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Creativity of same-discipline interactions

Kevyn Yong
HEC Paris

yong@hec.fr

Abstract

This paper challenges the view that creativity is best fostered through cross-discipline interactions. I argue that same-discipline interactions will produce greater creativity as competence-based trust and open critical discussion increases. Using a complete network method, I tested this idea in a multi-disciplinary biotechnology R&D laboratory on two aspects of the creative process: gaining new insights and combining knowledge to generate new ideas. Results showed that competence-based trust had a greater positive effect on gaining new insights for same-discipline interactions, whereas the positive effect of open critical discussion on gaining new insights was the same for both types of interactions. In contrast, open critical discussion had a greater positive effect on combining knowledge to generate new ideas for same-discipline interactions, whereas the positive effect of competence-based trust on combining knowledge to generate new ideas was the same for both types of interactions. These results suggest that research could uncover new insights by studying the mechanisms that amplify or inhibit the creative potential of both types of interactions.

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CREATIVITY OF SAME-DISCIPLINE INTERACTIONS

Abstract

This paper challenges the view that creativity is best fostered through cross-discipline interactions. I argue that same-discipline interactions will produce greater creativity as competence-based trust and open critical discussion increases. Using a complete network method, I tested this idea in a multi-disciplinary biotechnology R&D laboratory on two aspects of the creative process: *gaining new insights* and *combining knowledge to generate new ideas*. Results showed that competence-based trust had a greater positive effect on *gaining new insights* for same-discipline interactions, whereas the positive effect of open critical discussion on *gaining new insights* was the same for both types of interactions. In contrast, open critical discussion had a greater positive effect on *combining knowledge to generate new ideas* for same-discipline interactions, whereas the positive effect of competence-based trust on *combining knowledge to generate new ideas* was the same for both types of interactions. These results suggest that research could uncover new insights by studying the mechanisms that amplify or inhibit the creative potential of both types of interactions.

Key words: creativity; multi-disciplinary; competence-based trust; open critical discussion

In fact, basic research, with its long-term perspective accompanied by a strong emphasis on disciplinary excellence and multi-disciplinary interactions, is a necessary foundation for a successful innovation ecosystem.

- Dr. Subra Suresh, Director of the National Science Foundation, July 2011

The above quote echoes a widely held view in creativity research that multi-disciplinary settings stimulate creativity (e.g. Amabile & Khaire, 2008; Keller, 2001; Taylor & Greve, 2006). Multi-disciplinary settings expose an individual to two types of dyadic interactions that can influence individual creativity: cross-discipline and same-discipline interactions. Defining creativity as the process of generating novel and useful ideas that lead to innovations (Amabile, 1988; Audia & Goncalo, 2007; Nonaka, 1994), most creativity researchers argue that cross-discipline interactions stimulate creativity because they provide greater access to diverse knowledge (e.g. Ancona & Caldwell, 1992; Baer, 2010; Cummings, 2004; Guimera et al., 2005; Keller, 2001; Lovelace et al., 2001; Reagans & Zuckerman, 2001; Sethi et al., 2001; Sutton & Hargadon, 1996; Taylor & Greve, 2006). Similarly, social networks researchers have found that network interactions and structures that provide access to diverse knowledge stimulate creativity (e.g. Burt, 2004; Perry-Smith, 2006; Sosa, 2011; Uzzi & Spiro, 2005; Rodan & Galunic, 2004). Exposure to diverse knowledge acquired through cross-discipline interactions encourages thinking differently which increases the likelihood of novelty either through gaining new insights or through combining knowledge to generate new ideas (Dunbar, 1999; Finke, Ward, & Smith, 1992; Fleming, Mingo, & Chen, 2007; Hargadon & Bechky, 2006). For example, Apple's design team sought and gained new insights into creating the vibrant colors for iMac designs by learning the finer art of coloring jellybeans from candy-makers (Burrows, 2006).

However, the link between cross-discipline interactions and creativity is not a straightforward one. Several meta-analyses suggest that the link is weaker than previously thought (Bowers, Pharmer, & Salas, 2000; Hülsheger, Anderson, & Salgado, 2009; Weber & Donohue, 2001). For example, a recent meta-analysis found that cross-discipline diversity alone has a weak link to creativity, but the moderating mechanisms associated with discussing and exploring opposing ideas and perspectives in a cross-discipline context have a much stronger link (Hülsheger et al., 2009). Thus, the link between cross-discipline interactions and creativity depends on moderating mechanisms that facilitate the exchange and use of diverse knowledge that lead to “revising fundamental assumptions, engaging in cognitive restructuring, and generating novel insights” (Mannix & Neale, 2005: p. 42).

While much is known about the link between cross-discipline interactions and creativity, very little is known about the link between same-discipline interactions and creativity or the moderating mechanisms by which these interactions might positively influence creativity. Surprisingly, there is no prior research on the subject. I argue that same-discipline interactions can also encourage thinking differently, albeit through divergence in deep knowledge and problem-solving approaches. For example, although the respective expertise of two microbiologists may overlap a great deal on domain-specific microbiology knowledge, there will be significant differences in terms of deep knowledge accumulated from having unique experiences within microbiology and working on different specialized topics.

