 1993; Gruenfeld, Thomas-Hunt, & Kim, 1998; Wong, et al., 2011) and because, to the author's knowledge, they have never previously been assessed via SNA methods and thus little is known about the appropriateness of combining them into a single quantitative mean composite estimate. Unless noted, T2 measures were used for team outcome variables assessed at multiple time points to capture longitudinal team processes.

Chapter 4: Results

Sample Characteristics and Data Screening

A total of 114 individuals across 31 teams participated in this study. The response rate for the first and second surveys was 100 percent. For the third survey, three individuals chose not to respond, making the response rate for this time point 97.40 percent. Due to the low proportion of missing data, mean imputation was applied to these three missing cases for variables relevant to tests of hypotheses. No univariate or multivariate outliers on variables of interest were observed. A mean composite variable, expertise sharing as assessed by Faraj and Sproull's (2000) Bring Expertise to Bear scale, did exceed conventional skew and kurtosis scores, *skew* = -2.22, *kurtosis*

= 7.07 (see Tabachnick & Fidell, 2013). A reverse log transformation was applied, such that the transformed variable met conventional criteria, *skew* = -0.70, *kurtosis* = 0.20.

The sample was composed of individuals from 22 student teams (*n* = 84), four research or lab teams (*n* = 12), and five startup teams (*n* = 18). Sixteen teams participated in the dyad condition and 15 teams participated in the collective condition. The most common education level was bachelor's degree (*n* = 64), followed by master's degree (*n* = 42), and the average age of participants was approximately 29 years. The most common reported ethnicity of participants was white (*n* = 52) followed by Asian (*n* = 35). Subsequent tests of manipulation checks, covariates, and hypotheses were performed using a combination of SPSS, R, and M*plus*.

Manipulation and Sample Integrity Checks

Manipulation checks were done at both the individual and team levels. At the individual level, the manipulation check variables included expertise sharing as measured by the reverse log of Faraj and Sproull's (2000) Bring Expertise to Bear scale, and one original item asking how many teammates participants had engaged in direct, one-on-one conversation with in the session. At the team level, these variables were also used as manipulation checks along with an additional original SNA item assessing actionable expertise exchange (T2) during the training session.

At the individual level, assigned condition (collective vs. dyad) led to significantly different scores on the proportion of teammates with which respondents reported engaging in direct conversation, $t(112) = -2.55$, $p < .05$, such that dyad condition participants reported higher proportions ($M = 0.98$, $SD = 0.10$) than in the collective condition ($M = 0.87$, $SD = 0.29$). No significant difference was observed between the dyad and collective conditions for expertise sharing, $t(112) = 0.19$, $p = .85$. At the team level, the proportion of team conversation partners was higher in the dyad ($M = 0.98$, $SD = 0.06$) than collective ($M = 0.88$, $SD = 0.14$) condition,

$t(29) = -2.65$, $p < .05$. Neither expertise sharing, $t(29) = 0.19$, $p = .85$, nor expertise exchange, $t(29) = -1.53$, $p = .14$, showed a significant difference based on condition at the team level, although expertise exchange trended toward marginal significance such that teams in the dyad condition were somewhat more likely to report denser patterns of expertise exchange between pairs of teammates. Results of manipulation checks suggested that randomly assigned condition had the desired effect of increasing one-on-one conversation between team members, but the manipulation itself may not have increased perceptions of expertise transfer between teammates.

In the interest of ensuring that student and professional teams could be meaningfully combined into the same sample, an additional check at the team level assessed if the nonstudent teams perceived themselves to be more intellectually diverse than members of student teams. In particular, there was no observed difference between student and professional teams in ratings of dyadic expertise similarity at T0, $t(29) = -0.49$, $p = .63$, or T1, $t(29) = -0.14$, $p = .89$, reinforcing the notion that all teams sampled qualified as expertise-diverse KWTs. In addition, the author's informal observation of teams during training sessions likewise did not suggest expertise-diverse teams of students processed information or assigned taskwork in a manner distinct from what has been identified in the literature at the professional level (see Bruns, 2013), nor did student teams appear to possess inherently different degrees of knowledge about the content or utility of their teammates' expertise compared with professionals (see Obstfeld, 2005; Wheelan, 2009).

A final assessment of the effectiveness of randomization into conditions was done via independent samples *t*-tests assessing the difference in potential covariates across conditions. Only one variable, team tenure, was shown to be significantly different by condition, $t(29) = -2.63$, $p < .05$, such that the dyad condition had longer tenure. Examining further, this was found to be due to three dyad teams with high tenure not quite large enough to be deemed univariate outliers. Refer to Table 1 for means and standard deviations for potential covariates by condition, and reports of significance testing across condition for each variable—and note that the standard deviation for tenure in the dyad condition was twice that of control. Table 1 excludes variables explicitly tested above as manipulation checks (i.e., those expected to differ across conditions).

Covariate Screening and Aggregation Statistics

All potential covariates were correlated with each dependent variable (Meyers, Gamst, & Guarino, 2013)—problem-oriented innovativeness at the individual level (see Table 2) and both dimensions of integrative complexity at the team level (see Table 3). For innovativeness (T2), correlations were generated with authority differentiation, team tenure, topic tenure, previous participation in an IDR team, whether a team received outside funding, team size, age, gender, and ethnicity at the individual level. Due to the high proportion of white and Asian respondents, ethnicity was recoded as “white” or “nonwhite.” In addition to covariates proposed above in the Measures section, any variable deemed conceptually relevant was also tested, including whether or not the team was composed of students and the site where training was administered. Of these, funding, $r = 0.22$, $p < .05$, authority differentiation, $r = 0.26$, $p < .05$, and student team versus nonstudent team, $r = 0.29$, $p < .05$, were significantly associated with innovativeness—those whose teams received outside funding, had more centralized leadership, and were not students also tended to report higher innovativeness.

For team level dependent variables, namely, the conceptual integration and evaluative differentiation dimensions of integrative complexity (T2), both expertise similarity and shared leadership SNA measures were added as potential covariates. For the sake of brevity in reporting results, integration and differentiation will be referred to as IC-IC and IC-ED, respectively, in the Results section. For IC-ED, previous IDR participation, $r = 0.43$, $p < .05$, shared leadership, $r =$

0.52, $p < .01$, and expertise similarity, $r = 0.37$, $p < .05$, were significantly positively correlated, such that teams with a higher proportion of members with past IDR experience, higher shared leadership, and higher mutual expertise similarity reported team outcomes of higher IC-ED. For IC-IC, IDR participation, $r = 0.42$, $p < .05$, and shared leadership, $r = 0.57$, $p < .05$, were also significantly positively correlated. Significant covariates were included in subsequent hypothesis tests, supplemented by conceptually relevant covariates where appropriate. See Tables 2-3 for correlations between potential covariates at the individual and team levels, Tables 4-5 for the descriptive statistics for variables relevant to tests of hypotheses, and Tables 6-7 for bivariate correlations between variables relevant to tests of hypotheses. Finally, although team tenure was shown to lack association with any potential dependent variables (the conceptual basis for use as a covariate; Meyers et al., 2013), given the significant difference observed for team tenure across conditions, Table 8 demonstrates via correlations that tenure showed no significant association with any other variable relevant to hypothesis testing—bolstering results of covariate screening.

Aggregation statistics were computed for compositional variables in team level analyses (i.e., those assessed via mean composite scores of individual items). Mean square estimates from random effects ANOVAs were used to compute ICC(1)—a proportion of variance explained by group membership—and ICC(2)—the reliability of group-level means (see Bliese, 2000)—for team vision, compositionally measured psychological safety, and problem oriented innovation. The r_{wg}—a within group correlation that does not take into account between groups variance—is also listed. For team vision, about 12% of the variance in visioning was explained by group/team membership, $ICC(1) = .12$, group mean reliability was a bit low, $ICC(2) = .35$, and mean r_{wg} was sufficient, $r_{wg} = 0.87$. For psychological safety, 28% of variance was due to group membership, $ICC(1) = .28$, group mean reliability was adequate, $ICC(2) = .60$, and mean r_{wg} was sufficient,

r_{wg} = .70. For problem-oriented innovation, 8% of variance was accounted for by group, *ICC(1)* = .08, group mean reliability was low, *ICC(2)* = .25, and r_{wg} failed to meet conventional cutoff criteria, r_{wg} = .53. Note that while ICC(1) values met criteria for team-level aggregation (Bliese, 1998), ICC(2) and r_{wg} for innovativeness in particular were low[1] (see Biemann, Cole, & Voelpel, 2012; Fleiss, 1986). Given this, hypothesis tests using problem-oriented innovativeness as the dependent variable did not use mean composites of the construct. Tests of aggregation implied that conditional process analyses and multilevel analyses are needed to test hypotheses. As such, all reported weights are unstandardized unless explicitly stated, as is conventional for conditional process models (see Hayes, 2013) and multilevel analyses (see Hox, 2010). See Table 9 for a detailed overview of hypothesis testing approaches, analyses used, goals, and achieved results.

Testing Hypothesis 1: Effects of Assigned Training Conditions on Outcomes

Hypothesis 1a—expertise-diverse teams undergoing more dyadic exchange will report outcomes of higher integrative complexity—was assessed at the team level with two ANCOVAs to test differences between randomly assigned condition on IC-IC and IC-ED. For IC-IC, tested covariates included shared leadership, $F(1,22) = 3.17$, $p = .09$, past IDR participation, $F(1,22) = 1.13$, $p = .30$, and expertise similarity, $F(1,22) = 2.52$, $p = .13$. Given the potential link between integrative complexity and team size in knowledge work industries—large teams have inherently larger potential for outcomes that incorporate ideas from multiple areas of expertise—the number of members who attended the training session was also used as a covariate, $F(1,22) = 0.43$, $p = .52$. Lastly, to preempt tests of mediation and moderation in subsequent hypotheses, visioning, $F(1,22) = 2.01$, $p = .17$, transactive memory (SNA), $F(1,22) = 1.98$, $p = .17$, and compositionally measured psychological safety, $F(1,22) = 0.58$, $p = .46$, were included in the models. The test of H1a revealed a marginally significant difference for assigned condition on IC-IC (see Table 10),

$F(1,22) = 3.77$, $p = .06$, such that teams in the dyad condition ($M = 5.40$, $SD = 0.70$) reported the creation of outcomes displaying higher integration of diverse ideas than teams in the collective condition ($M = 4.90$, $SD = 0.58$). For IC-ED, shared leadership, $F(1,23) = 3.73$, $p = .07$, past IDR participation, $F(1,23) = 2.76$, $p = .11$, and team size, $F(1,23) = 0.60$, $p = .45$, acted as covariates, with visioning, $F(1,23) = 0.31$, $p = .58$, transactive memory, $F(1,23) = 0.55$, $p = .47$, and team psychological safety, $F(1,23) = 0.06$, $p = .81$, likewise included in the model. No significant difference was observed between conditions, $F(1,23) = 1.64$, $p = .21$. Results showed partial support for H1a (see Table 10).

Hypothesis 1b—that expertise-diverse teams that engage in more dyadic exchange will have outcomes of higher innovativeness—was assessed using a multilevel regression due to both the poor aggregation statistics reported for innovativeness and the higher power afforded by use of individual level measurements. A null model assessing the amount of variance accounted for in innovativeness due to team membership revealed consistency with the ICC(1) reported in the aggregation statistics, $ICC = .07$. Covariates included outside funding, $B = 0.13$, $t = 0.53$, $p = .60$, authority differentiation, $B = 0.29$, $t = 3.29$, $p < .01$, and number of members, $B = 0.30$, $t = 2.74$, $p < .05$. Authority differentiation and team size showed a significant association with team innovativeness, such that teams with more centralized leadership and larger team size tended to report more innovative outcomes. As with tests of H1a, team visioning, $B = 0.31$, $t = 1.65$, $p = .10$, transactive memory, $B = 0.50$, $t = 2.13$, $p < .05$, and psychological safety, $B = 0.19$, $t = 1.65$, $p = .10$, were included in the model to be consistent with subsequent models. Assigned condition positively predicted innovativeness, $B = 0.63$, $t = 2.95$, $p < .01$, such that teams assigned to the dyad condition reported being more innovative with respect to problem solving two weeks after the training session concluded. The results offered positive support for H1b (see Table 11).

Testing Hypotheses 2-5: Mediation by Transactive Memory and Team Visioning

To test the mediation hypotheses proposed in H2-H5, bootstrapped conditional process models tested dual mediation on team-level dependent variables assessing integrative complexity (SPSS PROCESS model 6 with 10,000 bootstrapped samples; Hayes, 2013). Multilevel SEM (MSEM) was used to test the team innovativeness dependent variable for which aggregation was not justified. Although previous recommended sample size requirements for SEM are slightly larger than what was available in this study, more recent literature supports use of smaller sample sizes in cases when the SEM model has fewer parameters or does not use latent constructs, both of which were true for models tested here (e.g., Sideris, Simos, Papanicolaou, & Fletcher, 2014; Wolf, Harrington, Clark, & Miller, 2013). For this reason, models specified were tested as path models using mean composites to generate team-level estimates of constructs. It should also be noted that the team-level sample size met criteria for multilevel modeling with respect to the desired sample at the highest level of analysis relative to model complexity (i.e., > 30 groups; see Scherbaum & Ferreter, 2009). Team level mediations are addressed first.

Tests of team-level mediation. Due to the complexity of statistical models and the low team-level sample size, all covariates initially tested are reported but estimates for the variables directly relevant to hypothesis tests were derived from models with only statistically significant covariates retained. For IC-IC, shared leadership, $B = 0.29$, $t = 2.49$, $p < .05$, $LLCI = 0.05$, $ULCI = 0.53$, past IDR participation, $B = -0.01$, $t = -0.06$, $p < .95$, $LLCI = -0.46$, $ULCI = 0.43$, expertise similarity, $B = 0.08$, $t = 1.06$, $p = .30$, $LLCI = -0.07$, $ULCI = 0.22$, and team size, $B = -0.10$, $t = -1.00$, $p = .33$ $LLCI = -0.30$, $ULCI = 0.10$, acted as initial covariates. Shared leadership displayed statistical significance—teams reporting higher shared leadership also reported higher integration in team outcomes—and was retained in the dual mediation model with IC-IC as the outcome.

