Informing Science: the International Journal of an Emerging Transdiscipline

An Official Publication of the Informing Science Institute InformingScience.org

Inform.nu

Volume 21, 2018

FACILITATING INNOVATION IN INTERDISCIPLINARY TEAMS: THE ROLE OF LEADERS AND INTEGRATIVE COMMUNICATION

Maritza R. Salazar*	University of California at Irvine, Irvine, CA, USA	smaritza@uci.edu
Theresa K. Lant	Pace University, Pleasantville, NY, USA	tlant@pace.edu

* Corresponding author

ABSTRACT

Aim/Purpose	The complexity of scientific problems has spurred the development of transdisciplinary science, in which experts are brought together to collaborate across disciplinary and practice boundaries. These knowledge diverse teams can produce novel solutions, but they often fail to achieve their potential.
Background	Leaders have a crucial role to play in enabling effective collaboration among these diverse experts. We propose that a critical predictor of whether a newly formed interdisciplinary team will perform well is the leader's *multidisciplinary breadth of experience*, which we define as a leader's possession of significant experience in multiple areas of research and practice. We suggest that these leaders will have the capability to skillfully manage the interactions within the team.
Methodology	We test our prediction in a sample of 52 newly formed interdisciplinary medical research teams. We also observe and examine the communication patterns in a subset of these teams.
Contribution	There is a lack of systematic study of the impact leaders have on newly formed interdisciplinary science teams whose members have little or no prior collaborative experience with each other, possess specialized knowledge, and have limited overlapping expertise. This study combines quantitative and qualitative methods to examine the effect of leader multidisciplinary experience on team communication patterns and innovation.
Findings	Our study finds that teams are more innovative when their leader has a moderate breadth of multidisciplinary expertise. Exploration of team communication patterns suggests that leaders with moderate multidisciplinary breadth of expe-

Accepting Editor Gaetano Lotrecchiano │Received: October 14, 2017│ Revised: March 21, March 29, 2018 │ Accepted: April 9, 2018.

Cite as: Salazar, M. R., & Lant, T. K. (2018). Facilitating innovation in interdisciplinary teams: The role of leaders and integrative communication. *Informing Science: the International Journal of an Emerging Transdiscipline, 21,* 157-178. https://doi.org/10.28945/4011

	rience actively stimulated information sharing across expert domains by choosing cross-cutting topics and drew individuals' attention to the knowledge and approaches of others in the team.
Recommendations for Practitioners	Insights from this work can have practical implications regarding how to best select and train leaders to facilitate cross-boundary collaboration in transdisciplinary science. This study elucidates a variety of communication strategies that leaders can to enhance the team innovativeness.
Recommendation for Researchers	Further investigation into the underlying psychological states that these communication strategies elicit is needed. Future research should investigate psychological mediators such as knowledge consideration, perspective taking, and cognitive flexibility.
Impact on Society	Transdisciplinary science is needed to solve society's most complex problems. The more insight we gather about factors that can help these knowledge diverse teams to be successful, but more society will benefit.
Future Research	More research is needed on team formation, leader experience, and team outcomes in transdisciplinary science teams in a variety of contexts.

Keywords interdisciplinary teams, multidisciplinary breadth of experience, team innovation

INTRODUCTION

Major changes are underway in the organization and management of knowledge work, including the way in which science is conducted and translated into innovation. The complexity of scientific problems, coupled with a growing need for specialized expertise (Becker & Murphy, 1992; Jones, 2009), has spurred more transdisciplinary science, in which experts are brought together to collaborate across disciplinary and practice boundaries (Paruchuri, 2010; Wuchty, Jones, & Uzzi, 2007). The goal of bringing diverse expertise to bear on a given problem is to provide the requisite variety of knowledge and breadth of expertise needed to tackle the most difficult scientific puzzles (Kerr & Tindale, 2004). These collaborations often involve nascent teams of experts without prior joint work experience and without training in team project management. These teams face the dual challenge of needing to bridge across knowledge boundaries to develop integrated innovations while lacking the skills and experience to manage such a difficult process. Thus, identifying the conditions that enable effective cross-boundary collaboration in newly formed teams is essential if this new design of scientific knowledge work is to be successful in generating innovation.

For generations, fundamental discipline-based science has been the pathway to scientific discoveries. Theory-driven basic research, fueled by the pursuit of attaining "knowledge deeper within the tree of information" (Fang & Casadevall, 2010, p. 564) has led to significant discoveries that have shaped fields such as medicine. Noteworthy examples are the work on telomeres that resulted in treatments for cancer and research on retroviruses led to therapies to treat HIV. Basic scientists typically do not begin their investigations with the practical implications of their work in mind; rather they are driven by a deep interest in understanding the natural world. The journey from fundamental scientific discovery to practical application is seldom straightforward. The road is long and circuitous (Garud & Rappa, 1994). This has led to frustration with the length, expense, and uncertain payoff from basic research. In medical science, funding agencies and policy makers alike have argued that therapies for a disease can be more readily identified by bringing basic scientists, clinical practitioners, and patient-oriented researchers together to collaborate in teams composed of experts from a variety of research disciplines and practice areas (Chen, Farh, Campbell-Bush, Wu, & Wu, 2013; Rip, 2004; Winter & Berente, 2012).

Despite the promise of teams that combine distinct theoretical and methodological perspectives to solve complex problems (Hessels & Van Lente, 2008), the presence of diverse expertise does not automatically produce desired outcomes (e.g., Homan, van Knippenberg, Van Kleef, & De Dreu, 2007, Simons, Pelled, & Smith, 1999). When the knowledge boundaries between team members are "thick" and thus difficult to span due to differences in training, language, interpretation, and interests (Edmondson & Harvey, 2016), the gaps in understanding can seem insurmountable (Carlile, 2004; Cronin & Weingart, 2007). To accomplish the aims of transdisciplinary science, utilizing knowledge resources effectively is essential. This requires the ability to coordinate team interactions in a way that facilitates the sharing, consideration, evaluation, and integration of relevant knowledge. Unfortunately, research to date has found that interdisciplinary teams often lack the effective coordination necessary to live up to their potential (Austin, 2003; Bunderson & Sutcliffe, 2002; Cummings & Kiesler, 2005).

Although enablers of interdisciplinary effectiveness such as a shared identity (Bunderson & Sutcliffe, 2002) and prior collaborative experience (Cummings & Kiesler, 2005) have been shown to support improved team functioning in teams with longer tenure, less is understood about the factors that support team effectiveness in newly formed interdisciplinary teams when a shared identity has not formed and members have little to no collaborative history. When experts first come together to work on an interdisciplinary team, we suggest that leaders have a crucial role to play in enabling effective collaboration among these diverse experts order to facilitate common ground and to develop a shared direction. First, leaders can influence how team members respond to new perspectives and can also regulate the interactions among individuals (C. L Jackson & LePine, 2003; LePine & Van Dyne, 2001; Van Knippenberg, 2011). Indeed, the skillful facilitation of team processes by leaders has been shown to increase team effectiveness in general (Eisenbeiss, van Knippenberg, & Boerner, 2008; Mathieu, Maynard, Rapp & Gilson, 2008; Tansley & Newell, 2007; Zaccaro, Rittman & Marks, 2001) and innovation in particular (Mumford, Scott, Gaddis, & Strange, 2002). However, to date there have not been systematic studies of the impact of leaders on newly formed interdisciplinary science teams whose members have little or no prior collaborative experience with each other, possess specialized knowledge and have limited overlapping expertise.

We propose that in these teams a critical predictor of whether a newly formed interdisciplinary team will perform well is the leader's *multidisciplinary breadth of experience*, which we define as a leader's possession of significant expertise in multiple areas of research and/or practice. Leaders of nascent interdisciplinary teams will need deep knowledge and experience in at least one domain to gain legitimacy. Yet, they will also need to understand both research and clinical aspects of a disease to facilitate communication and understanding among individuals in the team who have expertise ranging from bed to bedside. As we explain in the following section, we hypothesize that a moderate degree of multidisciplinary breadth of experience will be most effective. We test our prediction in a sample of 52 newly formed interdisciplinary medical research teams, each of which worked together to produce a research proposal, and plan to explore the cause, treatment, and cure for a complex medical disease. We also explore the communication patterns in a subset of teams to generate insights about how leaders with differing degrees of multidisciplinary breadth of experience manage the communication processes within their teams.