Moreover, I argue that individuals in same-discipline interactions are better able to apply diverse knowledge acquired through same-discipline interactions to push the boundaries of a knowledge domain, as opposed to those applying diverse knowledge acquired through cross-discipline interactions (Reagans & Zuckerman, 2001). This contention is based on Taylor and Greve’s (2006) assertion that creativity “requires the application of deep knowledge because individuals must understand a knowledge domain to push its boundaries with any nontrivial likelihood of success.” (p. 724). Open-source communities like Linux and Red-Hat, for example, thrive by drawing from the diverse expertise of a community of hackers; each hacker possessing a unique set of diverse knowledge and experience with software development (Lee & Cole, 2003; von Krogh & von Hippel, 2006). Given that the link between cross-discipline interactions and creativity is weak when examined without moderating mechanisms (Hülsheger et al., 2009; Mannix & Neale, 2005), and the link between same-discipline interactions and creativity appears strong, I suggest that, under the right conditions, same-discipline can stimulate greater creativity than cross-discipline interactions.

The key to studying the link between same-discipline interactions and creativity is identifying the moderating mechanisms that activate the creative potential present within same-discipline interactions. For this reason, I examine *competence-based trust* and *open critical discussion* as moderating mechanisms that bring out the creative potential in both cross-discipline and same-discipline interactions. Competence-based trust is defined as the degree to which an individual trusts the domain expertise and competence of the other person (Mayer, Davis, & Schoorman, 1995). Open critical discussion is defined as the degree to which an individual is comfortable having her ideas critically analyzed and assessed by others as well as her being comfortable critically analyzing and assessing others' ideas (Edmondson, 1999; Ellis, Hollenback, Ilgen, Porter, West, & Moon, 2003; Schulz-Hardt et al., 2006; Tjosvold, 1982). I suggest that both competence-based trust and open critical discussion affect the extent to which an individual is motivated to think differently, and determines the extent to which she is willing to engage in the effort required to combine diverse knowledge to generate new ideas.

While creativity has generally been defined as the process of generating novel and useful ideas (Amabile, 1988; George, 2007; Woodman et al., 1999), the creative process is generally divided into two aspects: *Gaining new insights* and *combining knowledge to generate new ideas*. Gaining new insights captures the "Eureka!" moment when individuals obtain a fresh perspective on their own ideas and start to think differently (e.g. Cronin, 2004; Zhong, Dijsksterhuis, & Galinsky, 2008) while combining knowledge to generate new ideas captures active brainstorming and thoughtful combination of previously un-related knowledge (e.g. Hargadon & Bechky, 2006; Sutton & Hargadon, 1996; Taylor & Greve, 2006).

The goal of this research is to examine how competence-based trust and open critical discussion moderates the link between same-discipline interactions and these two aspects of creativity. To this end, I study a biotechnology research and development laboratory where scientists engage a mix of both cross-discipline and same-discipline interactions to develop new ideas, solutions, and tools to investigate basic and applied problems in the biological sciences. Analyses indicate that with greater competence-based trust and open critical discussion, same-discipline interactions can present a creative advantage over cross-discipline interactions. In particular, the results show that competence-based trust has a greater positive effect on *gaining new insights* for same-discipline interactions, while the positive effect of open critical discussion on *gaining new insights* was the same for both types of interactions. In contrast, open critical discussion has a greater positive effect on *combining knowledge to generate new ideas* for same-discipline interactions, whereas the positive effect of competence-based trust on *combining knowledge to generate new ideas* was the same for both types of interactions. These results make a contribution to creativity research by showing that varied factors can have different moderating effects on different aspects of creativity. More broadly, these results suggest that future research could uncover new insights into creativity by studying the moderating mechanisms that amplify or inhibit the creative potential of both cross-discipline and same-discipline interactions.

THEORY

To study the moderating mechanisms that brings out the creative potential in both cross-discipline and same-discipline interactions, I consider the moderating roles of competence-based trust and open critical discussion, both of which have been found to foster cognitive openness (Mikulincer & Arad, 1999) and the effective exchange and use of unique knowledge (Ellis et al., 2003).

Competence-based Trust and Creativity

Individual creativity requires thinking differently. Thinking differently involves being cognitively open to integrating the diverse knowledge shared by others in a way that motivates taking a new perspective (Mikulincer & Arad, 1999). The challenge to thinking differently, however, is the tendency to believe in the merits of one's own knowledge and ideas (Heath & Gonzalez, 1995; Smith, 2003). This belief causes one to evaluate and use diverse knowledge offered by others in a way that supports one's own perspective (Greitemeyer & Schulz-Hardt, 2003; Heath & Gonzalez, 1995; Shane, 2000; Smith, 2003). When others offer diverse knowledge in harmony with what one knows much attention is paid to using this knowledge to bolster confidence in one's perspective (Heath & Gonzalez, 1995). When others offer contradictory diverse knowledge, this knowledge is either ignored as irrelevant (Gigone & Hastie, 1993) or distorted to fit with what one thinks (Russo, Meloy, & Medvec, 1996; Russo, Meloy, & Wilks, 2000). Evidence suggests that people distort diverse knowledge even if they have inferior ideas (Russo, Carlson, & Meloy, 2006), or if they actively seek out disconfirming diverse knowledge (Heath & Gonzalez, 1995). People develop personal ownership of their ideas and, in making these ideas part of how they see themselves, tend to be cognitively defensive when faced with contradictory diverse knowledge (De Dreu & van Knippenberg, 2005). As a result, there is a tendency to use diverse knowledge offered by others in ways that converge rather than diverge from one's initial ideas (Smith, 2003).