For the dual mediation model predicting IC-IC, the condition did not predict transactive memory,[2] *B* = -0.07, *t* = -0.51, *p* = .61, *LLCI* = -0.37, *ULCI* = 0.22, or team visioning, *B* = -0.04, *t* = -0.33, *p* = .74, *LLCI* = -0.25, *ULCI* = 0.18 (*a* paths). These results failed to support H2 or H4. Transactive memory did predict IC-IC,[3] *B* = 0.54, *t* = 2.19, *p* < .05, *LLCI* = 0.03, *ULCI* = 1.04, however, such that a higher reported salience of complementarity of teammate expertise to one's own work was associated with significantly higher integration of diverse concepts in outcomes at the team level. Visioning marginally negatively predicted IC-IC, *B* = -0.58, *t* = -1.69, *p* = .10, *LLCI* = -1.28, *ULCI* = 0.13 (*b* paths). Results showed partial support for H3a and no support for H5a. Tests of indirect effects do not support the mediation of assigned condition to IC-IC via transactive memory, *Effect* = -0.04, *LLCI* = -0.21, *ULCI* = 0.21, or via visioning, *Effect* = 0.02, *LLCI* = -0.12, *ULCI* = 0.17 (*a**b* effect). Condition significantly predicted IC-IC in the direct effect model, *B* = 0.39, *t* = 2.07, *p* < .05, *LLCI* = 0.01, *ULCI* = 0.77, and was marginal in the total effect model (*c* path), *B* = 0.37, *t* = 1.85, *p* = .08, *LLCI* = -0.04, *ULCI* = 0.78, reinforcing H1a.

When assessing mediation on IC-ED, initial covariates included shared leadership, *B* = 0.47, *t* = 2.10, *p* < .05, *LLCI* = 0.01, *ULCI* = 0.94, past IDR participation, *B* = 0.62, *t* = 1.87, *p* = .07, *LLCI* = -0.06, *ULCI* = 1.31, and team size, *B* = 0.13, *t* = 0.80, *p* = .43, *LLCI* = -0.20, *ULCI* = 0.46. Shared leadership displayed statistical significance, such that higher shared leadership was associated with higher evaluative differentiation, and past IDR participation displayed marginal significance, such that teams with a higher proportion of members with IDR experience reported higher differentiation. Both were retained in the mediation test. Condition again did not predict TMS, *B* = -0.10, *t* = -0.64, *p* = .53, *LLCI* = -0.41, *ULCI* = 0.22, or visioning, *B* = -0.03, *t* = -0.27, *p* = .79, *LLCI* = -0.26, *ULCI* = 0.20 (*a* paths), failing to support H2 and H4. Neither TMS,[4] *B* = 0.24, *t* = 0.79, *p* = .44, *LLCI* = -0.39, *ULCI* = 0.88, nor visioning, *B* = -0.32, *t* = -0.73, *p* = .47, *LLCI* = -1.21, *ULCI* = 0.57, predicted ID-ED (*b* paths), and indirect effects for TMS, *Effect* = -0.02, *LLCI* = -0.20, *ULCI* = 0.15, and visioning, *Effect* = 0.01, *LLCI* = -0.08, *ULCI* = 0.17, were not significant (*a**b* effects). Condition also failed to predict IC-ED in the direct effect model, *B* = 0.27, *t* = 1.11, *p* = .28, *LLCI* = -0.23, *ULCI* = 0.78. Results failed to support H3a and H5a.

Post hoc tests of team-level mediation. Given that the dyadic condition was designed to increase expertise exchange and condition was marginally positively associated with actionable expertise exchange in manipulation checks, this variable was substituted for assigned condition as an independent variable in the team-level tests of mediation hypotheses reported above, using identical covariates (see Figure 2). For the IC-IC, shared leadership was a significant covariate, *B* = 0.55, *t* = 2.88, *p* < .05, *LLCI* = 0.16, *ULCI* = 0.94. Expertise exchange marginally positively predicted TMS, *B* = 0.21, *t* = 1.99, *p* = .06, *LLCI* = -0.01, *ULCI* = 0.43, lending potential support for H2, but was not associated with team visioning, *B* = 0.07, *t* = 0.88, *p* = .39, *LLCI* = -0.10, *ULCI* = 0.25 (*a* paths), failing to support H4. In the final model, TMS was marginally positively predictive of integration,[5] *B* = 0.51, *t* = 1.85, *p* = .08, *LLCI* = -0.06, *ULCI* = 1.09, and visioning showed a marginally negative effect, *B* = -0.61, *t* = -1.63, *p* = .12, *LLCI* = -1.38, *ULCI* = 0.16 (*b* paths). Transactive memory was a marginally significant mediator, *Effect* = 0.11, *LLCI* = -0.07, *ULCI* = 0.37, but visioning was not, *Effect* = -0.05, *LLCI* = -0.14, *ULCI* = 0.07 (*a**b* effects). Expertise exchange was not significantly predictive of IC-IC in the final mediation model, *B* = -0.04, *t* = -0.25, *p* = .81, *LLCI* = -0.39, *ULCI* = 0.30 (*c'* path). Results may offer partial support for H3a but still failed to support H5a. See Figure 2 for a path diagram of mediation via TMS.

For IC-ED, shared leadership, *B* = 0.54, *t* = 2.47, *p* < .05, *LLCI* = 0.09, *ULCI* = 0.99, and past IDR participation, *B* = 0.64, *t* = 2.08, *p* < .05, *LLCI* = 0.01, *ULCI* = 1.27, acted as covariates. Expertise exchange failed to predict either TMS, *B* = 0.04, *t* = 0.46, *p* = .65, *LLCI* = -0.16, *ULCI*

= 0.25, or team visioning, *B* = 0.09, *t* = 1.08, *p* = .29, *LLCI* = -0.08, *ULCI* = 0.26 (*a* paths). Both TMS,[6] *B* = -0.43, *t* = -1.18, *p* = .25, *LLCI* = -1.17, *ULCI* = 0.31, and team visioning, *B* = -0.44, *t* = -1.03, *p* = .32, *LLCI* = -1.33, *ULCI* = 0.45, failed to predict IC-ED. The bootstrapped indirect effects for TMS, *Effect* = -0.02, *LLCI* = -0.15, *ULCI* = 0.10, and visioning, *Effect* = -0.04, *LLCI* = -0.22, *ULCI* = 0.06, were likewise nonsignificant. Expertise exchange did not predict IC-ED in the final mediation model, *B* = 0.22, *t* = 1.19, *p* = .24, *LLCI* = -0.16, *ULCI* = 0.61. Results failed to support H2, H3a, H4, or H5a when predicting IC-ED.

Multilevel tests of mediation. Multilevel SEM was employed to assess the potential dual mediation of innovativeness. Given that some variables were assessed only at the team-level (i.e., SNA statistics), different models must be specified with the partitioned within (individual-level) and between group (team-level) variance. Due to the limitations of model specification in M*plus* when using different within and between group models—in this case, a variable may not act only as a predictor at one level of analysis and only as outcome at another simultaneously—psychological safety was added to the model without the test of an interaction effect (see tests of H6b). For variables measured compositionally (i.e., assessed by each individual and therefore varying within groups), the same paths were specified within and between groups. Thus, the only model specification differences between levels address relations between team-level constructs or covariates. Further, M*plus* does not yet permit bootstrapping of multilevel models (Muthen & Muthen, 2017) therefore estimates of indirect effects cannot be bootstrapped in the same manner as a conditional process model (e.g., Hayes, 2013). Reported estimates for model parameters were taken from the group-level given that the motivation behind using multilevel modeling in this paper is primarily to account for nesting, avoid aggregation of team innovativeness, and to maximize statistical power, and because all the hypotheses were specified at the team level.

In a dual mediation multilevel path model assessing the impact of assigned condition on team innovativeness through TMS and team visioning, using authority differentiation, $B = 0.12$, $t = 1.04$, $p = .30$, and student vs. nonstudent, $B = 0.11$, $t = 1.41$, $p = .16$, as covariates, the model displayed good fit, $\chi^2 = 15.61$, $\chi^2/df = 1.42$, $CFI = .92$, $TLI = .80$, $RMSEA = .06$. The variance associated with group membership was higher than previous models after explicitly accounting for indirect effects in the model, $ICC = .20$. Condition failed to predict either team visioning, $B = 0.09$, $t = 0.81$, $p = .42$, or transactive memory, $B = 0.12$, $t = 0.84$, $p = .40$ (*a* paths), failing to support H2 or H4. Assigned condition marginally predicted team innovativeness, $B = 0.49$, $t = 1.88$, $p = .06$ (*c'* path), offering support for H1. Transactive memory predicted problem-oriented innovativeness,[7] $B = 0.86$, $t = 2.39$, $p < .05$, such that expertise complementarity and the use of a TMS was associated with higher innovativeness, while team visioning did not, $B = -1.11$, $t = -1.13$, $p = .26$ (*b* paths). Tests of indirect effects for both TMS, $Effect = 0.10$, $t = 0.78$, $p = .44$, and visioning did not attain statistical significance, $Effect = -0.10$, $t = -0.68$, $p = .50$. Results failed to support either H3b or H5b.

Post hoc multilevel tests of mediation. Expertise exchange (T1) was substituted for the assigned condition in the above multilevel path model, again using authority differentiation, $B = 0.11$, $t = 0.91$, $p = .36$, and student versus nonstudent, $B = 0.13$, $t = 1.38$, $p = .17$, as covariates (see Figure 3). Model fit was middling to adequate, $\chi^2 = 22.24$, $\chi^2/df = 2.02$, $CFI = .85$, $TLI = .65$, $RMSEA = .09$. Expertise exchange did not predict innovation, $B = 0.27$, $t = 0.92$, $p = .36$ (*c'* path). Expertise exchange positively predicted both visioning, $B = 0.15$, $t = 2.19$, $p < .05$, and TMS, $B = 0.25$, $t = 2.93$, $p < .001$ (*a* paths), offering potential support for H2 and H4. Visioning, in turn, did not significantly predict team innovativeness, $B = -1.30$, $t = -0.88$, $p = .38$, but TMS was positively predictive,[8] $B = 0.93$, $t = 2.50$, $p < .05$ (*b* paths), such that teams reporting higher transactive memory also reported higher innovativeness. Tests of indirect effects did not show a mediation effect for visioning, *Effect* = -0.20, *t* = -0.82, *p* = .41, but displayed a positive indirect effect for TMS, *Effect* = 0.23, *t* = 1.95, *p* = .05, such that expertise exchange was linked to more salient expertise complementarity, which was in turn associated with higher team innovativeness. Note, as mentioned, tests of indirect effects cannot be bootstrapped in MSEM in M*plus.* Results offered tentative support for H3b. See Figure 3 for a path diagram of the successful mediation.

Testing Hypothesis 6: Moderation by Psychological Safety

Psychological safety was added as a moderator to tests of mediation reported above. For team-level dependent variables analyses were run via SPSS PROCESS model 7 testing a single moderator and mediator—PROCESS does not permit moderators in models with more than one mediator. Four models for moderated mediation (2 mediators X 2 dependent variables) assessed H6 at the team level. At the individual level, the psychological safety interaction term was added to the reported MSEM model when predicting both mediators (on the *a* paths; see Figure 1). All moderation tests used identical covariates to those tested in previously reported models. Unless the estimate of an effect changed significance or direction, only the results of moderation tests are reported for the sake of brevity.

Team-level moderation analyses. Testing the moderation of psychological safety on the relationship between assigned condition and transactive memory, as well as on the mediation of the IC-IC outcome, the interaction between condition and safety predicting the TMS mediator did not attain statistical significance, *B* = -0.07, *t* = -0.23, *p* = .82, *LLCI* = -0.70, *ULCI* = 0.56, nor did the test of moderated mediation assessing the extent to which mediation varies across levels of safety, *Effect* = -0.03, *LLCI* = -0.54, *ULCI* = 0.49. The main effect of psychological safety did display marginal significance, *B* = 0.33, *t* = 1.84, *p* = .08, *LLCI* = -0.04, *ULCI* = 0.70, however. Results of moderation using IC-ED as the outcome were similar, with respect to tests of moderation, *B* = 0.01, *t* = 0.01, *p* = .99, *LLCI* = -0.64, *ULCI* = 0.65, and moderated mediation, *Effect* = 0.01, *LLCI* = -0.41, *ULCI* = 0.53. The main effect of safety failed to attain significance, *B* = 0.23, *t* = 1.33, *p* = .20, *LLCI* = -0.13, *ULCI* = 0.60, however. Results failed to support H6a.

Adding the psychological safety moderator to the test of mediation of assigned condition predicting team visioning, as well as the mediation of the IC-IC outcome, the interaction between condition and psychological safety was marginally significant, *B* = 0.37, *t* = 1.76, *p* = .09, *LLCI* = -0.07, *ULCI* = 0.82, such that higher psychological safety in the dyad condition was associated with higher team visioning (see Figure 4). In the presence of the interaction, the main effect for safety was nonsignificant, *B* = 0.02, *t* = 0.16, *p* = .87, *LLCI* = -0.24, *ULCI* = 0.28. The indirect effect assessing moderated mediation was also nonsignificant, *Effect* = -0.13, *LLCI* = -0.46, *ULCI* = 0.15. Given that the model assessing the *a* path of this mediation was identical to that of the mediation predicting differentiation, the test of moderation, *B* = 0.37, *t* = 1.78, *p* = .09, *LLCI* = -0.06, *ULCI* = 0.79, and the main effect, *B* = 0.03, *t* = 0.25, *p* = .80, *LLCI* = -0.21, *ULCI* = 0.27, were unsurprisingly consistent. The test of moderated mediation was also nonsignificant, *Effect* = -0.07, *LLCI* = -0.44, *ULCI* = 0.26. Results showed partial support for H6b.