Effects of Leader Multidisciplinary Breadth of Experience on Team Innovation

The complex nature of scientific discovery often necessitates interdisciplinary collaboration among investigators from across scientific fields (Falk-Krzesinski et al., 2010). The move towards transdisciplinary science has increased the need for scientists and practitioners to engage in teamwork that requires them to not just collaborate, but to integrate distinct expertise across traditional disciplinary boundaries. The potential benefit is that the heterogeneity of expertise in these interdisciplinary teams can lead to increased consideration and use of all available knowledge resources (e.g., Watson, Kumar & Michaelson, 1993), which can yield innovative solutions. However, team heterogeneity may also compromise performance, as it can trigger misunderstanding and conflict (S. E. Jackson & Joshi, 2011; van Knippenberg & Shippers, 2007). To illustrate this "double-edged sword" (van Knippenberg & van Ginkel, 2010), consider the success with which the Human Genome Project leveraged the varied, specialized expertise of its members (National Human Genome Research Institute, 2016), contrasted with the failure of the interdisciplinary effort responsible for the Challenger mission (Milliken, Lant, Bridwell-Mitchell, Starbuck, & Farjoun, 2005).

Research has suggested that mastery of domain relevant knowledge promotes *individual* creativity through improved ability to generate novel and appropriate solutions (Andrews & Smith, 1996; Mumford & Gustafson, 1988; Simonton, 1999). In interdisciplinary teams, individuals with specialized knowledge can contribute unique and valuable insight into a problem (Leahey, 2016). However, this specialization makes it difficult for individuals to share their contributions in a way that others understand and limits their ability to see how they could integrate their knowledge with their diverse team members. The lack of experience with problem-solving that incorporates multiple domains of knowledge may render the knowledge within the team incommensurate due to gaps in understanding (Cronin & Weingart, 2007). Moreover, the skills necessary to effectively negotiate contrasting perspectives and priorities among diverse experts (Long-Lingo & O'Mahony, 2010) are likely to be underdeveloped due to the prevalence of within-discipline training. Thus, teams composed of diverse specialists with little multidisciplinary experience will struggle to produce innovative approaches that incorporate integrated knowledge.

Because team leaders have a high-level view of a team's process, its task environment, and objectives (Morgeson, DeRue, & Karam, 2010) they are in a unique position to help minimize the adverse effects of diversity on team interactions. Currently there is limited research on how team leaders use their unique position to address the difficulty of integrating diverse expertise within a newly formed interdisciplinary team. Some studies have shown that transformational leadership, which emphasizes socioemotional support and recognition of the diverse needs and goals of team members, can foster improved creative performance of demographically or educationally diverse teams (Kearney & Gebert, 2009; Shin & Zhou, 2003). Other studies suggest that leaders with knowledge of different business functions are able to foster improved information sharing and unit performance (Bunderson & Sutcliffe, 2002). Baer (2010) demonstrates that when individuals possess expertise in a variety of domains they are better able to tap into and leverage the disparate ideas of others to generate new ideas. The breadth of a leader's task-relevant expertise has been shown to spur the creative performance of individual employees (Barnowe, 1975; Tierney, Farmer & Graen, 1999). Taken together, prior research would suggest that the breadth of leader expertise, especially when it overlaps with areas of expertise within the team, enhances a leader's ability to facilitate collective creativity. It remains unclear, however, whether a leader's multidisciplinary breadth of experience is beneficial in the formative stages of an interdisciplinary team when individuals represent vastly different disciplinary perspectives and share no prior collaborative history.

Gaining expertise in numerous domains can require a great deal of time, energy, and effort for individual investigators. Technological uncertainty (Fleming, 2001), logistical challenges (Long-Lingo & O'Mahony, 2010) coordination costs (Cummings & Kiesler, 2005) and role strain (Boardman & Bozeman, 2007) associated with working across multiple boundaries can all contribute to lower scientific productivity (Leahey, Beckman, & Stanko, 2015). The consequence can be reduced mastery in any area (Kovács & Sharkey, 2014). Given the importance of technical expertise for leaders seeking influence among highly trained individuals (Mumford et al., 2002), leaders with a large breadth of multidisciplinary experience risk reduced scientific credibility to influence team members successfully if they have not produced high impact interdisciplinary work. Given that interdisciplinary, high impact work can be elusive to many (Leahey et al., 2015), the lack of legitimacy could hinder a leader's legitimacy and undermine their ability to facilitate innovation. Moreover, highly trained professionals often struggle to accommodate the concepts of multiple fields to produce category-spanning ideas

(Lamont, Mallard, & Guetzkow, 2006), and leaders with high degree of multidisciplinary experience may lack the depth of expertise in the relevant knowledge arenas to support knowledge coordination and integration.

Thus, we suggest that a leader with moderate multidisciplinary breadth of experience will be most capable of facilitating innovation in interdisciplinary teams. They are likely to have depth of expertise in one area of work, while also having sufficient work experience in another to be able to identify interdependencies and complementarities between the two. Scientific contributions to a specialized domain will provide them with an acceptable amount of credibility to warrant the respect and followership of team members. Leaders will also have acquired various skills garnered from working across research and practice domains to foster collaboration across boundaries in a manner that an individual exposed to only one area would not. These arguments, therefore, suggest that relationship between leader multidisciplinary experience and team innovative performance will be positive up to a point and will begin to decline at high breadth of multidisciplinary experience, resulting in an inverted U-shaped pattern.

> *Hypothesis 1:* The relationship between leader multidisciplinary experience and team innovativeness will be curvilinear, such that innovation is highest when the level of multidisciplinary breadth of experience is moderate.

METHOD

RESEARCH SITE AND SAMPLE

The field study was set in a large medical center in the northeastern United States, referred to here as Metro Medical Center (MMC), which sought to reorganize the way it conducted medical research. The preparation for reorganization efforts began in August of 2007 with the appointment of a new Dean of Science who wanted to enhance interdisciplinary and translational research (Zerhouni, 2003) and funding for research at the institution. To accomplish this aim, the Vice Dean of Research formed a strategic science committee, composed of 13 expert faculty investigators from various academic departments, who would design and oversee an internal competition to identify interdisciplinary teams with cutting-edge research ideas that could attract funding to the University. All of these expert judges were full-time, tenured research faculty at MMC. Each judge had conducted scientific work that has had an international impact in their own fields. All of the judges had led at least one or more large, federally funded research grants. In October of 2007, an official announcement was made throughout MMC requesting proposals from newly formed interdisciplinary teams. Sixty-one teams self-organized in response to the call for proposals. The teams worked together from early October through December 1, 2007, and each submitted a letter of intent and abbreviated proposal. In January 2008, the expert panel of faculty judges assessed each proposal based on the degree of innovativeness. To avoid potential bias or conflict of interest, no expert faculty judge evaluated a project if they were in any way affiliated with one of the teams. In the end, 18 teams were selected to submit a full research proposal by April 1, 2008. On April 6, 2008, six of the original 61 teams were designated as "Centers of Excellence."

The Dean of Research reached out to the University's business school in August 2007 for involvement in the kick-off and competition process, which is how our research team became involved. In October 2007, our research team began to collect data from several sources, including individual curriculum vitae, interviews, observation, documents, and the administration of a web-based survey to all people who were listed as members of the 61 newly formed interdisciplinary teams. None of the data collected from this research effort was provided for evaluation during the competition process. Due to limited CV data for some teams, 52 teams are included in the study, consisting of 394 full-time faculty members (64% male; 36% female). The dependent variable, team innovativeness, was measured based on scoring sheets provided to us by the strategic science committee after they evaluated team proposals. The teams in our sample have education and work area diversity on the two dimensions that characterize interdisciplinary translational science teams: disciplinary diversity (biochemistry, immunology, etc.) and area of practice diversity (basic research, clinical research, medical practitioner).

Measures

Innovativeness

Team innovativeness was measured using MMC's strategic science committee's rating of each team's research proposal. The expert faculty judges in the committee used a scoring sheet that included the following assessment criteria: (a) the proposed project makes distinct contributions to basic, translational, and clinical science, and (b) the proposed project benefits the MMC's clinical mission to provide world-class care to patients. These broadly accepted criteria are used by organizations such as the National Institutes of Health (http://www.niaid.nih.gov/researchfunding/grant/strategy/pages/5scoring.aspx#b). After considering these criteria, at least three expert committee members independently rated each team's proposal on a scale from 1 ("Not at All Innovative") to 6 ("Very Innovative"). These scores were then averaged to provide a final score. To avoid conflicts of interest, committee members did not serve as evaluators for teams on which they were also members. Interrater agreement was high, rwg = .92 (Bliese, 2000), permitting the creation of composite ratings of team innovativeness.