This evaluation bias, however, might be mitigated by competence-based trust. Competence-based trust is defined as having confidence in another person's intellectual abilities and viewing that person as an expert in her discipline (Mayer et al., 1995). Such trust facilitates the perceived usefulness of being open to listening and learning from the knowledge source (Abrams, Cross, Lesser, & Levin, 2003; Levin & Cross, 2004). Competence-based trust motivates an individual to think more deeply about diverse knowledge by reducing cognitive resistance towards contradictory knowledge elements and improving the integration of diverse knowledge (Szulanski, 1996). This cognitive openness to integrating diverse knowledge facilitates the discovery of new and useful ideas. Even if an individual is familiar with the strengths and weaknesses of her own ideas, competence-based trust motivates her to actively consider how the other person's unique knowledge might inform her thinking. *Does the unique knowledge reveal strengths and weaknesses that she has overlooked? How might this unique knowledge help her think of ideas that really push the boundaries of the domain she is working in?* As such, given the tendency to be cognitively defensive against diverse knowledge and to use it in ways consistent with initial ideas, I suggest that competence-based trust should mitigate the evaluation bias because "knowledge seekers who trust a source's competence to make suggestions and influence their thinking are more likely to listen, to absorb, and take action on that knowledge" (Levin & Cross, 2004: p. 1480).

H1a: Competence-based trust is positively related to *gaining new insights*.

H1b: Competence-based trust is positively related to *combining knowledge to generate new ideas*.

Open critical discussion and Creativity

Individual creativity also requires the thoughtful exchange of diverse knowledge to generate novelty. Yet, there is a tendency to focus on overlapping knowledge when problem-solving instead of exchanging and discussing diverse knowledge (Gigone & Hastie, 1993; Stasser & Stewart, 1992). People are generally uncomfortable discussing their unique ideas for fear of being evaluated and revealing they do not know something (Lee, 1997; Lee, Edmondson, Thomke, & Worline, 2004). Those who openly discuss their unique ideas with others run the risk of revealing the flaws in their thinking, or appearing incompetent, which can result in being ascribed a low status amongst their co-workers (Edmondson, 1999; Owens & Sutton, 2001). Even if an individual is comfortable openly discussing her ideas with another person, the other person is less inclined to exchange and discuss unique knowledge that contradict or challenge her ideas. This is to avoid the interpersonal conflict that often arises from such challenges (Jehn & Bendersky, 2003; Jehn & Mannix, 2001; Lovelace et al., 2001; Simons & Peterson, 2000). In offering opinions or perspectives that challenges the individual's ideas, the other person risks the individual taking the challenges personally and interpreting them as personal attacks on her intelligence. Thus, despite the wisdom that having very different ideas combined with low interpersonal conflict is ideal for fostering creativity, empirical work indicates that such ideal situations are unlikely since individuals are unable to separate interpersonal conflict from having very different ideas (Simons & Peterson, 2000; De Dreu & Weingart, 2003). Moreover, when an individual is explaining her ideas to another person, the other person is likely to generate similar rather than different ideas (McGlynn, McGurk, Effland, Johll, & Harding, 2004; Paulus & Yang, 2000; Valacich, Dennis, & Connolly, 1994). Listening to the individual explain her initial ideas readily brings to mind – or makes salient in the other person's mind – unique knowledge that supports or validates the individual's ideas (Dugosh, Paulus, Roland, & Yang, 2000; Paulus & Yang, 2000). Thus, openly discussing ideas is often biased towards discussing knowledge and ideas that are consistent rather than constructively different from the individual's initial ideas.

This avoidance bias is mitigated by being comfortable engaging in open critical discussion, which is defined as the ability to openly exchange and critically discuss both one's own and others' knowledge and ideas (Johnson, Johnson, & Tjosvold, 2000; Schulz-Hardt, Brodbeck, Mojzisch, Kerschreiter, & Frey, 2006; Tjosvold, 1982). Open critical discussion is characterized by asking many questions to gain an understanding of the other person's ideas and knowledge, thereby involving "a full and critical discussion of the available data and ideas" (Ellis et al., 2003: p. 823). Given that the open exchange and critical discussion of diverse knowledge fosters creativity in dyadic interactions (Hargadon & Bechky, 2006; Sosa, 2011), creativity therefore should depend on open critical discussion. I expect that open critical discussion will determine the extent to which diverse knowledge is thoughtfully exchanged such that the individual learns something new and uses this new perspective to generate creative ideas or solutions.

H2a: Open critical discussion is positively related to *gaining new insights*.

H2b: Open critical discussion is positively related to *combining new information to generate new ideas*.