Post hoc team-level moderation analyses. As with previous hypothesis tests, expertise exchange was substituted for condition. In a team-level mediation model predicting IC-IC via transactive memory, the interaction between dyadic expertise exchange and safety did not show statistical significance, *B* = 0.09, *t* = 0.62, *p* = .54, *LLCI* = -0.20, *ULCI* = 0.38, although the main effect of safety did, *B* = 0.30, *t* = 2.24, *p* < .05, *LLCI* = 0.02, *ULCI* = 0.59. The test of moderated mediation was not significant, *Effect* = 0.03, *LLCI* = -0.25, *ULCI* = 0.18. Predicting IC-ED, the moderation effect, *B* = 0.01, *t* = 0.09, *p* = .93, *LLCI* = -0.27, *ULCI* = 0.30, main effect of safety, *B* = 0.22, *t* = 1.65, *p* = .11, *LLCI* = -0.05, *ULCI* = 0.49, and moderated mediation, *Effect* = 0.01, *LLCI* = -0.30, *ULCI* = 0.16, failed to show statistical significance. Results failed to support H6a.

Using expertise exchange to predict IC-IC via team visioning, the test of moderation, *B* = 0.01, *t* = 0.02, *p* = .98, *LLCI* = -0.23, *ULCI* = 0.23, main effect of psychological safety, *B* = 0.15, *t* = 1.40, *p* = .18, *LLCI* = -0.07, *ULCI* = 0.37, and moderated mediation, *Effect* = 0.01, *LLCI* = -0.17, *ULCI* = 0.23, did not attain significance when using the IC-IC outcome. Similarly, when using the IC-ED outcome, the moderation, *B* = 0.01, *t* = 0.03, *p* = .97, *LLCI* = -0.21, *ULCI* = 0.22, main effect, *B* = 0.15, *t* = 1.56, *p* = .13, *LLCI* = -0.05, *ULCI* = 0.35, and the moderated mediation effect, *Effect* = 0.01, *LLCI* = -0.17, *ULCI* = 0.20, were likewise not significant. Results failed to support H6b. As stated, refer to Table 9 for an overview of tests of hypotheses.

Multilevel moderation analyses. Psychological safety was added as a moderator in the dual mediation multilevel path model used to assess H3b and H5b. M*plus* does not permit the bootstrapping of MSEM models, therefore a test of moderated mediation is not reported. For the mediation model predicting the IC-IC, the fit of the model remained adequate, χ^2 = 21.68, χ^2/df = 1.28, *CFI* = .91, *TLI* = .81, *RMSEA* = .05. The main effect of safety was significant when used to predict both visioning, *B* = 0.41, *t* = 2.48, $p < .05$, and transactive memory, *B* = 0.75, *t* = 3.35, $p < .01$, but the interaction term did not predict either visioning, *B* = -0.25, *t* = -0.58, *p* = .56, or TMS, *B* = -0.42, *t* = -0.93, *p* = .35. These results failed to support H6a or H6b.

Post hoc multilevel moderation analyses. As with other tests of hypotheses, expertise exchange was substituted for condition. With psychological safety as a moderator in a multilevel path model using expertise exchange to predict innovativeness via team visioning and transactive memory, model fit was somewhat poorer than that of previous models, χ^2 = 28.98, χ^2/df = 1.71, *CFI* = .84, *TLI* = .67, *RMSEA* = .08. The main effect of safety predicted both team visioning, *B*

= 0.28, $t = 2.00$, $p < .05$ and TMS, $B = 0.51$, $t = 2.88$, $p < .01$, but the interaction terms failed to attain significance when predicting visioning, $B = 0.14$, $t = 0.93$, $p = .35$, or TMS, $B = 0.11$, $t = 0.53$, $p = .60$. Results failed to support H6a or H6b.

Chapter 5: Discussion

A central purpose of this study was to use a naturalistic training intervention to highlight forms of collaboration often overlooked, yet critical to success in today's expertise-diverse KWT that must integrate skillsets inter-paradigmatically. This was achieved through an emphasis on dyadic interaction between individuals from different expertise domains, highlighting expertise complementarity in addition to cultivating knowledge, vision, and motivation shared identically in common, and a procedural focus on cognitive hybrid interdependence to achieve innovation at the team level (Bruns, 2013; Cross & Sproull, 2004; Edmondson & Harvey, 2016; Girotra et al., 2010; Kozlowski & Ilgen, 2006; Tannenbaum et al., 2012). To this end, results of the hypothesis tests revealed that random assignment of teams to the dyad (experimental) condition did indeed lead to outcomes of higher reported innovativeness when assessed two weeks after the training session (H1b), and, with respect to conceptual integration of ideas across expertise domains, teams in the dyad condition also reported outcomes of higher integrative complexity than in the collective (control) condition (H1a). A causal inference may be made for these results, such that more frequent, explicitly dyadic interaction in expertise diverse teams can lead to outcomes of higher innovativeness and conceptual integration.

Although outcomes are self-reported, past research has shown that it is often the teams themselves who are best suited to judge the quality of outcomes in highly specialized knowledge work (e.g., Amabile, 1982). Mediation hypotheses could not be supported when assessing impact of assigned condition, however. One moderation test showed marginal support, such that teams in the dyad condition with higher reported psychological safety reported a greater extent of team visioning (H6b). Although it is not statistically significant, this result trends in the hypothesized direction and may suggest that teams with dyads willing to exchange individualized impressions of how the team should go about its work in team contexts perceived as safe could lead to widely distributed, emergent and robust agreement with the team's vision over time (see Frazier et al., 2016) as opposed to being a product of top-down communication or somewhat more superficial agreement in "team meeting" settings, as could have been the case in control teams.

Another central thesis of the paper was that dyadic interaction increases the frequency of actionable expertise exchange (e.g., Cross & Sproull, 2004; Faraj & Sproull, 2000). Results show that impact of the training on a measure of expertise exchange in the relatively small team level sample trends marginally positive. When using direct reports of actionable expertise exchanged in dyads during training instead of assigned condition itself—although it sacrifices the potential for causal inference—the observed relationship of expertise exchange to conceptual integration is mediated by salience of expertise complementarity—a core aspect of functioning transactive memory systems (i.e., its differentiation, Peltokorpi, 2008). As such, teams with denser patterns of expertise exchange also tended to report more differentiated transactive memory systems, a feature that, in turn, positively predicted both conceptual integration (H3a) and innovativeness (H3b), respectively. Further, actionable expertise exchange in dyads was consistently positively associated with TMS (H2) and visioning (H4). No tests of moderation were successful using expertise exchange as the exogenous predictor, however.

Overall, results show consistency with the study's core logic—expertise-diverse KWTs increasingly rely on deeper specialization (Von Nordenflycht, 2010), and achieve innovation and knowledge integration via “consultation” (Bruns, 2013) with the intellectually distant skill sets of teammates, especially in dyads (Tannenbaum et al., 2012), leading to macrocognitive knowledge building that precedes the creation of shared team-level outcomes (Hargadon & Bechky, 2006). Closer examination of hypothesis tests in this study offers more detail. First, assigning a team to the dyad condition did indeed result in more dyad-level conversations among members. The link between expertise exchange and team outcomes could be explained by a heightened salience of how each member’s respective skillset was different than but still useful to the day-to-day work of others, and to teamwork as a whole—the differentiation component of TMS. Although results using expertise exchange as the predictor lacked causal inference, the finding is highly consistent with past research showing that compilational knowledge, and transactive memory in particular, is predictive of performance outcomes in knowledge teams (e.g., DeChurch & Mesmer-Magnus, 2010a; Kozlowski & Ilgen, 2006; Lewis, 2003; Peltokorpi, 2008).

With respect to null results, two are particularly noteworthy. First, neither assignment to condition nor actionable expertise exchange was associated with evaluative differentiation—a historically important dimension of integrative complexity (see Driver & Streufert, 1969), and mediation and moderation tests failed for this outcome variable as well. This result may be due to emphasis placed in the training on knowledge integration as the ultimate goal of expertise-diverse teamwork (see Girotra et al., 2010, Hargadon & Bechky, 2006) rather than the awareness of team members’ differentiated contributions to team outcomes, or due to the assumption that evaluative differentiation would be a natural consequence of the training session rather than an outcomes that would require targeting by the researcher. Alternatively, the generally small team sizes in this study may have served to systematically capture outcomes from teams where all members worked on all aspects of team knowledge products. Another explanation could be the relatively short time scale of the study relative to the duration of teams' project work. Indeed, it is possible that knowledge of distinct individual contributions emerges more slowly over time, as it requires not only knowledge of others' skillsets but highly detailed understanding of how they are using them when completing nuanced taskwork. Given that expertise-diverse KWTs spend more time doing their work in a distributed fashion—often physically removed from teammates (Bruns, 2013)—the salience of members' differentiated contribution to outcomes may be less apparent than in teams where members are in closer behavioral collaboration.

Of additional interest is that team visioning—a compositional construct—did not mediate team outcomes in the presence of the compilational component of transactive memory, which did act as a successful mediator between expertise exchange and conceptual integration and between expertise exchange and innovativeness. While it is possible that this measure did not adequately capture team visioning and thus did not function as a proxy of compositional knowledge, it is worth noting that this finding is consistent with team cognition literature asserting compilational knowledge is more critical in teams where expertise diversity and specialization are high (e.g., DeChurch & Mesmer-Magnus, 2010a; Kozlowski & Chao, 2012a; Kozlowski & Ilgen, 2006). Although not a successful mediator, visioning did marginally negatively predict the conceptual integration dimension of integrative complexity. While visioning has been repeatedly associated with positive team outcomes across teamwork contexts (e.g., Anderson & West, 1996; Salazar et al., 2012; West, 1990), it is also stated to be differentially related to outcomes in different stages of teaming (e.g., Marks, Mathieu, & Zaccaro, 2001). Given that the present sample is comprised almost exclusively of newly formed teams, it is conceivable that narrowing on a team vision too early is counterproductive and detracts from the cognitive flexibility required to create problem spaces that allow for input from each member's diverse skillset in a manner that permits creation of integratively complex outcomes (see Fiore & Schooler, 2004).

A final note pertains to covariates examined in the study. Two covariates—both related to leadership—consistently predicted team outcomes. At the team level, the extent to which team members look to one another for leadership (Carson et al., 2007) was positively associated with the conceptual integration of team outcomes. This is consistent with the notion that intellectually distant specialists must look to one another to bridge understanding of their respective expertise domains in order to generate knowledge products that represent varied aspects of each of their skillsets (Salazar et al., 2012). With respect to innovation, however, authority differentiation acts as a significant covariate, such that more centralized leadership was associated with problem-oriented innovativeness. While perhaps initially counterintuitive, these results are not mutually exclusive. Note that the innovativeness outcome was specifically related to a team's ability to solve problems, and research has highlighted the difficulty expertise-diverse teams in particular can encounter without a coherently defined problem space in which exchange can occur—such as may be offered by a single decision maker (Eigenbrode et al., 2007; Slyngstad et al., 2017).

Contributions of the Present Study

This paper makes several notable contributions to team cognition and macrocognition research, and to organizational research in general. Beginning with more general contributions, this study succeeds in embodying the spirit of calls for more truly multilevel research that have been strongly voiced over the last two decades (e.g., Kozlowski & Klein, 2000), as well as more recent calls to examine organizational phenomena at the dyadic level of analysis (e.g., Borgatti et al., 2009; Tannenbaum et al., 2012). More notably, it has overcome several methodological and statistical challenges to doing true multilevel research, such as the often cited poor experimental control in organizational studies, the inclusion of hypothesis testing explicitly modeling multiple levels of analysis simultaneously and the varied statistical assessment strategies needed to do so (e.g., Scherbaum & Ferreter, 2009), and the improper operationalization of cognitive constructs (e.g., Kozlowski & Chao, 2012a, Kozlowski et al., 2013). Specifically, the present study was a true field experiment—an especially rare feat in team-level studies using naturalistic training—that also exceeded minimum sample size requirements for multilevel analysis. It additionally furthered the trend toward rigorous inclusion of social network analysis in studies of teams and organizations (e.g., Borgatti et al., 2013; Knoke & Yang, 2008; Wasserman & Faust, 1994) by applying the method to model compilational cognition (see Fiore & Wiltshire, 2016; Kozlowski & Chao, 2012a; Kozlowski et al., 2013), an approach that accurately captures compilational constructs and better distinguishes them from compositional ones while retaining an element of feasibility, given that SNA methods are highly compatible with common survey methodology. Finally, it was a longitudinal examination of teamwork with three distinct points of observation.

This research makes several conceptual contributions. It is among the first to explicitly name expertise diversity as a core driver of qualitative characteristics of the structure and content of team processes. While past research has frequently attempted to assess effects of information or expertise diversity on team functioning and performance (e.g., Joshi & Roh, 2009), this study more clearly defines the nature of expertise-diversity by incorporating the notion of knowledge boundaries (Edmondson & Harvey, 2016) and charts their effects conceptually and empirically on team processes and outcomes. As was supported by the results, this study elevates the role of dyadic expertise exchange and compilational emergent cognition over collective compositional cognition in teams with high member expertise diversity without denying the importance of the latter to innovation, and in doing so reasserts the importance of structural features of cognition in teams as well as appropriate strategies for measuring them. Additionally, by explicitly comparing the effects of compilational and compositional knowledge mediating the role of team interactions in the creation of innovative outcomes, this study serves as one of the first multilevel empirical (and to the author's knowledge, the first experimental) tests of a macrocognitive framework, and demonstrates that macrocognition is well suited for use with conventional constructs from team cognition despite originating from distinct literature. In using multiple outcome measures, this paper initiates discussion about types of training interventions effective for increasing innovation versus conceptual integration, as well versus evaluative differentiation of team outcomes.