The assessment of innovation we used is related to the consensual assessment approach, which argues that the most valid assessment of the creativity of an idea is the collective judgment of recognized experts in the field (Amabile, 1982). Moreover, the use of expert, independent evaluators for the dependent variable (i.e., innovativeness) enables us to overcome common method bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). To further understand the specific components of innovation that our one-item measure captured, however, we also correlated it with additional data that we collected from committee members as they assessed the final phase of ratings. This scoring sheet asked them to assess the proposals in terms of novelty. Their assessment of innovativeness was found to be correlated significantly with novelty (r= .74).

Multidisciplinary Breadth of Leader Experience

Each team in our sample had a single leader and no leader led more than one team. To assess the influence of leader breadth of multidisciplinary experience on team innovativeness, we used CVs to code the degree of substantive experience in areas of research and practice. We developed a list of 16 work history indicators within the domains of either academic research or clinical medical practice (see Appendix A) based on interviews with faculty. Two independent coders counted the number of indicators of experience in the domains of academic research and clinical medical practice. Extensive experience as a researcher suggested years of cultivating skills related to conducting scientific studies and also being part of or leading research laboratories. Extensive experience in clinical medical practice involved years of apprenticeship, plus mastery as signaled by certification by boards or membership in clinical societies. Inter-rater agreement was above .80 (Cohen's kappa), so we calculated the average (across coders) count of types of experience for each leader (0 to 16). In our sample, this count ranged from 6 to 15; the mean being 9.6. Our check of counts for each leader confirms that those with scores of 6-7 had experience in only research or clinical practice, not both (low breadth). Leaders with scores of 13-15 had clear and substantial work area breadth that included both research and practice. Several individuals with scores of 8-10 had primary experience in one domain, and minimal experience in the other. The ordinal counts capture the essence of the distribution from low to high breadth of multidisciplinary experience.

Control Variables

Analyses controlled for a number of variables. In order to disentangle the impact of leader breadth of experience from that of team members, we also controlled for team *member* breadth of experience. Procedures used to measure breadth of experience for team members were the same as those for leaders. Drawing on data from each team member's CV, we also controlled for educational background diversity of the team, dominant work area diversity of the team, team size, gender diversity of the team, and tenure rank diversity of the team. The number of individuals listed as core team members in the team's letter of intent was used as the measure of team size. Teams in our sample were generally medium-sized (M = 8.03, SD = 3.06), and ranged in size from 4 to 17 members. Blau's (1977) formula was used to compute educational background diversity (48 specialized disciplinary departments), dominant work area diversity (basic research, clinical and population research, clinical practice, surgeon), tenure rank diversity (assistant, associate, full professor) and gender diversity. The Blau's (1977) index of heterogeneity, $1-\sum(P_i)^2$, is calculated where P_i is the proportion of a team's members in the ith category (e.g., Wiersema & Bantel, 1992). This is the most common index for measuring diversity as variety (Harrison & Klein, 2007) and has a range of 0 – 1. For educational background diversity, the minimum and maximum levels of disciplinary heterogeneity in our sample were .32 and .90, respectively, and the average heterogeneity was .64. For team dominant work area diversity, the minimum and maximum indices were .00 and .81. The mean was .47. Finally, we also controlled for the leader's depth of expertise in the topic area by using the C.V. and calculating the proportion of the leader's publications in the team's focal topic area. We did so by counting the number of publications focused on the team's disease topic and dividing this number by the total number of publications they had published to date.

RESULTS

Test of Hypothesis: Effect of Leader Breadth of Experience

Table 1 presents descriptive statistics and correlations for all variables. Table 2 presents the analyses used to test our hypothesis. The main effect of leader breadth of multidisciplinary experience is significant (B = .12, $p < .04$). Thus, scores for team innovation increased with the breadth of leader experience. The square term of leader breadth of experience (B = -.04, $p < .04$) is negative and significant, providing support for the inverted U shape effect predicted in Hypothesis 1. This curvilinear effect indicates that at very high levels of breadth of experience, the effect on team innovation begins to decline. Regarding control variables, we found a negative relationship between gender diversity and innovation (B = -1.12, p = .05). Team diversity is measured with two indicators – educational background diversity (B = -0.02, ns) and dominant work area diversity (B =1.90, $p < .05$).

Table 1. Means, Standard Deviations, and Correlations

Variable	M (SD)	Min	Max	1	2	3	4	5	6	7	8
1. Team Size	7.58 (3.45)	4	25								
2. Gender Diversity	.59 (.26)	.11	1.00	-.19							
3. Tenure Rank Diversity	.73 (.20)	.13	1.21	-.03	.16						

Variable	M (SD)	Min	Max	1	2	3	4	5	6	7	8
4. Team Education Background Diversity	.65 (.13)	.32	.90	-.02	-.02	-.04					
5. Team Dominant Work Area Diversity	.47 (.16)	.00	.81	-.07	-.04	-.04	.32*				
6. Team Member Breadth of Experience	8.25 (1.41)	5.57	11.2	-.14	.02	-.18	-.04	-.22			
7. Leader Breadth of Experience	9.63 (2.30)	5	15	.05	-.00	.02	.13	.09	.03		
8. Leader Topic Expertise Depth	.55 (.23)	.04	1.00	.23	-.11	-.03	-.11	.04	-.08	.16	
9. Team Innovation	3.80 (.86)	2.00	5.60	.11	-.04	-.30*	.12	.34*	.02	.33*	.31*

Table 2. Effect of Leader Breadth of Experience on Team Innovation

	B	*SE B*	*β*
Team Size	.00	.03	.12
Gender Diversity	-1.12	.56	-.25*
Tenure Rank Diversity	.17	.40	.05
Team Education Background Diversity	-.10	.84	-.02
Team Dominant Work Area Diversity	1.91	.70	.36*
Team Member Breadth of Experience	.04	.08	.06
Leader Topic Expertise Depth	.73	.48	.20
Leader Breadth of Experience	.12	.05	.31*
Leader Breadth of Experience - Squared	-.04	.02	-.27*
Notes: $R^2 = .29$ ($p < .05$).			

Our quantitative analysis found that leaders with moderate levels of breadth of experience had the largest positive impact on team innovation. We predicted that this would be the case, arguing that leaders with both depth and breadth of experience would be more likely to foster cross disciplinary collaboration and innovation. While there is general consensus that the generation of new ideas and solutions occurs through the dialectic integration of insights and perspectives (Hargadon & Bechky, 2006; Long-Lingo & O'Mahony, 2010; Okhuysen & Eisenhardt, 2000; Sawyer, 2003), it is unclear what approaches to communication these leaders used to manage interaction in their teams. In order to gain further insight into the behaviors and communication practices of leaders, we conducted a comparative case qualitative analysis of the observational and interview data we had collected concurrently with the quantitative data.

Comparative Case Analysis: Exploring Leader Communication Behaviors

Sample

We began the process of recruiting teams for observation in October 2007, soon after the initial call for proposals. Our aim was to obtain as much real-time interview and observational data as possible. Recruitment of teams involved first inviting leaders of the newly formed teams at MMC to take part in a qualitative study. Twelve team leaders responded to our solicitation and we began by conducting semi-structured interviews with each of them and observing their team meetings. In January 2008, a subset of the 61 teams in the competition was selected by the Strategic Science Committee to develop a full proposal. Six of the twelve teams we were observing were chosen for this last step in the competition. Thus, we continued interviews and observation of meetings with these six teams. All observational and interview data were collected before the selection of finalist teams.

For the supplemental study, proposals were once again evaluated by the strategic science committee at MMC. We were able to not only gather a rating of proposal idea novelty as we did in the primary study, but to also collect a one-item measure of knowledge integration. The integration of knowledge in a proposal was based on the following three criteria: 1) integration across projects; 2) integration between areas of practice (basic and clinical researchers) and 3) integration across disciplinary areas. The scores ranged from 1 (no knowledge integration) to 6 (great deal of knowledge integration). As with the rating of innovativeness, each team's rating of knowledge integration was based on the average score provided by at least three external ratings from expert members of the evaluation committee. Once again, no expert judge rated any proposal where he or she might be biased due to a potential conflict of interest.