Same-Discipline Interactions and Creativity

I have argued that competence-based trust and open critical discussion facilitates thinking differently and the thoughtful exchange of diverse knowledge, both of which are necessary for creativity. I further argue that these positive effects of competence-based trust and open critical discussion on creativity will be greater for same-discipline interactions than for cross-discipline interactions. This is because the thoughtful exchange of diverse knowledge to think differently in same-discipline interactions will involve diverse knowledge that is deeper than the diverse knowledge exchanged in cross-discipline interactions. For example, a discussion between product designers and jelly-bean makers on how to manufacture colored plastic appear vibrant-looking involves the exchange of different but relatively codified and less deep knowledge on coloring techniques compared to the exchange of relatively less codified and deeper knowledge differences on hacking protocols between two hackers discussing how to solve a problem in the source code. Since the knowledge non-overlap for same-discipline interactions is smaller than the non-overlap in cross-discipline interactions, same-discipline interactions offer a smaller pool of diverse knowledge. Nonetheless, a smaller but deeper pool of diverse knowledge will be positively associated with creativity to a greater extent because creativity "requires the application of deep knowledge because individuals must understand a knowledge domain to push its boundaries with any nontrivial likelihood of success" (Taylor & Greve, 2006: p. 724; see also Sternberg & O'Hara, 2000). In other words, participants in same-discipline interactions are in a better position to detect errors and make critical suggestions than cross-discipline interactions (e.g., Lee & Cole, 2003).

Same-discipline interactions also involve greater absorptive capacity than cross-discipline interactions. People "find it easier to absorb new ideas in areas that they have some expertise and find it more difficult to absorb new ideas outside of their immediate area of expertise" (Reagans & McEvily, 2003: p. 243). For example, a microbiologist will be more effective at pushing the boundaries of microbiology by applying diverse knowledge received from another microbiologist as opposed to applying diverse knowledge received from a chemical engineer (Taylor & Greve, 2006). It is true that cross-discipline interactions characterized by long-term collaboration could also develop a similarly effective absorptive capacity in the transfer of deep diverse knowledge (e.g. Hansen, 1999; Sosa, 2011). However, given the same long-term collaboration, same-discipline interactions should still hold an advantage over cross-discipline interactions because same-discipline interactions draw from a shared pool of expertise and techniques to communicate and apply diverse knowledge.

I expect therefore that with increased competence-based trust and open critical discussion, the positive effects of competence-based trust and open critical discussion on creativity will be greater for same-discipline interactions than for cross-discipline interactions.

H3a: As competence-based trust increases, it will have a greater positive impact on *gaining new insights* for same-discipline interactions than for cross-discipline interactions.

H3b: As competence-based trust increases, it will have a greater positive impact on *combining knowledge to generate new ideas* for same-discipline interactions than for cross-discipline interactions.

H3c: As open critical discussion increases, it will have a greater positive impact on *gaining new insights* for same-discipline interactions than for cross-discipline interactions.

H3d: As open critical discussion increases, it will have a greater positive impact on *combining knowledge to generate new ideas* for same-discipline interactions than for cross-discipline interactions.

Insert Figure 1 about here

METHODS

Research Setting

This study was conducted with a multi-disciplinary network of scientists working in a biotechnology research and development laboratory at a large northeastern university. This research setting was ideal for several reasons. Preliminary interviews with the laboratory director confirmed that the daily scientific work done in this setting is multi-disciplinary. Chemists, chemical engineers, microbiologists, molecular biologists, electrical engineers, amongst others, work together on different projects that address a variety of basic and applied problems in the biological sciences. One area of multi-disciplinary work uses protein engineering and expression techniques for developing recombinant anti-cancer therapeutics. A second area involves the design and engineering of portable sensor devices using nanofabrication methods. A third area explores how to use biomaterials to develop new methods for creating advanced microfluidic systems and nanostructured arrays for bio-analytical applications. Thus, creativity in this setting involves scientists combining knowledge from both cross-discipline and same-discipline interactions to develop new ideas, solutions, and tools.

This setting also made it possible to use a complete network method to collect multi-item measures of all dyadic interactions. Each scientist was presented with a roster of the names of all their colleagues working in the R&D laboratory, and instructed to respond to multiple questions about their dyadic interaction with each person on the list. Adopting a complete network method helps reduce bias in measurement such as respondents forgetting dyadic interactions (Brewer, 2000). However, collecting multi-item measures on all dyadic interactions demands a considerable effort on the part of the participant, with each additional contact in the network significantly increasing the number of responses each participant has to provide; this could lead to problems associated with response fatigue and disengagement. To mitigate response fatigue bias, a complete network method is typically adopted for samples ranging in size approximately between 20 and 40 people (e.g. Borgatti & Cross, 2003; Krackhardt, 1990, 1995; Casciaro, 1998; Casciaro, Carley, & Krackhardt, 1999). Researchers have used complete network methods to examine larger samples (> 50 people) but with limited measures of dyadic interactions. For instance, Labianca, Brass, and Gray (1998) used single-item measures of communication frequency and friendship, whereas Mehra, Kilduff, and Brass (1998) had participants go through the complete network and put a check beside each name for two items indicating similar social identity and friendship.

With the advantages and challenges of complete network methods in mind, I collected multi-item measures of each of the 471 dyadic interactions across 13 different scientific disciplines. Measures included a four-item measure of tie strength, a two-item measure of competence-based trust, a two-item measure of open critical discussion, a one-item measure of creativity as gaining new insights, and a one-item measure of creativity as combining knowledge to generate new ideas.