Limitations of the Present Study

Despite the contributions, this study is subject to several limitations. First, although the sample size met criteria for stable estimates in tested models, it likely still suffers from the low power that affects many studies of organizations behavior (Scherbaum & Ferreter, 2009). Data were also collected using self-report methods, and the pitfalls of common method bias are well documented (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), even if unavoidable in this study. Further, it is sensible to question the extent to which complex team behaviors such as expertise exchange can be accurately or fully captured with the single items conventionally used to assess dyadic interactions, despite the fact that this is common practice in research employing social network analysis (e.g., Carson et al., 2007), or how well the use of single constructs—transactive memory and visioning in this paper—can be said to serve as adequate proxies for compilational and compositional classes of constructs, respectively. Consistent with the previously mentioned limitations, feasibility due to survey length prohibits the inclusion of a more comprehensive list of constructs for either of these purposes, especially when measured via SNA. It is also worth questioning whether findings derived from this relatively small sample, which included many student teams, can be generalized to expertise-diverse teams in general, especially those at the most competitive levels of academia and industry—although it should be noted that some of these were included in the present sample. Lastly, although this study was longitudinal, its time scale was relatively short (two weeks) and it is unknown whether stronger or additional effects would have emerged over a longer period of time.

Directions for Future Research

The results of this paper suggest several potential avenues for future research. The first is to discover conditions in which compositional knowledge acts as a successful mediator of dyadic team interactions in the presence of compilational constructs in highly expertise-diverse KWTs. The second is to discover moderators that are reliably associated with the formation of that team knowledge. Future research may also benefit from refining the training intervention such that it gives participants a strong impression that actionable expertise is being exchanged in the session itself. Indeed, the training was structured as an innovative approach to team meetings rather than a work session to make dyadic conversation more feasible to implement across the sample. An additional area of interest would be examination of teams over a longer period of time than the two weeks allotted in this study, despite the feasibility issues involved, as it is conceivable that some effects do not emerge until teams are more practiced in their project work and members have cultivated a more detailed knowledge of the expertise each of their teammates possess. As a corollary to this notion, further investigation of team tenure and how it relates to or interacts with dyadic team processes would be beneficial. As is shown in Table 2, team tenure in this study is somewhat confounded with other variables such as research site and outside funding received. A future assessment might explicitly seek to sample a wider range of teams with varying tenure and incorporate this construct explicitly into tests of hypotheses. In addition, a test of the results with a larger sample would also aid in generalizing results, particularly if the sample included a higher frequency of professional research or industry teams or if it compared inter-paradigmatic teams to those that process information intra-paradigmatically.

Conclusion

This paper sought to demonstrate that commonly cited modes of team cognition—those relying primarily on team-level interactions and sustained coordination—are inadequate when describing how innovation is achieved in today's increasingly common teams of intellectually distant specialists. In such teams, whereby expertise must be exchanged inter-paradigmatically, teams must rely on more distributed approaches to taskwork that emphasize complementarity of expertise and the formation of compilational knowledge structures to circumvent the obstacles encountered by semantic knowledge boundaries, such that breakthrough innovation at the team level emerges briefly and rarely due to upward cascades of expertise complementarity. Dyadic interaction is particularly important for the formation of team knowledge that leads to innovation in these collaborative contexts, and this study sought to apply a naturalistic training intervention in the form of a field experiment to improve the effectiveness of expertise-diverse teams from academia and industry. The results supported the core logic of the paper—more frequent dyadic exchange between members did indeed lead to higher integrative complexity and innovativeness in team-level knowledge products. Expertise exchange between members was also associated with team outcomes, a finding that was mediated by the formation of compilational knowledge—a transactive memory system—but not compositional knowledge. This study serves as a rigorous example of an investigation of the synthesis of current streams of research regarding innovation in teams of knowledge workers, and mirrors the trend in industry toward intellectual diversity.

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Footnotes

[1]Low aggregation statistics for the problem-oriented mean composite variable could not be improved by running these statistics within assigned experimental condition.

[2]Transactive memory as assessed by Lewis's (2003) item (adapted via SNA) was ineffective in the mediation models. This is potentially due to self-selection of members into teams and thus advance knowledge of who had which skills, producing low variance on this variable. Each transactive memory effect reported is assessed via Faraj and Sproull's (2000) expertise complementarity dimension assessed via SNA.

[3]Using Lewis's (2003) item as mediator: $B = 0.05$, $t = 0.23$, $p = .82$, $LLCI = -0.39$, $ULCI = 0.49$.

[4]Using Lewis's (2003) item as mediator: $B = 0.19$, $t = 0.76$, $p = .46$, $LLCI = -0.33$, $ULCI = 0.70$.

[5]Using Lewis's (2003) item as mediator: $B = -0.04$, $t = -0.16$, $p = .87$, $LLCI = -1.37$, $ULCI = 0.45$.

[6]Using Lewis's (2003) item as mediator: $B = 0.08$, $t = 0.32$, $p = .75$, $LLCI = -0.47$, $ULCI = 0.64$.

[7]Using Lewis's (2003) item as mediator: $B = 0.37$, $t = 1.42$, $p = .16$.

[8]Using Lewis's (2003) item as mediator: $B = 0.29$, $t = 1.13$, $p = .26$.

Table 1

T-Tests of Potential Covariates by Condition (N = 31)

#	Scale	n_{dyad}	M_{dyad}	SD_{dyad}	$n_{control}$	$M_{control}$	$SD_{control}$	df	*t*	*p*
1	Nonstudent [a]	16	0.44	0.51	15	0.13	0.35	29	-1.91	.07
2	Education Level	16	1.75	0.99	15	1.48	0.48	29	-0.96	.35
3	Topic Tenure	16	55.62	21.08	15	51.72	19.53	29	-0.53	.60
4	Funded [b]	16	0.35	0.48	15	0.13	0.30	29	-1.52	.14
5	Nonwhite [c]	16	0.47	0.35	15	0.45	0.26	29	-0.21	.83
6	NonUS [d]	16	0.34	0.27	15	0.27	0.29	29	-0.66	.51
7	Authority Differentiation	16	2.17	0.93	15	1.98	0.80	29	-0.63	.53
8	Prev. Collaboration	16	0.30	0.28	15	0.23	0.27	29	-0.69	.50
9	Shared Leadership	16	4.55	0.65	15	4.29	0.74	29	-1.04	.31
10	Team Size	16	3.19	1.91	15	3.19	1.29	29	-0.01	.99
11	Past IDR Participation	16	0.79	0.27	15	0.53	0.48	29	-1.82	.08
12	Age	16	28.63	4.99	15	28.86	5.51	29	0.13	.90
13	Team Tenure (months)[LN]	16	1.78	0.86	15	1.13	0.41	29	-2.46	*

Note. [a] Whether the team was composed of nonstudent members, [b] Received outside funding, [c] Proportion of nonwhite teammates, [d] Proportion of teammates from outside the US

$^{+}p < .10$

$^{*}p < .05$

$^{**}p < .01$

[LN] Log transformed variable

Table 2

Correlations Assessing Potential Covariates for Problem-Oriented Innovativeness (n = 114)

	Construct	1	2	3	4	5	6	7	8	9	10	11
1	Tenure (months)	1										
2	Age	-.08	1									
3	Gender	-.19*	.06	1								
4	Nonwhite [a]	-.06	.07	.22*	1							
5	Funded [b]	.60**	-.12	-.02	-.02	1						
6	Auth. Diff. [c]	.37**	-.12	-.07	-.27**	.20*	1					
7	Nonstudent [d]	.49**	.03	-.04	-.12	.53**	.42**	1				
8	Research Site	.26**	-.19*	-.16^{+}	-.24**	.20*	.42**	.60**	1			
9	Past IDR Part. [e]	.13	.05	.05	.20*	.15	-.28**	-.05	-.34**	1		
10	Team Size	-.24*	.11	.04	-.03	-.29**	-.09	-.18^{+}	.02	-.42**	1	
11	Innovativeness	.18^{+}	-.06	-.02	-.07	.22*	.26**	.29**	.15	-.02	-.01	1

Note. [a] Reported nonwhite ethnicity, [b] Received outside funding, [c] Authority differentiation, [d] Reported being professional researcher, [e] Previous IDR experience

$^{+}p < .10$

$^{*}p < .05$

$^{**}p < .01$

Table 3

Correlations Assessing Potential Covariates for Integrative Complexity (n = 31)

	Construct	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Past IDR Part.[a]	1													
2	Research Site	-.45*	1												
3	Nonstudent [b]	-.07	.59**	1											
4	Topic Tenure	.10	.13	.39*	1										
5	Funded [c]	.19	.24	.60**	.24	1									
6	Team Size	-.43*	.06	-.17	.18	-.28	1								
7	Age	.16	-.29	.04	-.02	-.18	.04	1							
8	Nonwhite [d]	.30	-.42*	-.17	.02	-.02	-.02	.15	1						
9	Expertise Sim. [e s]	.34+	-.04	.03	-.04	.20	-.08	-.49*	-.04	1					
10	Past Collab.[f]	.23	.04	-.02	.27	.09	-.05	-.35+	-.03	.69**	1				
11	Shared Lead.[g s]	.18	.04	.07	-.01	.41*	-.25	-.09	-.03	.33+	.28	1			
12	IC-IC [h s]	.42*	.12	.21	.07	.26	-.20	-.15	.15	.54**	.30	.57**	1		
13	IC-ED [i s]	.43*	.05	.29	.24	.32+	-.20	-.04	-.02	.37*	.16	.52**	.82**	1	
14	Team Tenure (months)	.26	.36*	.61**	.24	.70**	-.42*	-.32+	-.14	.25	.22	.26	.31	.27	1

Note. [a]Past IDR experience, [b] Proportion of professional researchers, [c] Received outside funding, [d] Proportion of nonwhite teammates, [e] Expertise similarity, [f] Number of members with whom respondent had past collaborative experience, [g] Shared leadership, [h] Integrative complexity (conceptual integration), [i] Integrative complexity, evaluative differentiation, [s] Assessed via team-level SNA density measure

+$p < .10$

*$p < .05$

**$p < .01$

Table 4

Descriptive Statistics For Team Level Variables (N = 31)

#	Scale	*n*	*M*	*SD*	*Min.*	*Max.*	*Skew*	Kurtosis
1	Team Size	31	3.68	0.91	3.00	7.00	1.85	4.71
2	Past IDR. Participation	31	0.66	0.40	0.00	1.00	-0.66	-1.22
3	Research Site	31	0.26	0.44	0.00	1.00	1.13	-0.74
4	Nonstudent [a]	31	0.29	0.46	0.00	1.00	0.97	-1.13
5	Education Level	31	1.62	0.78	1.00	5.00	2.83	11.28
6	Topic Tenure	31	53.73	20.10	16.67	87.33	-0.13	-0.87
7	Funded [b]	31	0.25	0.41	0.00	1.00	1.21	-0.41
8	Age	31	28.74	5.16	18.20	42.75	0.48	0.89
9	Nonwhite [c]	31	0.46	0.30	0.00	1.00	0.12	-0.80
10	NonUS [d]	31	0.31	0.28	0.00	0.80	0.38	-1.12
11	Team Tenure (months) [LN]	31	1.47	0.74	0.39	3.40	1.22	0.98
12	Authority Differentiation	31	2.08	0.86	1.00	4.50	0.86	0.47
13	Shared Leadership [s]	31	4.42	0.69	3.00	5.67	-0.16	-0.28
14	Prop. Previous Collab.	31	0.25	0.27	0.00	0.83	0.79	-0.87
15	Condition	31	0.52	0.51	0.00	1.00	-0.07	-2.14
16	Expertise Exchange [s]	31	5.23	0.72	3.42	6.58	-0.23	0.14
17	Bring Expertise to Bear [m LN]	31	6.20	0.67	3.25	7.00	-1.29	3.95
18	Expertise Similarity [s m]	31	4.59	1.14	2.67	6.33	-0.17	-1.23
19	Dyad Pair Proportion [m]	31	0.93	0.12	0.65	1.00	-1.56	0.87
20	Team Vision	31	6.37	0.32	5.52	6.91	-0.78	0.51
21	Transactive Memory [s]	31	6.24	0.45	5.50	7.00	0.03	-1.06
22	Psych. Safety	31	5.79	0.68	3.95	6.67	-1.30	1.49
23	IC-ED [e s]	31	5.59	0.78	3.50	6.67	-0.71	0.18
24	IC-IC [f s]	31	5.16	0.68	4.00	6.33	0.06	-0.89

Note. [a] Whether the team was composed of nonstudent members, [b] Received outside funding, [c] Proportion of nonwhite teammates, [d] Proportion of teammates from outside the US, [e] Integrative complexity (conceptual integration), [f] Integrative complexity, evaluative differentiation [s] Assessed via social network density, [m] Manipulation check variable
[LN] Log transformed variable

Table 5

Descriptive Statistics For Individual Level Variables (N = 114)

#	Scale	*n*	*M*	*SD*	*Min.*	*Max.*	*Skew*	Kurtosis
1	Team Size	114	3.89	1.05	3.00	7.00	1.52	2.31
2	Past IDR. Participation	114	0.62	0.49	0.00	1.00	-0.51	-1.77
3	Research Site	114	0.27	0.45	0.00	1.00	1.04	-0.94
4	Nonstudent [a]	114	0.27	0.45	0.00	1.00	1.04	-0.94
5	Education Level	114	1.64	1.01	1.00	5.00	2.28	5.16
6	Topic Tenure	114	54.59	30.92	0.00	100.00	-0.18	-1.36
7	Funded [b]	114	0.22	0.42	0.00	1.00	1.38	-0.11
8	Age	114	28.97	8.54	18.00	68.00	1.92	4.62
9	Gender	114	0.61	0.49	0.00	1.00	-0.48	-1.81
10	Nonwhite [c]	114	0.46	0.50	0.00	1.00	0.18	-2.00
11	NonUS [d]	114	0.32	0.47	0.00	1.00	0.76	-1.45
12	Team Tenure (months) [LN]	114	1.40	0.81	0.00	3.71	1.39	1.69
13	Authority Differentiation	114	2.06	1.14	1.00	5.00	1.05	0.14
14	Prop. Previous Collab.	114	0.25	0.33	0.00	1.00	1.07	-0.16
15	Condition	114	0.46	0.50	0.00	1.00	0.14	-2.02
16	Bring Expertise to Bear [m LN]	114	1.34	0.43	0.00	1.83	-0.70	0.20
17	Dyad Pair Proportion [m]	114	0.92	0.22	0.00	1.00	-3.29	10.19
18	Team Vision	114	6.35	0.55	4.18	7.00	-0.80	1.00
19	Psych. Safety	114	5.76	0.92	2.57	7.00	-1.11	0.99
20	Problem Oriented Innov.	114	5.49	1.08	2.00	7.00	-0.89	0.76