Our assessment of the features of the six teams in the supplementary study made them appropriate for comparative case analysis (Yin, 2015). The teams had commonalities such as having a single leader, skill differentiation (variety of domain expertise), task type (developing a brief and full proposal), temporal stability (mid-January to April 1st) and the same organizational context (MMC). They also differed in key ways. Of theoretical interest to us was that the leaders in our study had variance in breadth of multidisciplinary experience (ranging from a low to a high), allowing for meaningful comparison of leader behaviors. The leaders were all mid-career, full professors, had organizational tenure of at least 7 years, and had obtained their own external funding. Of the six leaders, CVs indicated that three of them published over 60% of their work on the disease topic being explored by their team, while the remaining three had 40% or fewer of their publications in their team's focal area. Men led five of the six teams in the supplementary study, a proportion similar to that of the sample of 61 teams analyzed in the quantitative study. The six teams had similar gender diversity ($M = .54$, $S.D. = .23$) and educational background diversity ($M = .67$, $S.D. = .09$), work area breadth ($M = .51$, $S.D. = .12$) and team size ($M = 8.43$, $S.D. = 4.11$).

Data Collection Procedures

Observations. One of the authors attended and observed team meetings from mid-January 2008 to the end of March 2008. The teams held an average of six meetings over this time. Each team was observed at least three times. Meetings were audio recorded and transcribed. Notes were taken during observations and further elaborated upon following each observation period (Emerson, Fretz, & Shaw, 1995). In total, we attended 30.5 hours of team meetings over a period of three months. All meetings took place at the research site, typically lasting from 60 to 90 minutes.

To uncover how leaders with varying levels of breadth of experience led team meetings we examined team interaction by studying statements made during meetings. The codes we used to analyze team communication during meetings closely aligned with the coding scheme developed by Kauffeld and Lehmann-Willock (2012). Their coding scheme builds upon the existing team process literature (e.g., Cooke & Szumal, 1994; Okhuysen & Eisenhardt, 2002; Wittenbaum, Hollingshead, & Botero, 2004). It covers four facets of verbal face-to-face meeting behavior including problem-focused, procedural, socioemotional, and action-oriented statement, as described in Appendix B. The problem-focused statements were directly related to differentiating the problem, finding appropriate solutions, and evaluating those solutions. Problem-focused codes we used included defining a problem, statements about who knows what, and asking questions about ideas. The procedural communication was aimed at structuring the meeting process (e.g., clarifying roles and goal orientation). Example codes used to analyze socioemotional communication included codes such as agreeing or cutting someone off. Similarly, action-oriented statements describe a team's willingness to improve their work (e.g., taking responsibility or action planning) or to not take action (e.g., no interest in taking charge or complaining). As we began to code team meeting transcripts, new codes also emerged from the data (Agar, 1980). For instance, when leaders described problems as intersecting various disciplines or practice areas, we coded this as describing a cross-cutting problem and when problems were framed for specialists, we coded it as domain-specific. Finally, axial coding was used to search for particular leader statements and convert them into higher order categories (e.g., problem construction and restructuring interaction to be more cross-boundary). Two coders, who were research assistants, were blind to team identity and the final outcome scores. The coders were also provided our coding schema to analyze the transcripts. They coded independently and identified all second-order codes and obtained an acceptable level of interrater reliability (>80%). Disagreements were resolved through discussion.

Interviews. We conducted 46 semi-structured interviews (Wengraf, 2001) with both team members and leaders to aid in our understanding of the work the teams were doing, how they conducted the work, and their perceptions of the collaboration. One interview was conducted with each of the 46 individuals in our sample. Interviewees represented diverse disciplines, allowing the research team access to multiple perspectives and reducing the potential for bias (Krefting, 1991). Interviews occurred at different phases of the team collaboration and interviews were recorded, transcribed, and coded. We coded searching constantly for emergent themes (Rubin & Rubin, 2011) to better identify how members perceived the team leader, the impact of team leader communication and meeting facilitation, and their influence on team innovative performance. Often these interviews contained information about their perceptions of the team process (e.g., socioemotional statements) or their engagement with the team (e.g., action-oriented statements).

Comparative Case Analysis

We used a comparative case method to explore similarities and differences in the communication used by leaders with varying degrees of work area breadth to structure team interaction. This approach enables us to uncover why different processes and outcomes emerged across our sample, despite similarities across cases (Van de Ven & Poole, 1995). Although all leaders engaged in encouraging, socioemotional statements to motivate contributions from members, only leaders with moderate and high breadth of experience facilitated information sharing from a wide variety of team members;

leaders with low breadth of experience sought engagement from only a subset of team members. Further, only leaders with moderate breadth of experience yielded synergistic cross-boundary interactions across departmental and specialist areas around a joint problem focus. By bringing together diverse experts around cross-cutting research problems, leaders with moderate breadth of experience were, therefore, able to foster more expertise integration and innovation.

Findings: Problem construction to foster cross-boundary integration

The process of identifying the problem is thought to be the first stage of the creative process (Amabile, 1996) and has the potential to shape not only the way that people respond to it, but the extent to which ideas produced are novel and useful (Berg, 2014). Research suggests that leaders tend to be primarily responsible for the problem construction process, even in self-managing teams (Nygren & Levine, 1996). The examination of team problem construction is critical to understanding interdisciplinary team effectiveness as it can affect perspective taking or team members' attempts to understand the thoughts and motives of others (Hoever, van Knippenberg, van Ginkel & Barkema, 2012), and the social interaction among members. By constructing and framing the team's joint problem a particular way (Boland & Tensaki; 1995), leaders have the potential to influence whether team members discover new ways to integrate their heterogeneous inputs.

Drawing upon their experiences from different domains of work, all leaders in the sample valued pulling together distinct domains of expertise together in interdisciplinary teams. The influence of training across disciplinary fields and practice areas is well-reflected in the quote below by a leader with high multidisciplinary breadth of experience. One shared,

> *"I was a neurologist in a past life. I'm an MD/Ph.D. …lived in both worlds, and I thought, I should probably step up to the plate, but do it in a way, where it is not about me, it's about making the program work. Foster interactions so that people feel like everyone is getting something out of [the team]. The team, together, could be much better if we bring in all of these different elements. People will feel like it is worthwhile. That's the genesis."*

Despite valuing interdisciplinary collaboration, leaders with high breadth of expertise struggled to identify how to integrate members of their teams around joint projects or problems. The focus of team problems tended to be either oriented toward clinical or research interests, rather than both. For instance, the problem construction of one leader with high multidisciplinary breadth of experience, but more of a clinical background, focused their team on several clinically-oriented areas of inquiry, while the construction of more basic research projects was left to teammates who had more basic research expertise. As a result, separate clinical and basic projects were developed in isolation, without joint discussion of how they might influence one another. Links between projects in this team were largely limited to sharing of specimens from the clinic to be studied by researchers. Another leader with high multidisciplinary breadth of experience lamented that bench to bedside collaboration mostly involved using a "syringe and a FedEx package" to send specimens from the clinic to the lab for "that kind of research" to be done by others.

One leader with low multidisciplinary breadth of experience, a Ph.D. focused on fundamental aspects of the medical disease problem, also expressed enthusiasm about working with clinicians and more clinically-oriented researchers. He described himself as trying to "improve the basic research" related to the disease given the primarily clinical concentration of the university, with an emphasis on "balancing the efforts" between research and clinical care efforts because of the historic focus at the institution on clinically-oriented work. Problem construction, therefore, leaned heavily towards basic research at the exclusion of the input of more clinically-oriented team members. Group discussion tended to start with an overview of basic research – which often was well-aligned with the personal research interests of the team leader – and to rarely include branches to clinically oriented research or work. Team conversation involved basic scientists and rarely involved individuals from other work areas. A clinician team member shared that the team would have performed better, "if there were a component that related to clinical stuff."

Problem construction by a team leader with low breadth of experience and less topic area expertise focused almost exclusively on improving the clinical management of the disease. Perhaps unable to construct problems that meaningfully included more basic research on the disease topic, he did seek the contribution of more research oriented investigators by asking them to suggest more fundamental research aims and objectives for the group. Members of these teams expressed that their leaders would frequently engage the team in overly general discussions, asking such questions as "What are we—what do they want ...what's really going on here, and what should we do?" and that their team had failed to develop "fine-grained hypotheses." Generally, the clinical and research endeavors were largely kept separate. "I felt sad for him" shared one team member during a one-on-one interview, "knowing that he couldn't do the basic science – it's not in his background." One interviewee reported during an interview that their team's proposal reflected "individuals writing up their own vision" without "collectively coming together." Leaders with little multidisciplinary breadth of experience also tended to over-structure the team problem space, orienting it around sub-themes or smaller research aims that favored a single discipline rather than many. Such meetings were spent discussing the research of particular team members, and discussions were often dominated by individuals possessing the same disciplinary training as the presenter without acknowledgement of the value of alternative perspectives. Thus, the various efforts led by this team were disconnected, and the final product was characterized by individuals drafting sections independently.