Sample

Four hundred and seventy-one dyadic interactions were identified from a sample of 33 scientists comprised of the laboratory director, research associates, postdoctoral fellows, graduate and advanced undergraduate students. The advanced undergraduate students were included because they actively contributed to research design and running experiments.

The average scientist was approximately 27 years old (M_{age} = 27.30, SD_{age} = 7.20) and had worked in this laboratory for about three years (M_{tenure} = 3.19, SD_{tenure} = 3.64). Thirty-five percent of the scientists were female. The scientific discipline expertise consisted of seven microbiologists, six chemists, four biologists, three electrical engineers, three bio-molecular engineers, two biotechnologists, two chemical engineers; and one each of the following: bio-engineer, bio-medical engineer, chemical biologist, material engineer, molecular biologist, and micro-fabrication engineer.

Because the laboratory director was designated to evaluate scientific projects as part of the larger study from which this data is drawn, he was not surveyed on any of the dyadic measures to avoid bias. Thus, thirty-two scientists were surveyed. Twenty-nine of these thirty-two returned the surveys (an 88 percent response rate). Of the three scientists who did not return surveys, one research associate was on maternity leave, one doctoral candidate had recently graduated, and one research associate declined participation. Nevertheless, while these three scientists and the laboratory director did not provide any data, their names were still included on the complete network. Thus, the data collected in this study should be representative of the whole network structure. As such, the twenty-nine scientists who provided data on their dyadic interactions reported an average of approximately nineteen interactions ($M_{no.\ of\ interactions}$ = 18.53, $SD_{no.\ of\ interactions}$ = 7.63), yielding a dataset of 471 dyadic interactions.

Data Collection

I collected the data in three phases, each approximately a month apart. Spacing out the data collection helped mitigate response fatigue bias that can result from collecting multi-item measures using a complete network method. Moreover, this approach helped to establish some (though non-definitive) support for causal direction of the independent and dependent variables. The scientists reported requiring between 30 and 60 minutes to complete each survey. They were guaranteed confidentiality and surveys were returned directly to me.

Phase 1: Independent and Control Variables. In phase one, I collected data on age, gender, and position to control for people's affinity to engage in dyadic interactions with similar others

(Ibarra, 1992; McPherson, Smith-Lovin, & Cook, 2001). I also collected data on the scientists' scientific discipline expertise according to their 'home' departments at the university. I operationalized scientific discipline similarity of dyadic interactions by constructing a dummy variable with cross-discipline interactions assigned a value of 1 and same-discipline interactions assigned a value of 0.

Phase 2: Independent and Control Variables. In phase two, I gave each scientist a list of the names of all the scientists and they used a seven-point scale to rate their dyadic interactions with each laboratory member on measures of competence-based trust, open critical discussion, and tie strength to control for dyadic network cohesion.

For competence-based trust, each scientist responded to two questions I adapted from previous work (Mayer et al., 1995; McAllister, 1995): "How much do you trust this person's intellectual abilities?" and "How often do you seek work-related advice from this person because this person is an expert in his/her research area?" For open critical discussion, each scientist responded to two questions I adapted from previous work (Ellis et al., 2003; Tjosvold, 1982): "How comfortable are you openly discussing your ideas with this person?" and "How comfortable are you critically discussing this person's ideas?" Principal component analysis using varimax rotation indicated that the four items loaded onto two factors with factor loadings ranging from 0.74 to 0.93 with 86.68 percent of the variance accounted for. Cronbach's alpha was 0.77 for the two-item measure of competence-based trust and 0.88 for the two-item measure of open critical discussion.

To control for dyadic network cohesion, I had each scientist respond to a four-item measure of tie strength based on work interaction frequency and friendship closeness (Granovetter, 1973; Hansen, 1999; Marsden & Campbell, 1983); two questions assessing work interaction frequency and two questions assessing friendship closeness (e.g. Borgatti & Cross, 2003; Cross & Cummings, 2004). To measure work interaction frequency, I averaged i's response to the question "How frequently do you have work-related interactions with person j?" and j's response to the question "How frequently does person i have work-related interactions with you?" (ICC = 0.89). To measure friendship closeness, I averaged i's response to the question "To what extent do you consider person j a close friend?" and j's response to the question "To what extent does person i consider you a close friend?" (ICC = 0.92). Principal component analysis using varimax rotation indicated that both work interaction frequency and friendship closeness loaded on to one factor with a factor loading of 0.86 and 74.23 percent of the variance accounted for. Thus, I averaged work interaction frequency and friendship closeness as a measure of tie strength between i and j.

I used this measure of tie strength to calculate dyadic network cohesion (Burt, 1992; Reagans & McEvily, 2003; Sosa, 2011). Dyadic network cohesion is a triadic density measure of strong third-party ties around a dyad: $c_{ij} = \Sigma P_{iq}P_{qj}$, for $q \neq i, j$, P_{iq} is i's tie strength to q as a proportion of the aggregate level of tie strength across all of i's dyadic interactions, and P_{qj} is q's tie strength to j as a proportion of the aggregate level of tie strength across all of q's dyadic interactions. Strong third-party ties directly connect i to j to the extent that i have a strong tie to q and q has a strong tie to j (Reagans & McEvily, 2003). Thus, summing $P_{iq}P_{qj}$ across all dyadic ties to q measures the overall tie strength of the third-party relationships around each dyad, i.e. dyadic network cohesion.