Note. [a] Whether the team was composed of nonstudent members, [b] Received outside funding, [c] Whether respondent was nonwhite, [d] Whether respondent was from outside the US, [m] Manipulation check variable
[LN] Log transformed variable

Table 6

Team-Level Correlations Between Variables of Interest (n = 31)

	Construct	1	2	3	4	5	6	7	8	9
1	Visioning	1								
2	Transactive Memory[s]	.38*	1							
3	KWKW[a s]	.45*	.50**	1						
4	Psych. Safety	.49**	.53**	.34^{+}	1					
5	Bring Expertise to Bear	.66**	.30^{+}	.34^{+}	.59**	1				
6	Expertise Exchange[s]	.41*	.52**	.56**	.29	.05	1			
7	IC-IC[b]	.12	.50**	.23	.30^{+}	.15	.29	1		
8	IC-ED[c]	.18	.37*	.26	.29	.13	.30^{+}	.82**	1	
9	Innovativeness	.01	.42*	.30^{+}	.01	.08	.37*	.55**	.54**	1

Note. [a] Know who knows what—omitted from reported hypothesis tests (see footnotes), [b] Integrative complexity (conceptual integration), [c] Integrative complexity (evaluative differentiation), [s] Assessed via team-level SNA density measure

$^{+}p < .10$

$^{*}p < .05$

$^{**}p < .01$

Table 7

Individual-Level Correlations Between Variables of Interest (n = 114)

	Construct	1	2	3	4	5	6	7	8	9
1	Visioning	1								
2	Transactive Memory[s]	.28**	1							
3	KWKW[a s]	.31**	.53**	1						
4	Psych. Safety	.32**	.36**	.23*	1					
5	Bring Expertise to Bear	.44**	.23*	.22*	.45**	1				
6	Expertise Exchange[s]	.29**	.54**	.59**	.20*	.07	1			
7	IC-IC[b]	.13	.56**	.28**	.23*	.13	.34**	1		
8	IC-ED[c]	.15	.43**	.30**	.21*	.10	.34**	.84**	1	
9	Innovativeness	.21*	.24*	.17+	.15	.23*	.22*	.32**	.30**	1

Note. [a] Know who knows what—omitted from reported hypothesis tests (see footnotes), [b] Integrative complexity (conceptual integration), [c] Integrative complexity (evaluative differentiation), [s] Assessed via team-level SNA density measure

$^{+}p < .10$

$^{*}p < .05$

$^{**}p < .01$

Table 8

Correlations Assessing Team Tenure's Relationship with Substantive and Manipulation Check Variables (n = 31)

	Construct	1	2	3	4	5	6	7	8	9	10	11
1	Condition	1										
2	Expertise Exchange [s]	.27	1									
3	Team Vision	.04	.38*	1								
4	Psych. Safety	-.21	.23	.49**	1							
5	Transactive Memory [s]	.02	.54**	.38*	.53**	1						
6	Bring Expertise to Bear [m]	-.07	.24	.66**	.59**	.30	1					
7	Expertise Similarity [m]	.07	.41*	.06	.01	.32+	.12	1				
8	Innovativeness [DV]	.39*	.53**	.01	.01	.42*	.08	.43*	1			
9	IC-ED [a DV]	.35+	.69**	.18	.29	.37*	.13	.32+	.54**	1		
10	IC-IC [b DV]	.37*	.70**	.12	.30	.50**	.15	.50**	.55**	.82**	1	
11	Tenure (months) [LN]	.44*	.17	.11	.04	.02	-.06	.22	.30	.27	.31	1

Note. [a] Integrative complexity (evaluative differentiation), [b] Integrative complexity (conceptual integration), [s] Assessed via social network density, [m] Manipulation check variable, [DV] Dependent variable

+$p < .10$

*$p < .05$

**$p < .01$

[LN] Log transformed variable

Table 9

Overview of Hypothesis Testing Approach [a]

Hypothesis	Dependent Variable [b]	Path Tested	Level of Analysis	Analysis [c]	Analysis Type	Result
H1a	IC-IC	Condition → IC-IC	Team	ANCOVA	Main Effect	Supported
H1b	Innovativeness	Condition → Innov.	Multilevel	MLM	Main Effect	Supported
H2	TMS	Condition → TMS	Team	PROCESS	Main Effect	Null
H2	TMS	Exp. Exch. → TMS	Team	PROCESS	Main Effect	Marginal
H2	TMS	Condition → TMS	Multilevel	MSEM	Main Effect	Null
H2	TMS	Exp. Exch. → TMS	Multilevel	MSEM	Main Effect	Supported
H3a	IC-IC	Condition → TMS → IC-IC	Team	PROCESS	Mediation	Null
H3a	IC-IC	Exp. Exch. → TMS → IC-IC	Team	PROCESS	Mediation	Supported
H3b	Innovativeness	Condition → TMS → Innov.	Multilevel	MSEM	Mediation	Null
H3b	Innovativeness	Exp. Exch. → TMS → Innov.	Multilevel	MSEM	Mediation	Supported
H4	Visioning	Condition → Visioning	Team	PROCESS	Main Effect	Null
H4	Visioning	Exp. Exch. → Visioning	Team	PROCESS	Main Effect	Null
H4	Visioning	Condition → Visioning	Multilevel	MSEM	Main Effect	Null
H4	Visioning	Exp. Exch. → Visioning	Multilevel	MSEM	Main Effect	Supported
H5a	IC-IC	Condition → Visioning → IC-IC	Team	PROCESS	Mediation	Null
H5a	IC-IC	Exp. Exch. → Visioning → IC-IC	Team	PROCESS	Mediation	Null
H5b	Innovativeness	Condition → Visioning → Innov.	Multilevel	MSEM	Mediation	Null
H5b	Innovativeness	Exp. Exch. → Visioning → Innov.	Multilevel	MSEM	Mediation	Null
H6a	TMS	Condition * Psych. Safety → TMS	Team	PROCESS	Moderation	Null
H6a	TMS	Exp. Exch. * Psych. Safety → TMS	Team	PROCESS	Moderation	Null
H6a	TMS	Condition * Psych. Safety → TMS	Multilevel	MSEM	Moderation	Null
H6a	TMS	Exp. Exch. * Psych. Safety → TMS	Multilevel	MSEM	Moderation	Null
H6b	Visioning	Condition * Psych. Safety → Visioning	Team	PROCESS	Moderation	Marginal
H6b	Visioning	Exp. Exch. * Psych. Safety → Visioning	Team	PROCESS	Moderation	Null
H6b	Visioning	Condition * Psych. Safety → Visioning	Multilevel	MSEM	Moderation	Null
H6b	Visioning	Exp. Exch. * Psych. Safety → Visioning	Multilevel	MSEM	Moderation	Null

Note. [a] Integrative complexity (evaluative differentiation) is excluded given that it unilaterally failed to support hypotheses, [b] Integrative complexity (conceptual integration) is abbreviated IC-IC, transactive memory is abbreviated TMS, [c] Analyses are as follows: Analysis of covariance (ANCOVA), Multilevel regression modeling (MLM), Boostrapped conditional process modeling (PROCESS), Multilevel structural equation modeling (MSEM).

Table 10

Condition Predicting Conceptual Integration (Team Level)

Dependent Variable: Integrative Complexity (Conceptual Integration)[b]

Source	Type III SS	df	Mean Square	*F*	*p*
Corrected Model	8.74[a]	8	1.09	4.69	.00
Intercept	.26	1	.26	1.14	.30
Shared Leadership [b]	.74	1	.74	3.17	.09
Past IDR Participation	.26	1	.26	1.13	.30
Psych. Safety	.13	1	.13	.58	.46
Team Size	.10	1	.10	.43	.52
Expertise Similarity [b]	.59	1	.59	2.52	.13
Visioning	.47	1	.47	2.01	.17
Transactive Memory [b]	.46	1	.46	1.98	.17
Condition	.88	1	.88	3.77	.07
Error	5.13	22	.23		
Total	838.91	31			
Corrected Total	13.86	30			

a. R Squared = .630 (Adjusted R Squared = .496)

b. Measured via SNA density

Table 11

Condition Predicting Innovativeness (Multilevel)[a]

Parameter	Estimate	Std. Error	df	*t*	*p*	95% CI Lower Bound	95% CI Upper Bound
Intercept	-2.11	1.84	31.97	-1.14	.26	-5.86	1.65
Condition	.63	.21	19.78	2.95	.01	.18	1.08
Team Size	.30	.11	12.65	2.74	.02	.06	.54
Funded	.13	.25	28.91	.53	.60	-.38	.64
Auth. Differentiation	.29	.09	60.53	3.29	< .001	.11	.46
Psych. Safety	.19	.11	93.46	1.65	.10	-.04	.42
Transactive Memory[b]	.50	.23	20.67	2.13	.05	.01	.98
Visioning	.31	.19	103.00	1.65	.10	-.06	.68

a. Dependent Variable: Problem Oriented Innovativeness.

b. Measured via SNA density.