Leaders with moderate breadth of experience more actively stimulated information sharing across expert domains by choosing cross-cutting topics. Cross-cutting problems focused on themes that the leader believed would appeal to the interest of a number of individuals within the team, even if each member might approach it drawing on different expertise and methodologies. We determined integrative problem construction occurred when topics were presented as requiring the contributions of diverse experts in the room and when coded dialogue of group discussion involved participation not only from a single discipline, but from a numerous individuals in the team who represented clinical and research domains of expertise and various disciplinary perspectives. As an example, one of the leaders with moderate multidisciplinary breadth of experience focused the team discussion around the cross-cutting topic of impulsivity. This topic was presented as having behavioral, social, genetic, and cognitive aspects that would require insights from all group members. Team members, in turn, shared an appreciation of the narrowed scope, stating in interviews that this structure allowed for enhanced cross-boundary collaboration. One stated, "I think if you want to have an effective group, you have to set some form of – you have to impose some structure on it, otherwise people are just going to kind of drift apart." Moreover, interviewees noted that the confined problem space seemed to "set clear expectations of what the leader wanted over time. And so you kind of knew what you at least were expected to produce." Another team member commented in an interview that he could "easily see how other people think about [the] problem and how they could adjust their thinking and vice versa to inform each other."

Given the variety of ways that individuals from different work areas and disciplines thought about impulsivity and its relationship to their disease question of focus, discussion of the cross-cutting topic elicited novel perspectives and ideas. After discussion of the topic in his team, one member shared his impression. He stated during an interview:

> *"It's nice because you have a common language in a sense that we're all trying to look at how impulsivity might be related to [the disease]. But one thing that came out was the different kinds of definitions of [the disease] and different kinds of impulsivity."*

Another cross-cutting approach to problem construction was taken by a leader with moderate breadth of experience by encouraging her team to try to "characterize [the disease] phenotypically using many approaches including genetics, imaging, and blood." In this case, ideas and projects emerged drawing participation from individuals across specialties who had not worked together previously. Following the discussion involving several different specialists who had not interacted previously, the group decided to explore the use of a new imaging technique that had not been used to study this disease in this organ. One team member shared that exposure to this new approach ultimately led to a subset of pulmonologists to "look at things in a way that they haven't been used to before."

Findings: Socioemotional communication and cross-boundary integration

Leaders with low breadth of experience struggled to foster interaction among the diverse experts in their team. Conversation during team meetings typically involved a subset of team members, consisting of a few highly-reputable team members who worked in the same work area as the team leader. During meetings, more peripheral members did attempt to join team discussions. In one exemplary instance, a clinician-surgeon seeking to contribute to a conversation dominated by researchers was cut off by the leader who quickly stating, "Ok, alright. Thanks for that" and returned to the original thread in the basic research conversation. Statements such as, "Great. Let's move on." were made without any request for further elaboration from the contributor. These negative socioemotional forms of communication signaled that their contributions were not as valuable as others. One teammate shared that although he did not feel that the leader was disrespectful toward his suggestions, his ideas were ultimately "dismissed" making him feel undervalued and less invested. Team members left meetings with the sentiment that "[clinical] input was not so valuable to them [basic scientists]" nor were basic science inputs viewed as "valuable to their [clinical] work, despite it being "interesting."

In contrast, leaders with high breadth of experience were inclusive of the multiple expert groups present within their team. Despite the time-pressure given the proposal deadline, these leaders regularly took meeting time to make the knowledge resources in the room visible to all team members. An example of this type of problem-orientated statement that helped to make the team's collective expertise visible is reflected in this quote below:

> "…so this project is unique as it has got a very rich central clinical program and then it has got I think also the underpinnings of a lot of terrific science that interfaces well with this clinical work."

Despite the clear expression of the value of the diverse expertise in the team by leaders with high breadth of experience, we witnessed few attempts to form bridges among expert groups represented within the team. For instance, one leader tended to spend the beginning of meetings focused on the interests of the basic researchers and the end of the meeting turn to topics of interest to the clinically oriented team members. During the basic research portion of the dialogue, he did actively "give hooks where other branches [of science] could fit into the discussion." In one conversation, for instance, this leader directed attention to a woman on the team in a different research field than himself, stating, "I thought Madelyn had an interesting project related to looking at sodium fluxes that may relate to what we're discussing here." When the conversation transitioned to a discussion of clinical research interests, the leader tried to link clinically-oriented team members together during the discussion, but was less unable to do so. The clinical conversation never opened up to involve research-oriented faculty. Ultimately, diverse experts interacted infrequently and worked on separate projects pertaining only to their own domain of expertise.

What distinguished leaders with moderate breadth of experience was that they did not keep the dialogue focused on any particular area of expertise, including their own. Rather, they actively drew individuals' attention to the knowledge and approaches of others in the team. In one meeting, for instance, a leader introduced a mathematician he had invited to the meeting and let him share, at length, his mathematical algorithm that could be applied to the team's work. Despite being from a completely different field, the leader encouraged the team to be open to how the mathematical approach could help with pressing group tasks, like "calculating organ fluctuation." Such knowledge management statements that involved asking questions of individuals from other areas of specialization to foster the team's collective consideration of alternative perspectives was how leaders with moderate breadth of experience structured integrative interaction among members. Another strategy to enhance individuals' engagement with the ideas of others in the team was to elicit expertise through inquiry. Leaders would ask questions such as, "Want to say a word about that? Nobody knows about your project," or "Do you want to take two minutes to tell everyone about your work?"

One leader described the process of actively moving the dialogue from one work area to the next in an interview, stating that it involved "turning the idea a bit and figuring out ways to relate it to some other perspective." To engage diverse experts with one another's ideas, questions to elicit divergent perspectives were common. For instance, in a conversation about a successful clinical drug, the leader probed "why the drug is having its effect at the cellular and pathology levels in the first place?" Peaking the interest of basic researchers, the conversation soon turned from being dominated by a small set of clinical researchers to also including basic scientists in the room. A synergistic dialogue ensued, and soon representatives from diverse work and disciplinary areas were collectively generating new hypotheses to test. Thus, we see leaders with moderate breadth of experience reconfiguring interaction away from working within disciplinary silos towards more cross-boundary collaboration.

The general pattern comparing breadth of multidisciplinary experience of the leader and team outcomes illustrates that teams with leaders possessing moderate breadth of experience ranked high on both innovativeness (M= 4.59) and integration (M = 4.61). The average innovation and integration for teams with leaders possessing high transdisciplinary experience was 4.25 and 4.27, respectively. Finally, the worst performing teams in the qualitative sample were led by those with low work breadth of experience. These teams averaged an innovativeness score of 3.72 and an integration score of 3.8.

DISCUSSION AND CONCLUSION

The dominant narrative in existing research on scientific leadership is to focus deeply in a domain of expertise. This specialized, domain-specific knowledge is what is argued to enable a leader to effectively guide and direct scientific work. However, the complexity of the problems that transdisciplinary science teams are trying to solve make it difficult for a leader to rely solely on a single domain of specialized expertise. Our data supports the notion that some amount of breadth of experience and expertise is critical when leading transdisciplinary science teams – particularly when they are newly formed. Our conceptual argument is that leaders need a moderate mix of breadth and depth of experience that reflects the distribution of diverse disciplinary expertise represented within the team in order to facilitate the coordination and integration of these varied perspectives. These results contribute to a very nascent literature on creative leadership in science (Vessey, Barrett, Mumford, Johnson, & Litwiller, 2016). Our findings do not, however, control for other individual differences among leaders in our sample, such as leadership style (Jung & Avolio, 1999) or transdisciplinary orientation(Misra, Stokols, & Cheng, 2015), which could provide further insight into the kind of individuals who would be best equipped to lead interdisciplinary research teams. Future research should examine these other possible determinants of team effectiveness.

Our supplemental study provides insight into how leaders with multidisciplinary breadth of experience foster knowledge integration. Our comparative case analysis suggests that the leaders with expertise about a disease garnered from experience conducting substantial academic research and having had clinical experience working with populations or individuals suffering from the disease were more adept at helping their translational science teams use their deep-level knowledge resources. They did so through two key mechanisms. First, they construct a cross-cutting problem focus that intersects with the interests and expertise of the individual members and coordinate discussion around it. Second, they also engage in socio-emotional communication that demonstrates that they value and appreciate the contribution of all diverse experts in the team, regardless of their work experience or disciplinary background.