Phase 3: Dependent and Control Variables. In phase three, I used the same complete network method to measure creativity for each dyadic interaction. Each scientist was asked to rate the extent to which the following occurs when she interacts with each of the scientists in the laboratory: (1) "How rarely do you gain new insights from information shared by this person?" (reverse-coded), and (2) "To what extent do you combine information shared by this person's with your own information to generate new ideas? I also collected information on the number of projects that each dyad worked on together to control for any confounding effects of repeated collaboration.

RESULTS

Descriptive statistics and correlations are reported in Table 1. Since data collected using a complete network method fails the assumption of independent observations because each scientist provides data on dyadic interactions to multiple scientists, I used linear mixed model regression analysis to test the hypotheses. Regression statistics are presented in Tables 2 and 3.

Insert Table 1 about here

Creativity as *Gaining New Insights*

Model 1 shows that the control variables position similarity ($\beta = -0.09$, $t = -0.39$, ns) and the number of projects worked on together ($\beta = 0.12$, $t = 1.48$, ns) had no effect on creativity as gaining new insights. However, gaining new insights was affected by age similarity ($\beta = -0.02$, $t = -2.02$, $p < 0.05$), gender similarity ($\beta = 0.65$, $t = 3.24$, $p < 0.01$), and dyadic network cohesion ($\beta = 10.39$, $t = 3.50$, $p < 0.01$). Results from model 1 indicate that gaining new insights is positively linked to having interactions to scientists who are older in age. Indeed, that age similarity is not correlated to open critical discussion ($r = -0.02$, ns) but significantly correlated to competence-based trust ($r = -0.25$, $p < 0.01$) suggests that gaining new insights is enhanced because scientists are more likely to take note of and listen to older rather than younger scientists. Conversely, gender similarity is negatively correlated to both competence-based trust ($r = - 0.13$, $p < 0.01$) and open critical discussion ($r = - 0.13$, $p < 0.01$). Scientists were more likely to listen to and were more comfortable engaging in open critical discussion with scientists of a different gender. Finally, the positive link between dyadic network cohesion and gaining new insights may be explained by the positive correlation dyadic network cohesion has with both competence-based trust ($r = 0.21$, $p < 0.001$) and open critical discussion ($r = 0.14$, $p < 0.01$).

Model 2 shows that discipline similarity did not have an effect on gaining new insights ($\beta = -0.50$, $t = -1.63$, ns). This is consistent with the argument that, by itself, diverse knowledge does not generate creativity with respect to gaining new insights. Instead, models 3 and 4 show that both competence based trust ($\beta = 0.45$, $t = 7.55$, $p < 0.001$) and open critical discussion ($\beta = 0.36$, $t = 6.82$, $p < 0.001$) have positive main effects on gaining new insights, which supports hypotheses 1a and 2a.

Model 5 shows a significant interaction effect of discipline similarity and competence-based trust on gaining new insights ($\beta = -0.36$, $t = -2.10$, $p < 0.05$) but model 6 shows that the interaction effect of discipline similarity and open critical discussion is not significant ($\beta = -0.18$, $t = -0.99$, ns). Moreover, including both interactions in the same regression model (model 7) reduces the likelihood of overestimating the coefficients of the explanatory variables. Model 7 shows that the interaction between discipline similarity and competence-based trust is significant ($\beta = -0.38$, $t = -2.03$, $p < 0.05$) but the interaction between discipline similarity and open critical is not ($\beta = -0.02$, $t = -0.10$, ns). These results therefore support hypothesis 3a but not 3c.

Insert Table 2 and Figure 2 about here

Creativity as *Combining Knowledge to Generate New Ideas*

Model 8 shows that the control variable position similarity (β = 0.05, t = 0.25, ns) had no effect on creativity as combining knowledge to generate new ideas. However, combining knowledge to generate new ideas was affected by age similarity (β = -0.05, t = -5.92, $p < 0.001$), gender similarity (β = 0.86, t = 5.31, $p < 0.001$), the number of projects worked on together (β = 0.40, t = 5.92, $p < 0.001$), and dyadic network cohesion (β = 10.78, t = 4.53, $p < 0.001$). Results from model 8 indicate that combining knowledge to generate new ideas is positively associated to having interactions to scientists who are older in age.

Model 9 shows that discipline similarity did not have an effect on combining knowledge to generate new ideas (β = -0.09, t = -0.36, ns). This is consistent with the argument that, by itself, diverse knowledge does not generate creativity with respect to combining knowledge to generate new ideas. Instead, models 10 and 11 show that both competence based trust (β = 0.43, t = 9.16, $p < 0.001$) and open critical discussion (β = 0.38, t = 9.35, $p < 0.001$) have positive main effects on combining knowledge to generate new ideas. These results thus support hypotheses 1b and 2b.