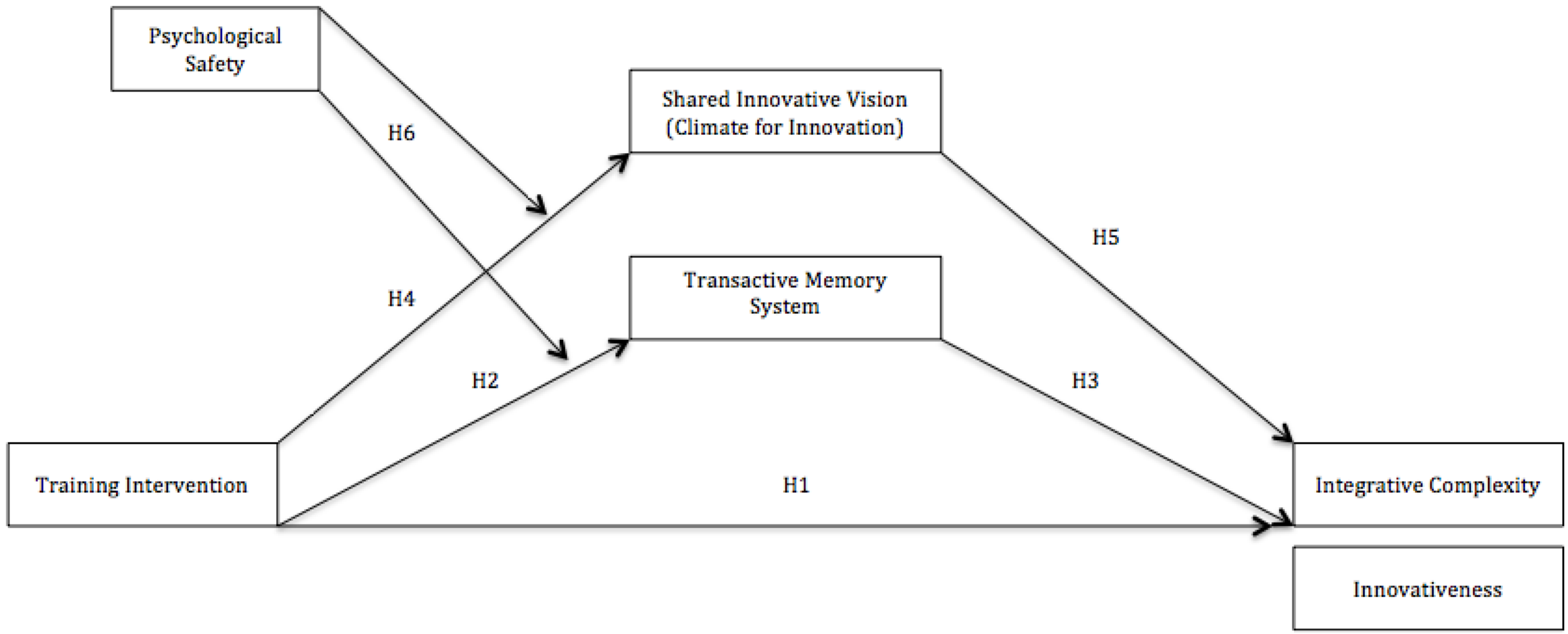

Figure 1. Proposed theoretical model

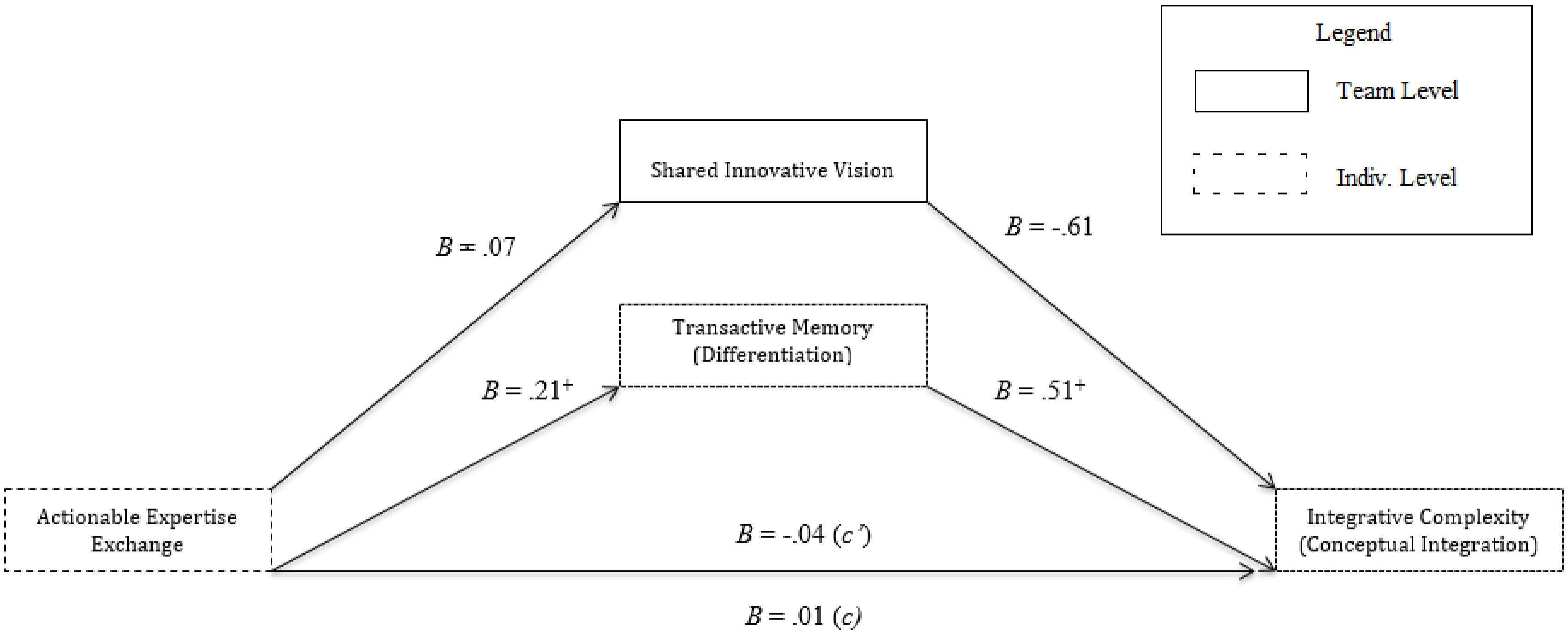

Figure 2. Marginally significant mediation of actionable expertise exchange to conceptual integration via transactive memory

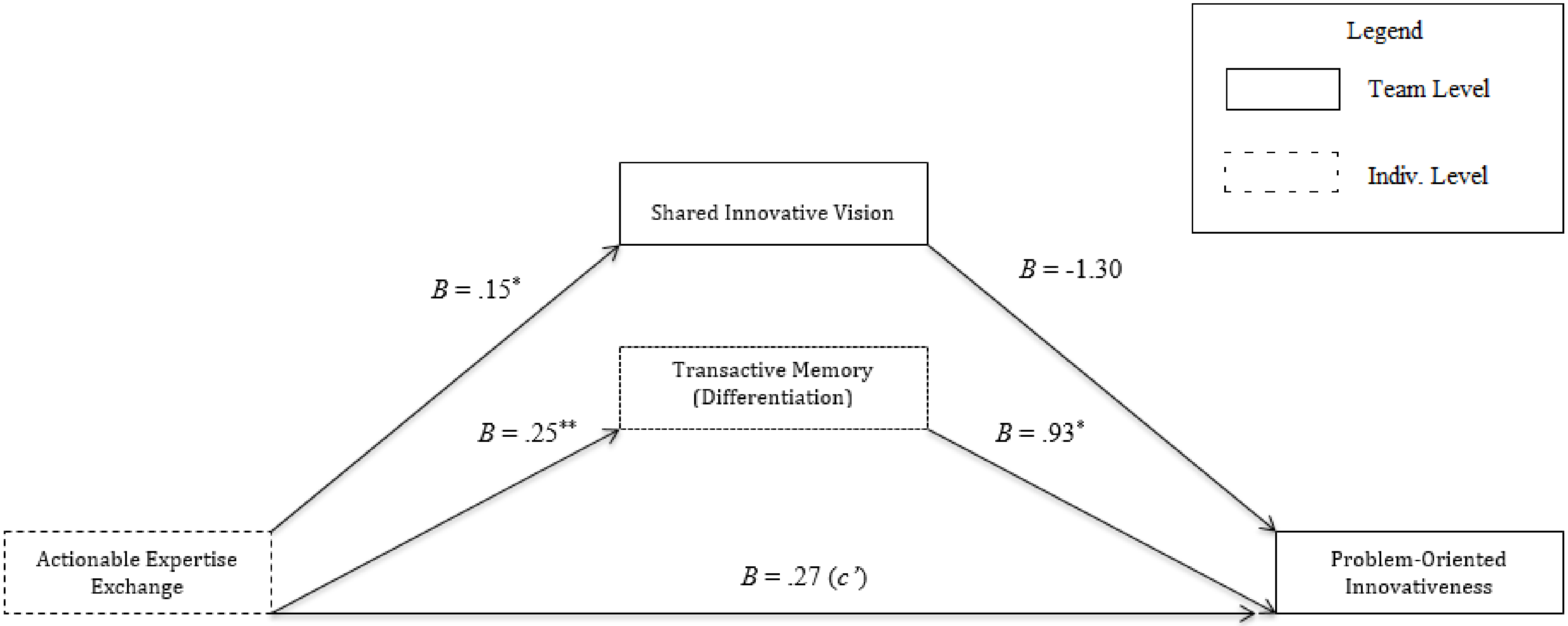

Figure 3. Marginally significant mediation of actionable expertise exchange to innovativeness via transactive memory

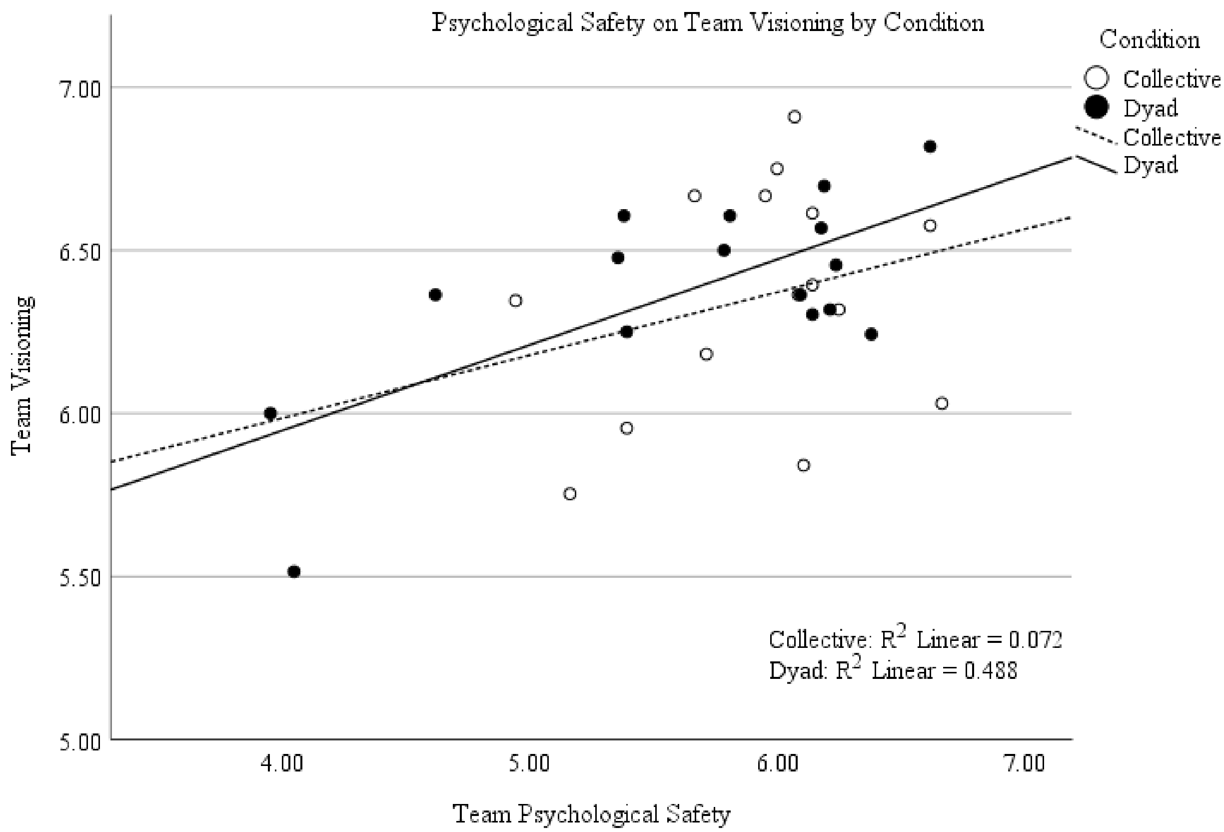

Figure 4. Interaction depicting psychological safety on team visioning by condition

Appendix A: Team Training Discussion Prompt

<u>Directions:</u> Use the prompts below, but answer questions in whatever order you think is best

- **<u>B</u>ring your diverse perspectives to the foreground:** *Share how you approach work for this team.*
Take turns summarizing your expertise as it relates to this team and its goals. How do your fields overlap in their conceptual approaches or methods? In what areas are they most distinct?

- **<u>R</u>eflect on your teammates' expertise:** *Try to see their work from their perspective.*
Do you have any questions about how your teammates do their work, specifically or in general?

- **<u>I</u>dentify areas for improvement**: *Elicit practical suggestions.*
Do you each have suggestions from your own expertise domain that might help each other? If helpful, summarize some tasks you are working on to start the conversation.

- **<u>D</u>evelop new plans for collaboration**: *Focus on your future work together.*
Think about how your expertise overlaps. Are there ways you could change how you work together to help your team achieve its goals? Try to focus on specific tasks.

- **<u>G</u>ive suggestions from your domain of expertise**: *Offer thoughtful input.*
Offer a way of thinking, a recent publication, method, or technique from your field that might help your teammates with something they are working on.

- **<u>E</u>valuate how you can help the team coordinate:** *Identify your expertise overlap*.
What unique skillset combinations do you possess that will help this team achieve its goals. Which tasks are they necessary for?

Please do not hesitate to ask us clarifying questions!

Appendix B: End of Training Collective Discussion Prompt

Reflecting on what you discussed today, take a few minutes to consider, as a team, the unifying goal that your team is pursuing and the strategies by which it is trying to achieve it. Have a member of your group write it below:

Now try to write down a few research projects that are aligned with your team's unifying goal, and which would help you to achieve it:

Appendix C: Pre-Training Survey

FACILITATING EMERGENT INNOVATION IN EXPERTISE-DIVERSE TEAMWORK

INFORMED CONSENT FORM

Principal Investigator(s): Maritza Salazar, PhD & Daniel Slyngstad, MA
Sponsor: University of California at Los Angeles (UCLA)
Investigational Site(s): University of California at Irvine (UCI)
Completion: To be completed online or in-person

Introduction: Researchers at UCI and Claremont Graduate University (CGU) are interested in studying topics related to team science. To do this, we need the help of people who agree to take part in this research study. The people conducting this research are Dr. Maritza Salazar at UCI and Daniel Slyngstad at CGU.

The inclusion criteria: Participants need to be over 18 and speak English. If you do not meet these requirements, you are not eligible to participate in this study. You must also be a member of an interdisciplinary research or startup team at UCI or UCLA composed of at least three members and participate in a team training and facilitation workshop offered by the researchers. If your team has more than six members, no more than six may participate in the training.

What you should know about a research study:

- Someone will explain this research study to you.
- A research study is something you volunteer for.
- Whether or not you take part is up to you.
- You should take part in this study only because you want to.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.
- Whatever you decide it will not be held against you.
- Feel free to ask all the questions you want before you decide.

Purpose of the research study: The purpose of this research is to increase understanding of how interdisciplinary teams produce innovative knowledge products that are the results of contributions from a diverse set of team members. We seek to employ a workshop-style training aid in this endeavor.

What you will be asked to do in the study: This research involves the testing of surveys and training materials. Future surveys will be administered on paper or online via Qualtrics. The researchers will distribute a URL address or paper version for each survey when it is time to take them. Depending on the survey, we estimate that these will take about 10-15 minutes per survey to complete. Upon completion of the surveys you will receive the debrief form. You will be asked to participate in a training session held at your institution during work hours, and your team's interactions will be recorded via handheld audio recorder.

Location: The research will take place online and at UCI or UCLA.

Time required: We estimate that surveys will take about 10-15 minutes per survey to complete, totaling about 30-45 minutes. Training sessions are expected to take approximately 90 minutes (including the time dedicated to the first two surveys), during which time your team will be able to incorporate its own work into the session.

Funding for this study: UCLA is paying for this research study.

Risks: This study involves minimal risk. You may feel uncomfortable with some of the more personal questions about your social networks. However, you have the right to withdraw from the study at any time.

Benefits: We cannot promise any direct benefits to you or others from your taking part in this research.

Compensation or payment: Participants will receive a $40 Amazon gift card upon completion of data collection (after completion of the third survey).

Confidentiality: We will limit the amount of personal data we collect from you to information that is absolutely necessary to complete the research. We cannot promise complete secrecy. As a part of their responsibility to protect human volunteers in research, the IRB at the UCI and CGU will have access to the research records. Confidentiality of the research records will be strictly maintained. Any identifying information collected from you will only be accessible to the research team. When stored and analyzed, subject numbers will be used rather than participant names. Diligent care will be taken to protect your identity and sensitive information. In any published research or presentation resulting from data collected from you, your organizational affiliation will be disguised under pseudonyms. Information collected on-line will be done through a secure website. Any hard copies of the data will be stored in locked filing cabinets that only researchers who are directly involved in the study and who have participated in the CITI training can access. We will ensure the security of any audio recordings with an alphanumeric identifier and a password accessible only to the research team. This audio file will be erased three years after the completion of the study. No individual names or organizations will be associated with the data. Only aggregated, de-identified data will be reported.

After the completion of the study, you will be given the option to indicate whether they would like to see the results from this study. Once a manuscript is written, we will share our results with you.