Even though leaders with high breadth of experience tried to involve team members with various types of expertise, they were less successful than leaders with moderate breadth of experience in facilitating synergies across domains of expertise. We view this as a by-product of the practical reality that too much breadth of experience is at odds with establishing a depth of expertise in at least one domain of practice. Without depth of knowledge, it is difficult to have sufficient perspective to meaningfully connect individual team members with one another's expertise. Least effective in facilitating innovation in interdisciplinary translational teams were those leaders who had expertise in either research or clinical work, but not both. Future research should explore whether there is a particular balance between breadth and depth that is critical for scientific leaders of interdisciplinary teams as it was beyond the scope of this project.

Limitations and Future Directions

Although this study makes a variety of contributions to the scientific understanding of the relationship between leader experience and the performance of newly formed transdisciplinary science teams, it has several limitations. First, this study was conducted in a single organization undergoing an intervention to foster the use of interdisciplinary collaboration to promote knowledge creation. Thus, the results are qualified by caveats typical of studies occurring within a single organization, including an idiosyncratic reward system, organizational culture, and motivation (e.g., interest in interdisciplinary collaboration). Features endemic to MMC's organizational context may limit generalizability.

Second, teams sampled in this study worked together for only a brief period and were engaged in a specific, yet complex task. The presence, consistency, and duration of the observed effects of team leaders may be inconsistent with those of other knowledge-creating teams with temporal stability (Hollenbeck, Beersma, & Schouten, 2012). Such inferences cannot be discerned from the current study. We do believe, however, that findings from this research generalize to many other project-based organizations where experts come together in teams to collaborate for a brief period of time (Edmondson & Nembhard, 2009; Huckman, Staats, & Upton, 2009). Moreover, we believe that the benefits of studying the predictors of innovation in real-world teams of scientific experts outweigh the inherent conceptual limitations of lab-based studies in which individuals do not typically possess and exchange deep expertise.

Finally, while our study does draw on interview and observational data to understand how a leader's multidisciplinary breadth of experience influences team process and performance, there remains the possibility that other individual-level leader difference could be important determinants as well. One possibility, for instance, is that leadership abilities or skills could have produced the differences that we observe rather than the breadth of prior multidisciplinary work experiences. Although we are doubtful of this possibility given that leaders in our sample had all led grant-funded teams in the past, future research should tease out these two drivers of influence to better understand the relative impact of a leader's work experiences and their skill as a leader.

Through the investigation into micro-processes that occur during social interaction of interdisciplinary science teams we elucidate a variety of communication strategies that leaders used to enhance the innovativeness of transdisciplinary science teams. This study highlights the strategies that effective team leaders can use even if they lack multidisciplinary experience. Further investigation into the underlying psychological states that these communication strategies elicit is needed. Future research should investigate the psychological mediators of this effect such as knowledge consideration (Kane, 2010), perspective taking (Hoever et al., 2012) or cognitive flexibility (De Dreu, Nijstad, & Baas, 2011).

In conclusion, this primary study illustrates that leaders' past work history affects interdisciplinary team performance. Specifically, we find a positive and significant relationship between teams led by leaders with moderate breadth of multidisciplinary experience and team innovativeness. Our supplementary analysis sheds light on how strategies including 1) presenting interdisciplinary teams with research problems that cross-cut members varied domains of expertise and 2) communicating in a way that is inclusive and respectful to all members of the team, regardless of their disciplinary or work background. We hope that the insights garnered from this study can have practical implications regarding how to best to select and train leaders to facilitate cross-boundary collaboration in interdisciplinary science teams.

REFERENCES

Agar, M. (1980). *The professional stranger*. New York: Academic Press.

Amabile, T. M. (1982). A consensual assessment technique. *Journal of Personality and Social Psychology, 43*, 997-1013. https://doi.org/10.1037/002 2-3514.43.5.997

Amabile, T. M. (1996). *Creativity in context: Update to the social psychology of creativity*. Westview press.

Andrews, J., & Smith, D. C. (1996). In search of the marketing imagination: Factors affecting the creativity of marketing programs for mature products. *Journal of Marketing Research*, 174-187. https://doi.org/10.2307/3152145

Austin, J. R. (2003). Transactive memory in organizational groups: The effects of content, consensus, specialization, and accuracy on group performance. *Journal of Applied Psychology, 88*(5), 866. https://doi.org/10.1037/0021-9010.88.5.866

Baer, M. (2010). The strength-of-weak-ties perspective on creativity: A comprehensive examination and extension. *Journal of Applied Psychology, 95*(3), 592. https://doi.org/10.1037/a0018761

Barnowe, J. T. (1975). Leadership and performance outcomes in research organizations: The supervisor of scientists as a source of assistance. *Organizational Behavior and Human Performance, 14*(2), 264-280. https://doi.org/10.1016/0030-5073(75)90029-X

Becker, G. S., & Murphy, K. M. (1992). The division of labor, coordination costs, and knowledge. *The Quarterly Journal of Economics, 107*(4), 1137-1160. https://doi.org/10.2307/2118383

Berg, J. M. (2014). The primal mark: How the beginning shapes the end in the development of creative ideas. *Organizational Behavior and Human Decision Processes, 125*(1), 1-17. https://doi.org/10.1016/j.obhdp.2014.06.001

Blau, P. M. (1977). *Inequality and heterogeneity: A primitive theory of social structure* (Vol. 7). Free Press New York.

Bliese, P. D. (2000). *Within-group agreement, non-independence, and reliability: Implications for data aggregation and analyses*. In K. J. Klein & S. W. J. Kozlowski (Eds.), Multilevel theory, research, and methods in organizations: Foundations, extensions, and new directions (pp. 349– 381). San Francisco: Jossey-Bass.

Boardman, C., & Bozeman, B. (2007). Role strain in university research centers. *Journal of Higher Education*, 430-463. https://doi.org/10.10 80/00221546.2007.11772323

Boland, R. J., Jr., & Tenkasi, R. V. (1995). Perspective making and perspective taking in communities of knowing. *Organization Science*, *6*(4), 350-372. https://doi.org/10.1287/orsc.6.4.350

Bunderson, J. S., & Sutcliffe, K. M. (2002). Comparing alternative conceptualizations of functional diversity in management teams: Process and performance effects. *Academy of Management Journal*, *45*(5), 875-893. https://doi.org/10.2307/3069319

Carlile, P. R. (2004). Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization Science, 15*(5), 555-568. https://doi.org/10.1287/orsc.1040.0094

Chen, G., Farh, J. L., Campbell-Bush, E. M., Wu, Z., & Wu, X. (2013). Teams as innovative systems: Multilevel motivational antecedents of innovation in R&D teams. *Journal of Applied Psychology, 98*(6), 1018-1027. https://doi.org/10.1037/a0032663

Cooke, R. A., & Szumal, J. L. (1994). The impact of group interaction styles on problem-solving effectiveness. *The Journal of Applied Behavioral Science*, *30*(4), 415-437. https://doi.org/10.1177/0021886394304005

Cronin, M. A., & Weingart, L. R. (2007). Representational gaps, information processing, and conflict in functionally diverse teams. *Academy of Management Review, 32*(3), 761-773. https://doi.org/10.5465/AMR.2007.25275511

Cummings, J. N., & Kiesler, S. (2005). Collaborative research across disciplinary and organizational boundaries. *Social Studies of Science, 35*(5), 703-722. https://doi.org/10.1177/0306312705055535

De Dreu, C. K., Nijstad, B. A., & Baas, M. (2011). Behavioral activation links to creativity because of increased cognitive flexibility. *Social Psychological and Personality Science, 2*(1), 72-80. https://doi.org/10.1177/1948550610381789

Edmondson, A. C., & Harvey, J. F. (2016). Unpacking team diversity: An integrative multi-level model of cross-boundary teaming. *Harvard Business School Technology & Operations Mgt. Unit Working Paper* (17-013).