Model 12 shows no significant interaction effect of discipline similarity and competence-based trust on combining knowledge to generate new ideas (β = -0.14, t = -1.02, ns) but model 13 shows that the interaction effect of discipline similarity and open critical discussion is significant (β = -0.31, t = -2.24, $p < 0.05$). Moreover, including both interactions in the same regression model (model 14) reduces the likelihood of overestimating the coefficients of the explanatory variables. Model 14 shows that the interaction between discipline similarity and competence-based trust is not significant (β = -0.05, t = -0.35, ns) but the interaction between discipline similarity and open critical discussion is significant (β = -0.30, t = -1.99, $p < 0.05$). These results support hypothesis 3d but not 3b.

Insert Table 3 and Figure 3 about here

DISCUSSION

In this study, I surveyed biotechnology scientists working in research and development to test the idea that same-discipline interactions can have a creative advantage over cross-discipline interactions. While most creativity research has focused on the individual, group, and network levels of analysis (e.g. Baer, 2010; Guimera, Uzzi, Spiro, & Amaral, 2005; Perry-Smith, 2006; Uzzi & Spiro, 2005), I focused on individual creativity at the dyadic level of analysis (e.g. Sosa, 2011). Results show that competence-based trust endowed a creative advantage for same-discipline interactions for gaining new insights, whereas open critical discussion endowed a creative advantage for same-discipline interactions for combining knowledge to generate new ideas. These results show that same-discipline interactions can have a creative advantage over cross-discipline interactions. Results also suggest that future research could uncover new insights into creativity by further exploring the different moderators that amplify the creative potential of both types of interactions.

Competence-based Trust and Creativity as Gaining New Insights

That competence-based trust endows a creative advantage for same-discipline interactions on gaining new insights suggests that individuals may be using diverse knowledge from same-discipline interactions in materially different ways from diverse knowledge in cross-discipline interactions. Creativity involves integrating diverse knowledge with existing knowledge to generate new insights (Cronin, 2004). Research suggests there are two ways that diverse knowledge can be integrated. It can be integrated through assimilation, which is defined as the adaptive processes of changing new knowledge to fit with existing knowledge structures (Kolb, Boyatzis, & Mainemelis, 2001). Alternatively, it can be integrated through accommodation, which is defined as the adaptive process of changing existing knowledge structures to fit with new knowledge (Kolb et al., 2001). I suggest that gaining new insights through same-discipline interactions primarily involves assessing if and how one should use the other person's perspective to change one's current perspective in fundamentally different ways; same-discipline interactions therefore may rely more on accommodation-based knowledge integration to gain new insights. I also suggest that gaining new insights through cross-discipline interactions primarily involves determining how to adapt and use the other person's perspective to inform one's current perspective and does not require any fundamental changes in thinking. Cross-discipline interactions therefore may rely more on assimilation-based knowledge integration. Knowledge integration through assimilation and accommodation mirrors the distinction between knowledge integration through exploration and exploitation (March, 1991). Exploration is defined as the adaptive process of seeking out new possibilities and exploitation is the adaptive process of using existing knowledge. This suggests that same-discipline interactions encourage exploration (i.e. a search for new undiscovered ideas) while cross-discipline interactions encourage exploitation (i.e. building on previously known knowledge to move incrementally forward). Thus, diverse knowledge from same-discipline interactions encourages thinking differently by challenging assumptions about cause-and-effect relationships within one's domain of expertise. Thinking differently in such a manner encourages the need for knowledge restructuring (Locke, Golden-Biddle, & Feldman, 2008), reflecting creativity as a process of conceptual recombination (Dunbar, 1997; Finke et al., 1992). Diverse knowledge from cross-discipline interactions, on the other hand, is used to refine one's initial ideas reflecting incremental change.

The proposition that unique knowledge retrieved from same-discipline interactions instigates explorative creativity whereas the unique knowledge retrieved from cross-discipline interactions instigates exploitative creativity complements recent networks research on creativity. For example, the notion that structural holes favor the idea generation stage whereas structural cohesion favors the implementation of ideas (Fleming et al. 2007). Similarly, the notion that *tertius iungens*, i.e. the third that joins, and *tertius gaudens*, i.e. the third that benefits, are interwoven throughout the creative process to support generating and implementing ideas (Lingo & O'Mahoney, 2010). Considered in conjunction with this research, the present study suggests that same-discipline interactions combined with structural holes and a tertius iungens orientation might be idea for idea generation whereas cross-discipline interactions combined with structural cohesion and a tertius gaudens orientation might be ideal for idea implementation.

Open Critical Discussion and Creativity as Combining Knowledge to Generate New Ideas

That open critical discussion facilitates a greater positive impact on combining knowledge to generate new ideas for same-discipline interactions suggests that individuals are better positioned to acquire and apply deeper diverse knowledge from same-discipline interactions to think creatively (Taylor & Greve, 2006). This is in part because individuals can rely on the expertise of same-discipline interactions to critically evaluate and check the errors in the individual's ideas and therefore provide better quality ideas to improve the individual's solution (Lee & Cole, 2003). This is also because participants in same-discipline interactions have the expertise to brainstorm more effectively in that they are better positioned to avoid the trap of production blocking (defined as the situation when one person talks about an idea to the exclusion of other ideas, e.g. Paulus & Yang, 2000) and are therefore more likely to exchange diverse knowledge (e.g. Sutton & Hargadon, 1996). In this way, same-discipline interactions offer an advantage in combining knowledge to generate new ideas by pushing the limits of one's domain with better quality error-checking and exchanging unique ideas borne of deep diverse knowledge.