Study contact for questions about the study or to report a problem: If you have any questions, concerns, complaints, or think the research has hurt you, please feel free to contact Maritza Salazar, Ph.D. at 909-607-3716 and via email at maritza.salazar@uci.edu or Daniel Slyngstad at 818-731-2820 and via email at daniel.slyngstad@cgu.edu.

Withdrawing from the study: If you decide to leave the research, simply tell the researcher that you no longer wish to participate.

Do you consent to participate in this study?

- ☐ I consent
- ☐ I DO NOT consent

If you DO NOT provide your informed consent to participate in this study, DO NOT complete the following pages and let an experimenter know of your decision. Otherwise, please begin the survey on the next page. Thank you!

Welcome to the survey! We thank you for agreeing to participate in this research. This is the first of three surveys. In this survey, we would like to gather some basic data about you, your educational and professional history, and your team.

What is your first and last name?

____

Please enter the team ID number assigned to your interdisciplinary research or startup team for this study (in the email we sent you with the survey link or in the welcome slide at the training).

____

In years and months, how long have you been a member of this interdisciplinary team?

____

What is the name of the medical campus or academic institution through which you are participating in this study (e.g., UCI, UCLA)?

____

What best describes your current position where you currently work?

- ☐ Research Assistant
- ☐ Post Doc
- ☐ Research Manager
- ☐ Program Coordinator
- ☐ Nurse
- ☐ Physician
- ☐ Epidemiologist
- ☐ Statistician
- ☐ Assistant Professor
- ☐ Associate Professor
- ☐ Advisor/Consultant
- ☐ Chief Executive Officer (CEO)
- ☐ Chief Technology Officer (CTO)
- ☐ Chief Financial Officer (CFO)
- ☐ Chief Operating Officer (COO)
- ☐ Software Engineer
- ☐ Other (Please describe): ____

What is your highest degree earned?

- ☐ BS
- ☐ MA/MS
- ☐ RN
- ☐ MD
- ☐ PhD
- ☐ MD-PhD
- ☐ Other ____

Of the following, what is your primary **academic discipline**?

- ☐ Accounting/Finance
- ☐ Biochemistry
- ☐ Bioinformatics
- ☐ Biology
- ☐ Biostatistics
- ☐ Business/Management
- ☐ Cancer Biology
- ☐ Cell Biology
- ☐ Chemistry
- ☐ Clinical Science
- ☐ Computer Science
- ☐ Endocrinology
- ☐ Engineering
- ☐ Epidemiology
- ☐ Genetics
- ☐ Immunology
- ☐ Information Technology
- ☐ Other (Please specify): ______________________________
- ☐ Medicine
- ☐ Metabolomics
- ☐ Microbiology
- ☐ Molecular Biology
- ☐ Neurobiology
- ☐ Neuroscience
- ☐ Nursing
- ☐ Nutrition
- ☐ Oncology
- ☐ Pharmacology
- ☐ Physiology
- ☐ Public Health
- ☐ Proteomics
- ☐ Radiology
- ☐ Technology

Of the following, what would you describe as your main **area of research or practice**?

- ☐ Accounting/Finance
- ☐ Aging/Gerontology
- ☐ Basic Research
- ☐ Business/Management
- ☐ Cancer
- ☐ Cardiovascular
- ☐ Cell Biology / Biochemistry / Developmental Biology
- ☐ Child Health
- ☐ Chronic Diseases
- ☐ Clinical Research
- ☐ Computational Research / Modeling
- ☐ Computer Science
- ☐ Epidemiological Studies
- ☐ Genetics / Genomics
- ☐ Global Health
- ☐ Health Outcomes Research
- ☐ Immunology / Transplantation Medicine
- ☐ Information Technology
- ☐ Microbiology / Infectious Disease
- ☐ Neurosciences / Psychiatry
- ☐ Population Sciences / Epidemiology / Cost & Comparative Effectiveness
- ☐ Provision of Clinical Care
- ☐ Software Engineering
- ☐ Stem Cells / Regenerative Medicine
- ☐ Technology
- ☐ Training and Education
- ☐ Translational Research
- ☐ Other (Please specify): ____

What percent of *all of your current work*, from 0-100%, is related to your team's topic domain or area of practice?

____

We will now ask you questions about your interdisciplinary team that is participating in this study. For all questions, please make sure to only think about the team that is participating in this study, and *do not think about different teams for different questions*.

Not including any monetary resources provided by your team members (e.g., funds unaffiliated with grant providing organizations), has your team received any funding as a group (e.g., federal grant)?

- ☐ No
- ☐ Yes

The following two questions will ask you to **count the number of people on your team**. The first will ask you to include yourself in the count, and the second will ask you to leave yourself out.

Please take a moment to make sure your answers to these questions are accurate. They are related to questions that come later and are ***very important*** to our research project.

***Including yourself*, **how many people are on your interdisciplinary team? This may be more than the number of people that are physically here with you today.

- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7
- ☐ 8
- ☐ 9
- ☐ 10
- ☐ 11 or more

NOT including yourself, how many of your teammates are *physically here with you today* (e.g., selecting "2" means that TWO OTHERS, not including yourself, are here with you)?

- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

NOT including yourself, please write the names of the other members of your team *who are attending the training with you*.

Your data will be kept strictly confidential, so please **do not use pseudonyms or nicknames**. It will prevent us from analyzing your responses properly. Don't worry if you don't have enough teammates with you to fill all the blanks.

- ☐ Teammate 1: ____
- ☐ Teammate 2: ____
- ☐ Teammate 3: ____
- ☐ Teammate 4: ____
- ☐ Teammate 5: ____

For each individual that you mentioned in the previous question, fill in their name again, **in the same order** in the blanks below, and **consider their area of expertise in relation to your**

own (e.g., their education, their professional training, and their area of practice).

On a scale from 1 to 7, **how similar is their area of expertise to yours?**

	Teammate Expertise Similarity
	Very Dissimilar *Very Similar*
Teammate 1: ________________________	1….2….3….4….5….6….7
Teammate 2: ________________________	1….2….3….4….5….6….7
Teammate 3: ________________________	1….2….3….4….5….6….7
Teammate 4: ________________________	1….2….3….4….5….6….7
Teammate 5: ________________________	1….2….3….4….5….6….7

For each individual, fill in their name again as you did in the previous question, **in the same order**, and indicate whether you have previously collaborated/are collaborating with them on other teams or projects.

	Previous Collaborative Experience	
	No	Yes
Have you previously collaborated with Teammate 1: ________________________ on other teams or projects?	☐	☐
Have you previously collaborated with Teammate 2: ________________________ on other teams or projects?	☐	☐
Have you previously collaborated with Teammate 3: ________________________ on other teams or projects?	☐	☐
Have you previously collaborated with Teammate 4: ________________________ on other teams or projects?	☐	☐
Have you previously collaborated with Teammate 5: ________________________ on other teams or projects?	☐	☐

Thank you for your responses thus far. We would like to finish the survey by asking you a few questions about your personal background. Please turn to the next page, read each question, and answer as honestly as possible.

What is your age in years?

____

I am...

- ☐ Male
- ☐ Female

What is your race/ethnicity?

- ☐ Hispanic/Latino
- ☐ Indigenous North American (including Alaska)
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White
- ☐ Two or more races
- ☐ Decline to state

In what country were you born?

____

Thank you for your responses! This is the end of the first survey. We hope you enjoy the training session! If you have any questions, do not hesitate to contact Maritza Salazar (maritza.salazar@uci.edu) or Daniel Slyngstad (daniel.slyngstad@cgu.edu). We appreciate you sparing your time for our research.

Appendix D: Proximal Post Training Survey

FACILITATING EMERGENT INNOVATION IN EXPERTISE-DIVERSE TEAMWORK

POST-TRAINING SURVEY

Welcome to the survey and thank you for participating in our research! We hope that you enjoyed the training session today.

We would like to begin this survey by asking you to complete a few tracking questions from the first survey. This will allow us to merge your responses across surveys.

What is your first and last name?

____

Please enter the team ID number assigned to your interdisciplinary research or startup team for this study (in the email we sent to you, or on the handouts/training welcome slide).

____

What is the name of the medical campus or academic institution through which you are participating in this study (e.g., UCI, UCLA)?

____

NOT including yourself, how many teammates are physically here with you today (e.g., selecting "2" means that TWO OTHER members of your team, not including yourself, are here with you today)?

Please take a moment to make sure your answer to this question is accurate. It is related to questions that come later and are *very important* to our research.

- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

NOT including yourself, please write the names of these other members of your team *who are attending the training with you*.

Your data will be kept strictly confidential, so **please do not use pseudonyms or nicknames.** It will prevent us from analyzing your responses properly. Don't worry if you don't have enough teammates with you to fill all the blanks.

- ☐ Teammate 1: ______________________________
- ☐ Teammate 2: ______________________________
- ☐ Teammate 3: ______________________________
- ☐ Teammate 4: ______________________________
- ☐ Teammate 5: ______________________________

For each individual you listed, fill in their name again **in the same order** and indicate whether you engaged in direct, one-on-one, **task-relevant** conversation with them *during today's session*.

	No, I did not.	Yes, I did.
I engaged in direct, one-on-one conversation with **Teammate 1:** ______________________________during the training session.	☐	☐
I engaged in direct, one-on-one conversation with **Teammate 2:** ______________________________during the training session.	☐	☐
I engaged in direct, one-on-one conversation with **Teammate 3:** ______________________________during the training session.	☐	☐
I engaged in direct, one-on-one conversation with **Teammate 4:** ______________________________during the training session.	☐	☐
I engaged in direct, one-on-one conversation with **Teammate 5:** ______________________________during the training session.	☐	☐

Thank you. Now we would like to ask you questions related to how your team processes information as a group, and about your interactions with other members. Please read each question carefully and answer as honestly as possible.

For each individual you listed previously, please fill in their name **in the same order**. **Consider their task-relevant knowledge and area of specialization,** and how it is **distinct from your own** (e.g., consider taskwork they are responsible for and the expertise required to complete it).

Please answer the following question for each individual on a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree … Strongly Agree
Teammate 1: _______________ has knowledge about aspects of the team's work that are distinct from my own.	1….2….3….4….5….6….7
Teammate 2: _______________ has knowledge about aspects of the team's work that are distinct from my own.	1….2….3….4….5….6….7
Teammate 3: _______________ has knowledge about aspects of the team's work that are distinct from my own.	1….2….3….4….5….6….7
Teammate 4: _______________ has knowledge about aspects of the team's work that are distinct from my own.	1….2….3….4….5….6….7
Teammate 5: _______________ has knowledge about aspects of the team's work that are distinct from my own.	1….2….3….4….5….6….7

For each individual you listed, write in their name again **in the same order**. **Consider their area of expertise** (e.g., their education, their professional training, and their area of practice) **and how it complements your own work on this team.**

Please answer the following question for each individual on a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree ... *Strongly Agree*
Teammate 1: ____________________ has skills or knowledge to contribute to the work I do on this team.	1….2….3….4….5….6….7
Teammate 2: ____________________ has skills or knowledge to contribute to the work I do on this team.	1….2….3….4….5….6….7
Teammate 3: ____________________ has skills or knowledge to contribute to the work I do on this team.	1….2….3….4….5….6….7
Teammate 4: ____________________ has skills or knowledge to contribute to the work I do on this team.	1….2….3….4….5….6….7
Teammate 5: ____________________ has skills or knowledge to contribute to the work I do on this team.	1….2….3….4….5….6….7

For each individual you listed, write in their names again **in the same order. Consider the extent to which they provided assistance to you *during the training session*.** Their assistance could have been conceptual (e.g., reframing a problem), procedural (e.g., suggesting a new method), or technical (e.g., advice about unfamiliar technology) in nature.

Please answer the following question for each individual from 1 (Strongly Disagree) to 7 (Strongly Agree).

During the training session today…

	Strongly Disagree … Strongly Agree
Teammate 1: ______________________________ shared expertise with me by providing practical assistance for an aspect of my work.	1….2….3….4….5….6….7
Teammate 2: ______________________________ shared expertise with me by providing practical assistance for an aspect of my work.	1….2….3….4….5….6….7
Teammate 3: ______________________________ shared expertise with me by providing practical assistance for an aspect of my work.	1….2….3….4….5….6….7
Teammate 4: ______________________________ shared expertise with me by providing practical assistance for an aspect of my work.	1….2….3….4….5….6….7
Teammate 5: ______________________________ shared expertise with me by providing practical assistance for an aspect of my work.	1….2….3….4….5….6….7

For each individual you listed**,** write in their names again **in the same order**. Consider the extent of your **joint contribution to the team's knowledge products** and answer on a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

For reference, knowledge products can be tangible (e.g., publications, drafts, products or deliverables), or they can be conceptual or methodological frameworks (i.e., ways of thinking about or doing things).

	Strongly Disagree … Strongly Agree
Innovation in this team is impossible without the *unique combination* of **Teammate 1: ________________________'s** and my ideas.	1….2….3….4….5….6….7
Innovation in this team is impossible without the *unique combination* of **Teammate 2: ________________________'s** and my ideas.	1….2….3….4….5….6….7
Innovation in this team is impossible without the *unique combination* of **Teammate 3: ________________________'s** and my ideas.	1….2….3….4….5….6….7
Innovation in this team is impossible without the *unique combination* of **Teammate 4: ________________________'s** and my ideas.	1….2….3….4….5….6….7
Innovation in this team is impossible without the *unique combination* of **Teammate 5: ________________________'s** and my ideas.	1….2….3….4….5….6….7

For each individual you listed**,** write in their names again **in the same order**. Answer the following question based on **what it is like to work with or interact with them in a professional setting**, on a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree … *Strongly Agree*
Teammate 1: _________________________________ will hold it against me if I make a mistake on this team.	1….2….3….4….5….6….7
Teammate 2: _________________________________ will hold it against me if I make a mistake on this team.	1….2….3….4….5….6….7
Teammate 3: _________________________________ will hold it against me if I make a mistake on this team.	1….2….3….4….5….6….7
Teammate 4: _________________________________ will hold it against me if I make a mistake on this team.	1….2….3….4….5….6….7
Teammate 5: _________________________________ will hold it against me if I make a mistake on this team.	1….2….3….4….5….6….7

Thank you for your responses thus far. There are just a few more sets of questions to go. We would like to conclude by asking you a few questions about your team in general. Please read each question carefully and answer as honestly as possible.