Edmondson, A. C., & Nembhard, I. M. (2009). Product development and learning in project teams: The challenges are the benefits. *Journal of Product Innovation Management, 26*(2), 123-138. https://doi.org/10.1111/j.1540-5885.2009.00341.x

Eisenbeiss, S. A., van Knippenberg, D., & Boerner, S. (2008). Transformational leadership and team innovation: integrating team climate principles. *Journal of Applied Psychology, 93*(6), 1438. https://doi.org/10.1037/a0012716

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (2001). Participant observation and fieldnotes. *Handbook of ethnography*, 352-368. https://doi.org/10.4135/9781848608337.n24

Falk-Krzesinski, H. J., Börner, K., Contractor, N., Fiore, S. M., Hall, K. L., Keyton, J., Uzzi, B. (2010). Advancing the science of team science. *Clinical and Translational Science, 3*(5), 263-266. https://doi.org/10.1111/j.1752-8062.2010.00223.x

Fang, F. C., & Casadevall, A. (2010). *Lost in translation—Basic science in the era of translational research*. Americal Society of Microbiology. https://doi.org/10.1128/IAI.01318-09

Fleming, L. (2001). Recombinant uncertainty in technological search. *Management Science, 47*(1), 117-132. https://doi.org/10.1287/mnsc.47.1.117.10671

Garud, R., & Rappa, M. A. (1994). A socio-cognitive model of technology evolution: The case of cochlear implants. *Organization Science, 5*(3), 344-362. https://doi.org/10.1287/orsc.5.3.344

Hargadon, A. B., & Bechky, B. A. (2006). When collections of creatives become creative collectives: A field study of problem solving at work. *Organization Science, 17*(4), 484-500. https://doi.org/10.1287/orsc.1060.0200

Harrison, D. A., & Klein, K. J. (2007). What's the difference? Diversity constructs as separation, variety, or disparity in organizations. *Academy of Management Review, 32*(4), 1199-1228. https://doi.org/10.5465/AMR.2007.26586096

Hessels, L. K., & Van Lente, H. (2008). Re-thinking new knowledge production: A literature review and a research agenda. *Research Policy, 37*(4), 740-760. https://doi.org/10.1016/j.respol.2008.01.008

Hoever, I. J., van Knippenberg, D., van Ginkel, W. P., & Barkema, H. G. (2012). Fostering team creativity: perspective taking as key to unlocking diversity's potential. *Journal of Applied Psychology, 97*(5), 982-996. https://doi.org/10.1037/a0029159

Hollenbeck, J. R., Beersma, B., & Schouten, M. E. (2012). Beyond team types and taxonomies: A dimensional scaling conceptualization for team description. *Academy of Management Review, 37*(1), 82-106.

Homan, A. C., van Knippenberg, D., Van Kleef, G. A., & De Dreu, C. K. (2007). Interacting dimensions of diversity: Cross-categorization and the functioning of diverse work groups. *Group Dynamics: Theory, Research, and Practice, 11*(2), 79. https://doi.org/10.1037/1089-2699.11.2.79

Huckman, R. S., Staats, B. R., & Upton, D. M. (2009). Team familiarity, role experience, and performance: Evidence from Indian software services. *Management Science, 55*(1), 85-100. https://doi.org/10.1287/mnsc.1080.0921

Jackson, C. L., & LePine, J. A. (2003). Peer responses to a team's weakest link: A test and extension of LePine and Van Dyne's model. *Journal of Applied Psychology, 88*(3), 459. https://doi.org/10.1037/0021-9010.88.3.459

Jackson, S. E., & Joshi, A. (2011). Work team diversity. In S. Zedeck (Ed.), *APA handbooks in psychology. APA handbook of industrial and organizational psychology, Vol. 1. Building and developing the organization* (pp. 651-686). Washington, DC, US: American Psychological Association. http://dx.doi.org/10.1037/12169-020

Jones, B. F. (2009). The burden of knowledge and the "death of the renaissance man:" Is innovation getting harder? *The Review of Economic Studies, 76*(1), 283-317. https://doi.org/10.1111/j.1467-937X.2008.00531.x

Jung, D. I., & Avolio, B. J. (1999). Effects of leadership style and followers' cultural orientation on performance in group and individual task conditions. *Academy of Management Journal, 42*, 208-218. https://doi.org/10.2307/257093

Kane, A. A. (2010). Unlocking knowledge transfer potential: Knowledge demonstrability and superordinate social identity. *Organization Science, 21*(3), 643-660. https://doi.org/10.1287/orsc.1090.0469

Kauffeld, S. & Lehmann-Willenbrock, N. (2012). Meetings matter: Effects of team meetings on team and organizational success. *Small Group Research, 43*(2), 130-158. https://doi.org/10.1177/1046496411429599

Kearney, E., & Gebert, D. (2009). Managing diversity and enhancing team outcomes: The promise of transformational leadership. *Journal of Applied Psychology, 94*(1), 77-89. https://doi.org/10.1037/a0013077

Kerr, N. L., & Tindale, R. S. (2004). Group performance and decision making. In *Annual eview of Psychology* (Vol. 55, pp. 623-655). https://doi.org/10.1146/annurev.psych.55.090902.142009

Krefting, L. (1991). Rigor in qualitative research: The assessment of trustworthiness. *American Journal of Occupational Therapy, 45*(3), 214-222. https://doi.org/10.5014/ajot.45.3.214

Kovács, B., & Sharkey, A. J. (2014). The paradox of publicity: How awards can negatively affect the evaluation of quality. *Administrative Science Quarterly*, *59*(1), 1-33. https://doi.org/10.1177/0001839214523602

Lamont, M., Mallard, G., & Guetzkow, J. (2006). Beyond blind faith: Overcoming the obstacles to interdisciplinary evaluation. *Research Evaluation, 15*(1), 43-55. https://doi.org/10.3152/147154406781776002

Leahey, E. (2016). From sole investigator to team scientist: Trends in the practice and study of research collaboration. *Annual Review of Sociology, 42*(1), 81-100. https://doi.org/10.1146/annurev-soc-081715-074219

Leahey, E., Beckman, C., & Stanko, T. (2015). Prominent but less productive: The impact of interdisciplinarity on scientists' research. *Administrative Science Quarterly*, *62*(1), 105-139.

LePine, J. A., & Van Dyne, L. (2001). Voice and cooperative behavior as contrasting forms of contextual performance: evidence of differential relationships with big five personality characteristics and cognitive ability. *Journal of Applied Psychology, 86*(2), 326. https://doi.org/10.1037/0021-9010.86.2.326

Long-Lingo, E. L., & O'Mahony, S. (2010). Nexus work: Brokerage on creative projects. *Administrative Science Quarterly, 55*(1), 47-81. https://doi.org/10.2189/asqu.2010.55.1.47

Mathieu, J., Maynard, M. T., Rapp, T., & Gilson, L. (2008). Team effectiveness 1997-2007: A review of recent advancements and a glimpse into the future. *Journal of Management, 34*(3), 410-476. https://doi.org/10.1177/0149206308316061

Milliken, F. J., Lant, T. K., Bridwell-Mitchell, E. N., Starbuck, W. H., & Farjoun, M. (2005). Barriers to the interpretation and diffusion of information about potential problems in organizations: Lessons from the space shuttle Columbia. In W. Starbuck & M. Farjoun (Eds.), *Organizations at the Limit* (pp. 246-266). Wiley-Blackwell.

Misra, S., Stokols, D., & Cheng, L. (2015). The transdisciplinary orientation scale: Factor structure and relation to the integrative quality and scope of scientific publications. *Journal of Collaborative Healthcare and Translational Medicine*, *3*(2), 1042.

Morgeson, F. P., DeRue, D. S., & Karam, E. P. (2010). Leadership in teams: A functional approach to understanding leadership structures and processes. *Journal of Management*, *36*(1), 5-39. https://doi.org/10.1177/0149206309347376

Mumford, M. D., & Gustafson, S. B. (1988). Creativity syndrome: Integration, application, and innovation. *Psychological Bulletin, 103*(1), 27. https://doi.org/10.1037/0033-2909.103.1.27

Mumford, M. D., Scott, G. M., Gaddis, B., & Strange, J. M. (2002). Leading creative people: Orchestrating expertise and relationships. *The Leadership Quarterly, 13*(6), 705-750. https://doi.org/10.1016/S1048-9843(02)00158-3

National Human Genome Research Institute. (2016). *An overview of the human genome project*. Retrieved from https://www.genome.gov/12011238/an-overview-of-the-human-genome-project/

National Research Council. (2015). *Enhancing the effectiveness of team science*. Washington, DC: The National Academies Press. https://www.nap.edu/catalog/19007/enhancing-the-effectiveness-of-team-science

Nygren, R., & Levine. (1996). Leadership of work teams: Factors influencing team outcomes. In M. M. Beyerlein, D. Johnson, & S. T. Beyerlein (Eds.), *Interdisciplinary Studies of Work Teams* (Vol. 3, pp. 67-104). Greenwich, CT: JAI Press.