Please state your team's overall objective or core mission. Try to write it in a way that someone *without* your specialized training would understand, and please do not confer with your teammates when answering.

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For the following questions, please **consider your team's core objectives, which you wrote out in the previous question,** using a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree … *Strongly Agree*
The team's objectives are clear.	1….2….3….4….5….6….7
The team's objectives are useful and appropriate.	1….2….3….4….5….6….7
I agree with the team's objectives.	1….2….3….4….5….6….7
The team's objectives are clearly understood by other members of the team.	1….2….3….4….5….6….7
My team members agree with the team's objectives.	1….2….3….4….5….6….7
The team's objectives can be achieved.	1….2….3….4….5….6….7
I think the team's objectives are worthwhile.	1….2….3….4….5….6….7
The team's objectives are worthwhile to the institution.	1….2….3….4….5….6….7
The team's objectives are worthwhile to the wider society.	1….2….3….4….5….6….7
The team's objectives are realistic and can be attained.	1….2….3….4….5….6….7
My team members are committed to the team's objectives.	1….2….3….4….5….6….7

For the following questions, please **consider how innovative you consider your team to be with respect to its problem solving,** compared to other teams in this topic domain (e.g., cancer biology, augmented reality). Consider how the statements apply to the team as a whole, from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree … *Strongly Agree*
This team can learn new ways to apply knowledge of familiar techniques and procedures to develop new and unusual solutions.	1….2….3….4….5….6….7
This team can seek out information on products or techniques that are new, and can learn how to apply them to develop new solutions to problems.	1….2….3….4….5….6….7
This team can identify and learn new skills and technologies that may be useful in solving unfamiliar problems.	1….2….3….4….5….6….7
This team can seek out and acquire information that may be useful in developing multiple solutions to problems.	1….2….3….4….5….6….7
This team can seek out and acquire knowledge that may be useful in satisfying unforeseen future task-related needs.	1….2….3….4….5….6….7

For the following questions, please **consider the way in which your team members interact, or share information or task-relevant perspectives with each other** using a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree … *Strongly Agree*
People in our team share their special knowledge and expertise with each other.	1….2….3….4….5….6….7
If someone in our team has some special knowledge about how to perform the team task, he or she is likely to tell the other members about it.	1….2….3….4….5….6….7
There is free exchange of information, knowledge, or sharing of skills among members of our team.	1….2….3….4….5….6….7
More knowledgeable team members freely provide other members with hard-to-find knowledge or specialized skills.	1….2….3….4….5….6….7

Consider your team's distribution of expertise (e.g., education, their professional training, and their area of practice). Please answer the following questions on a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	<u>Strongly Disagree</u> … *<u>Strongly Agree</u>*
Each team member has specialized knowledge of some aspect of our project.	1….2….3….4….5….6….7
I have knowledge about an aspect of the project that no other team member has.	1….2….3….4….5….6….7
Different team members are responsible for expertise in different areas.	1….2….3….4….5….6….7
The specialized knowledge of several different team members is needed to complete the project deliverables.	1….2….3….4….5….6….7
I know which team members have expertise in specific areas.	1….2….3….4….5….6….7

For the following questions, please **consider your interactions with your team members** using a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree … *Strongly Agree*
If you make a mistake on this team, it is often held against you.	1….2….3….4….5….6….7
Members of this team are able to bring up problems and tough issues.	1….2….3….4….5….6….7
People on this team sometimes reject others for being different.	1….2….3….4….5….6….7
It is safe to take a risk on this team.	1….2….3….4….5….6….7
It is difficult to ask other members of this team for help.	1….2….3….4….5….6….7
No one on this team would deliberately act in a way that undermines my efforts.	1….2….3….4….5….6….7
Working with members of this team, my unique skills are valued and utilized.	1….2….3….4….5….6….7

For the following question, please **select the ONE statement** that most accurately captures the type of **leadership** that existed within your team **during the training session today**. The differences between statements are important, so please read each carefully.

- ☐ There was no real leader; all members had equal amounts of influence and different individuals emerged as leaders at different times depending upon the nature of the task, the nature of the situation, or the schedule of other team members.
- ☐ There was no formal leader, but one team member almost always emerged as the informal leader most of the time. This person possessed critical task knowledge and interpersonal skills, but sought input from all team members prior to making decisions.
- ☐ The team voted on a leader, and although this person had critical task knowledge and interpersonal skills, they could also be voted out, and so they usually sought input from all team members prior to making decisions.
- ☐ There was one team member who was formally recognized as the official team leader, and this person generally sought input from most, but not all team members on decisions and would often delegate decisions.
- ☐ There was one team member who was formally recognized as the official team leader and this person made most, if not all, of the decisions, often after seeking no input or input from just one or two team members.

Thank you for your responses. You've finished the survey! If you have any questions, please do not hesitate to contact either Maritza Salazar (maritza.salazar@uci.edu) or Daniel Slyngstad (daniel.slyngstad@cgu.edu). We greatly appreciate you sparing your time today!

Appendix E: Distal Post Training Survey

FACILITATING EMERGENT INNOVATION IN EXPERTISE-DIVERSE TEAMWORK

POST-TRAINING SURVEY 2

We thank you for your continued participation in our research! This is the third and final survey associated with our study. Once you submit this survey, we will send you your $40 Amazon gift card. Please click to the next page to begin.

We would like to begin by asking you to complete a few tracking questions that will be familiar to you. The first set will allow us to more easily merge your responses across the two surveys. The second set will ensure subsequent survey questions display correctly.

What is your first and last name?

____

What is the name of the medical campus or academic institution through which you are participating in this study?

____

NOT including yourself, how many of your teammates attended the training session with you?

As an example, selecting "2" means that TWO OTHERS on your team attended the training with you (three people total, including yourself).

Please take a moment to make sure your answer to this question is accurate. It is related to questions that come later and is *very important* to our research.

- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

NOT including yourself, please write the names of these other members of your team *who attended the training with you*.

Your data will be kept strictly confidential, so **please do not use pseudonyms or nicknames.** It will prevent us from analyzing your responses properly.

- ☐ Teammate 1: ______________________________
- ☐ Teammate 2: ______________________________
- ☐ Teammate 3: ______________________________
- ☐ Teammate 4: ______________________________
- ☐ Teammate 5: ______________________________

Thank you. We would now like to ask you more questions about your team. Like the last survey, they will relate to how your team processes information and how you relate to other members.

Please make sure to only think about the team that is participating in this study and d*o not think about different teams for different questions*.

For each individual you listed, write in their names again **in the same order** and answer the following question **based on your experience with their leadership abilities.**

Please answer the following question for each individual on a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Not at All ... *A very great extent*
I rely on **Teammate 1:** ______________________ for leadership.	1….2….3….4….5….6….7
I rely on **Teammate 2:** ______________________ for leadership.	1….2….3….4….5….6….7
I rely on **Teammate 3:** ______________________ for leadership.	1….2….3….4….5….6….7
I rely on **Teammate 4:** ______________________ for leadership.	1….2….3….4….5….6….7
I rely on **Teammate 5:** ______________________ for leadership.	1….2….3….4….5….6….7

For each individual you listed, write in their names again **in the same order**. Consider the extent of your ***joint contribution*** to the team's knowledge products thus far, on a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

For reference, knowledge products can be tangible (e.g., publications, drafts, or other deliverables), or they can be conceptual or methodological frameworks (i.e., ways of thinking about or doing things).

	Strongly Disagree … Strongly Agree
The innovations produced by this team would have been impossible without the *unique combination* of **Teammate 1:** ______________________ **'s** and my ideas.	1….2….3….4….5….6….7
The innovations produced by this team would have been impossible without the *unique combination* of **Teammate 2:** ______________________ **'s** and my ideas.	1….2….3….4….5….6….7
The innovations produced by this team would have been impossible without the *unique combination* of **Teammate 3:** ______________________ **'s** and my ideas.	1….2….3….4….5….6….7
The innovations produced by this team would have been impossible without the *unique combination* of **Teammate 4:** ______________________ **'s** and my ideas.	1….2….3….4….5….6….7
The innovations produced by this team would have been impossible without the *unique combination* of **Teammate 5:** ______________________ **'s** and my ideas.	1….2….3….4….5….6….7

For each individual you listed, write in their names again **in the same order**. **Consider the extent of *their unique contribution* to the team's products thus far, apart from your own**, on a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

For reference, knowledge products can be tangible (e.g., publications, drafts, or other deliverables), or they can be conceptual or methodological frameworks (i.e., ways of thinking about or doing things).

	Strongly Disagree ... *Strongly Agree*
Teammate 1: ________________________________ 's expertise uniquely contributes to the team's outputs in a way that is *distinct from my own* contribution.	1….2….3….4….5….6….7
Teammate 2: ________________________________ 's expertise uniquely contributes to the team's outputs in a way that is *distinct from my own* contribution.	1….2….3….4….5….6….7
Teammate 3: ________________________________ 's expertise uniquely contributes to the team's outputs in a way that is *distinct from my own* contribution.	1….2….3….4….5….6….7
Teammate 4: ________________________________ 's expertise uniquely contributes to the team's outputs in a way that is *distinct from my own* contribution.	1….2….3….4….5….6….7
Teammate 5: ________________________________ 's expertise uniquely contributes to the team's outputs in a way that is *distinct from my own* contribution.	1….2….3….4….5….6….7

For each individual you listed, write in their names again **in the same order. Consider the extent to which they provided assistance to you over the last few weeks.** Their assistance could have been conceptual (e.g., reframing a problem), procedural (e.g., suggesting a new method), or technical (e.g., advice about unfamiliar technology) in nature.

Please answer the following question for each individual from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree … *Strongly Agree*
Teammate 1: ______________________ shared expertise with me by providing practical assistance for an aspect of my work.	1….2….3….4….5….6….7
Teammate 2: ______________________ shared expertise with me by providing practical assistance for an aspect of my work.	1….2….3….4….5….6….7
Teammate 3: ______________________ shared expertise with me by providing practical assistance for an aspect of my work.	1….2….3….4….5….6….7
Teammate 4: ______________________ shared expertise with me by providing practical assistance for an aspect of my work.	1….2….3….4….5….6….7
Teammate 5: ______________________ shared expertise with me by providing practical assistance for an aspect of my work.	1….2….3….4….5….6….7

For each individual you listed, fill in their name again **in the same order** in the blanks below and **consider their area of expertise in relation to your own** (e.g., their education, professional training, and their area of practice).

On a scale from 1 to 7, **how similar is their area of expertise to yours?**

	Teammate Expertise Similarity
	Very Dissimilar *Very Similar*
Teammate 1: ______________________________	1….2….3….4….5….6….7
Teammate 2: ______________________________	1….2….3….4….5….6….7
Teammate 3: ______________________________	1….2….3….4….5….6….7
Teammate 4: ______________________________	1….2….3….4….5….6….7
Teammate 5: ______________________________	1….2….3….4….5….6….7

Thank you for your responses thus far. You've completed about half of the survey! We would like to conclude by asking you some questions about your team in general and your perceptions of it, without asking about specific members. Please read each question carefully and answer as honestly as possible.

For the following questions, please **consider how innovative you consider your team to be with respect to its problem solving.** Consider how the statements apply *to the team as a whole* using a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree … *Strongly Agree*
This team learns new ways to apply knowledge of familiar techniques and procedures to develop new and unusual solutions.	1….2….3….4….5….6….7
This team seeks out information on products or techniques that are new, and learns how to apply them to develop new solutions to problems.	1….2….3….4….5….6….7
This team identifies and learns new skills and technologies that may be useful in solving unfamiliar problems.	1….2….3….4….5….6….7
This team seeks out and acquires information that may be useful in developing multiple solutions to problems.	1….2….3….4….5….6….7
This team seeks out and acquires knowledge that may be useful in satisfying unforeseen future task-related needs.	1….2….3….4….5….6….7

For the following questions, please **consider how innovative you think your team is relative to others in this topic domain (e.g., cancer biology)**, using a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree … *Strongly Agree*
The team initiates new procedures and methods.	1….2….3….4….5….6….7
The team develops innovative ways of accomplishing work targets/objectives.	1….2….3….4….5….6….7
The team develops new skills in order to foster innovations.	1….2….3….4….5….6….7
The team initiates improved learning strategies and methods.	1….2….3….4….5….6….7

For the following questions, please **consider how creative you consider your team to be in general** using a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree … *Strongly Agree*
The team comes up with new and practical ideas in solving problems.	1….2….3….4….5….6….7
The team easily develops new techniques and procedures related to the task.	1….2….3….4….5….6….7
When confronting problems, the team generates creative solutions.	1….2….3….4….5….6….7

For the following questions, please **consider how innovative you think your team is relative to others in this topic domain (e.g., cancer biology)**, using a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

	Strongly Disagree ... *Strongly Agree*
Team members express their own views directly to each other.	1….2….3….4….5….6….7
Team members try to understand each other's concerns.	1….2….3….4….5….6….7
Team members try to use each other's ideas.	1….2….3….4….5….6….7
Even when they disagree, team members communicate respect for each other.	1….2….3….4….5….6….7
Team members work for decisions they all accept.	1….2….3….4….5….6….7

Thank you for your responses! Before you submit the survey, please tell us what email you'd prefer for receiving your $40 Amazon gift card.

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Thank you for your responses. You've completed all three surveys! If you have any questions, please do not hesitate to contact Maritza Salazar (maritza.salazar@uci.edu) or Daniel Slyngstad (daniel.slyngstad@cgu.edu). We greatly appreciate the time you have given us!