Okhuysen, G. A., & Eisenhardt, K. M. (2002). Integrating knowledge in groups: How formal interventions enable flexibility. *Organization Science, 13*(4), 370-386. https://doi.org/10.1287/orsc.13.4.370.2947

Paruchuri, S. (2010). Intraorganizational networks, interorganizational networks, and the impact of central inventors: A longitudinal study of pharmaceutical firms. *Organization Science, 21*(1), 63-80. https://doi.org/10.1287/orsc.1080.0414

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879. https://doi.org/10.1037/0 021-9010.88.5.879

Rip, A. (2004). Strategic research, post-modern universities and research training. *Higher Education Policy, 17*(2), 153-166. https://doi.org/10.1057/ palgrave.hep.8300048

Rubin, H. J., & Rubin, I. S. (2011). *Qualitative interviewing: The art of hearing data*. Sage.

Sawyer, K. (2003). Evaluative processes during group improvisational performance. *Critical Creative Processes*, 303-327.

Shin, S. J., & Zhou, J. (2003). Transformational leadership, conservation, and creativity: Evidence from Korea. *Academy of Management Journal, 46*(6), 703-714. https://doi.org/10.2307/30040662

Simons, T., Pelled, L. H., & Smith, K. A. (1999). Making use of difference: Diversity, debate, and decision comprehensiveness in top management teams. *Academy of Management Journal, 42*(6), 662-673. https://doi.org/10.2307/256987

Simonton, D. K. (1999). Significant samples: The psychological study of eminent individuals. *Psychological Methods, 4*(4), 425. https://doi.org/10.1037/1082-989X.4.4.425

Tansley, C., & Newell, S. (2007). Project social capital, leadership and trust: A study of human resource information systems development. *Journal of Managerial Psychology, 22*(4), 350-368. https://doi.org/10.1108/02683940710745932

Tierney, P., Farmer, S. M., & Graen, G. B. (1999). An examination of leadership and employee creativity: The relevance of traits and relationships. *Personnel Psychology, 52*(3), 591-620. https://doi.org/10.1111/j.1744-6570.1999.tb00173.x

van de Ven, A. H., & Poole, M. S. (1995). Explaining development and change in organizations. *Academy of Management Review*, 510-540. https://doi.org/10.2307/258786

van Knippenberg, D. (2011). Embodying who we are: Leader group prototypicality and leadership effectiveness. *The Leadership Quarterly, 22*(6), 1078-1091. https://doi.org/10.1146/annurev.psych.58.110405.085546

van Knippenberg, D., & Schippers, M. C. (2007). Work group diversity. *Annual Review of Psychology, 58*, 515-541. https://doi.org/10.1146/annurev.psych.58.110405.085546

van Knippenberg, D., & van Ginkel, W. P. (2010). The categorization-elaboration model of work group diversity: Wielding the double-edged sword. In R. J. Crisp (Ed.), *The Psychology of Social and Cultural Diversity* (pp. 255-280). Wiley-Blackwell. https://doi.org/10.1002/9781444325447.ch11

Vessey, W. B., Barrett, J. D., Mumford, M. D., Johnson, G., & Litwiller, B. (2014). Leadership of highly creative people in highly creative fields: A historiometric study of scientific leaders. *The Leadership Quarterly*, *25*(4), 672-691. https://doi.org/10.1016/j.leaqua.2014.03.001

Watson, W. E., Kumar, K., & Michaelsen, L. K. (1993). Cultural diversity's impact on interaction process and performance: Comparing homogeneous and diverse task groups. *Academy of Management Journal, 36*(3), 590-602. https://doi.org/10.2307/256593

Wengraf, T. (2001). *Qualitative research interviewing: Biographic narrative and semi-structured methods*: Sage. https://doi.org/10.4135/9781849209717

Wiersema, M. F., & Bantel, K. A. (1992). Top management team demography and corporate strategic change. *Academy of Management Journal, 35*(1), 91-121. https://doi.org/10.2307/256474

Winter, S. J., & Berente, N. (2012). A commentary on the pluralistic goals, logics of action, and institutional contexts of translational team science. *Translational Behavioral Medicine, 2*(4), 441-445. https://doi.org/10.1007/s13142-012-0165-0

Wittenbaum, G. M., Hollingshead, A. B., & Botero, I. C. (2004). From cooperative to motivated information sharing in groups: Moving beyond the hidden profile paradigm. *Communication Monographs*, *71*(3), 286-310. https://doi.org/10.1080/0363452042000299894

Wuchty, S., Jones, B. F., & Uzzi, B. (2007). The increasing dominance of teams in production of knowledge. *Science, 316* (5827), 1036-1039. https://doi.org/10.1126/science.1136099

Yin, R. K. (2015). *Qualitative research from start to finish*: Guilford Publications.

Zaccaro, S. J., Rittman, A. L., & Marks, M. A. (2001). Team leadership. *The Leadership Quarterly*, *12*(4), 451-483. https://doi.org/10.1016/S1048-9843(01)00093-5

Zerhouni, E. (2003). The NIH roadmap. *Science, 302*(5642), 63-64 + 72. http://www.jstor.org/stable/3835267?origin=JSTOR-pdf

APPENDIX A. CODING SCHEMA FOR MULTIDISCIPLINARY BREADTH OF EXPERIENCE

Using curriculum vitae, points are given for clinical and research experiences. After aggregating the number of clinical and research experiences in the two tables below, the totals from columns C and F are tallied to provide a final score.

	A	B	C			D	E	F
	Clinical Experience	**Example**	**Yes or No**			**Research Experience Indicators**	**Example**	**Yes or No**
1	MD	Degree in medicine	1 or 0		9	PhD	Disciplinary Domain (biology, biochemistry, etc.)	1 or 0
2	Intern & residency	In clinical area of practice	1 or 0		10	Research fellow or postdoc	Participation in research in a lab or center	1 or 0
3	Clinical fellowship	In clinical area of practice	1 or 0		11	5 years of research experience	Time span from first to last publication	1 or 0
4	Licensure & certification	American boards, clinical license	1 or 0		12	Participation in research-oriented boards	Institutional Review Board, NIH/NSF review committees	1 or 0
5	5 years of practice	Time span from medical school to date	1 or 0		13	Peer reviewed publications	1st or 2nd authorship evident	1 or 0
6	Professional clinical societies	American Board of Pain Medicine, Anesthesiology, or other clinical specialty	1 or 0		14	Research awards	Albert Einstein Gold Medal, Outstanding Women in Science; Young Investigator Award, Career Scientist	1 or 0
7	Awards–clinical	Top Doctor, Who's Who	1 or 0		15	Research support	PI or co-PI on Grants	1 or 0
8	Leadership in clinical centers	Director of cancer center, Parkinson's, geriatrics	1 or 0		16	Leadership in research lab	Director of their own research lab	1 or 0
			Total					Total

Appendix B. Coding Schema for Leader Communication in Team Meetings

Interaction Analysis Categories	Interaction Analysis Sub Codes and Definitions
Problem-focused Statements	**Cross-cutting problem construction.** Leaders present the research problem along a continuum from being narrow, discipline-specific aspect of the team's overall research project or on a broad, cross-cutting topic that integrates many interests.
Procedural Statements	**Cross-boundary team reflection.** Using descriptive statements to provide an overview of the expertise that team members possess and have access to.
Socioemotional Statements	**Encouraging cross-boundary participation**. The extent to which leaders increase awareness and use of heterogeneous knowledge of team members through introductions, referrals, and asking questions about diverse expertise.
Action-oriented Statements	**Interest in cross-disciplinary contribution.** Signalizing interest in ideas and options that bridge disciplinary and work areas of team members.

Biographies

Maritza Salazar, Ph.D. is an Assistant Professor at the Paul Merage School of Business. She earned her PhD in Management from the Stern School of Business at New York University. Her research is focused on improving the collaboration processes and performance outcomes in knowledge-diverse and culturally diverse teams. Professor Salazar is the recipient of numerous research awards including several major multi-year grants from the National Science Foundation on team science in healthcare and the physical sciences. She has also consulted, advised, or spoken about her team science research at various academic institutions including the National Academies of Science and the National Institutes of Health.

Theresa Lant, Ph.D. is Professor of Management and Academic Director of Arts and Entertainment Management at Pace University. She received her Ph.D. from Stanford University in 1987. Dr. Lant is an internationally recognized scholar for her research on learning and adaptation in teams and organizations. Her current work explores cognition and learning processes in interdisciplinary teams, with a focus on team leadership and innovation in medical research. Dr. Lant's research has been recognized by a *National Science Foundation* grant to study and train interdisciplinary medical research teams. She has served in a variety of leadership roles in the Academy of Management and the INFORMS College on Organization Science. Her publications have appeared in *Clinical and Translational Science, Small Group Research, Group and Organization Management, Journal of Economic Behavior and Organization, Journal of Management, Management Science*, *Organization Science,* and *Strategic Management Journal.*