Optimal distinctiveness theory, however, offers an alternative explanation of why same-discipline interactions can have a creative advantage over same-discipline interactions in terms of combining knowledge to generate new ideas (Brewer, 1991). This theory asserts that people seek the right balance of being distinctive and similar to others. The need to be distinctive motivates taking a different perspective when exchanging and discussing ideas with same-discipline interactions. Thus, the creative advantage that same-discipline interactions offer might be explained by the need to be intellectually distinctive. An individual may therefore detect errors and suggest solutions to the other person to demonstrate her intellectual uniqueness and ability to think independently. This is consistent with recent research showing that the individualistic values for distinctiveness was shown to drive creativity within group interactions more than collectivistic values (Goncalo & Staw, 2006).

The difference is that while I have offered an abilities-based explanation, optimal distinctiveness theory offers a motivation-based explanation. Thus, considered in conjunction with optimal distinctiveness theory, the present study suggests that the right combination of abilities and motivation is required to realize the creative potential of same-discipline interactions.

Limitations and Future Directions

This study has several limitations. First, the findings and implications of the present study are based on a relatively small sample size of thirty-three biotechnology scientists. One should therefore be cautious generalizing the findings and implications of this study to large organizations where creativity is important, such as Google and General Electric. Nevertheless, these findings might be generalized to similarly sized innovation groups within large organizations, small-to-medium sized enterprises, and high-technology start-ups. Moreover, following recommendations to examine micro-mechanisms (e.g. Fleming et al., 2007; Zhou et al., 2009), the smaller sample made it feasible to adopt a complete-network method to study the micro-mechanisms underlying individual creativity in closer detail. Indeed, future research might consider using complete-network methods to unpack the links between creative cognition, dyadic network characteristics, and micro-mechanisms related to acquiring and applying diverse knowledge.

A second limitation is how discipline expertise was operationalized. Instead of the dummy variable used in the present study, future work might consider several different alternatives. For example, expertise could be operationalized in terms of the number and variety of projects that one works on with different social interactions (e.g. Sosa, 2011). Alternatively, it could be operationalized in terms of variety-based and separation-based differences. Variety-based differences reflect using different knowledge sources to problem-solve (Harrison & Klein, 2007). For example, microbiologists and chemical engineers draw from non-overlapping knowledge domains to work on the same problem. Separation-based differences reflect holding opposing positions on the same problem-task (Harrison & Klein, 2007). For example, no two microbiologists have exactly the same knowledge stock in microbiology and they will draw from the differences to work on the same problem-task. Finally, expertise could be operationalized in terms of how much an individual has experience in different but interrelated disciplines. For example, comic book creators who have substantial experience working in different disciplines within the comic book industry were found to be the best integrators of knowledge from different sources (Taylor & Greve, 2006). Future research might consider the link between expertise and creativity in closer detail.

A third limitation of this study is that it focuses on individual creative cognition and not on tangible innovation outcomes. However, given that creative cognition is the source of new ideas from which innovations are developed and implemented (Amabile, 1988; Fleming et al., 2007), it is valuable to study the micro-mechanisms that affect creative cognition. Even if creative cognition does not always lead to innovation, it involves experimentation that reveals insights, learning, and the fresh ideas that emerge from these failures. Future research might take a closer look at how both successful and failed experimentation affects the link between creative cognition and innovations.

Managerial Implication and Conclusion

The key managerial implication is that managers can foster creativity by organizing work between those with very different experiences in the same discipline. Managers should be cognizant, however, that the creative potential of these interactions will only be realized in the presence of competence-based trust and open critical discussion. Even though these two mechanisms are correlated, they are distinct and operate independently of each other. If there are strong organizational norms for open critical discussion but there is no competence-based trust in the source of alternative ideas, the alternative ideas will either be ignored or used in a way that is consistent with initial ideas. Similarly, if there is competence-based trust but the participants are uncomfortable engaging in open critical discussion, little or no critical thinking will take place. Thus, managers interested in creativity should ensure that both competence-based trust and open critical discussion are present, especially for same-discipline interactions.

In conclusion, that same-discipline interactions can have a creative advantage over cross-discipline interactions suggests there is more to discover about the creative potential of same-discipline interactions than previously thought. More generally, the results of this study suggest that the link between diverse knowledge and creativity has less to do with the *amount* of diverse knowledge present in interactions. Rather, creativity is tied to *how* diverse knowledge is *acquired* and *used*.

REFERENCES

Abrams, L. C., R. Cross, E. Lesser, D. Z. Levin 2003. Nurturing interpersonal trust in knowledge-sharing networks. *Academy of Management Executive* **17** 64-77.

Amabile, T. M. 1988. A model of creativity and innovation in organizations. B. Staw and L. L. Cummings, eds. *Research in Organizational Behavior* **10**. JAI Press, Greenwich, 123-167.

Amabile, T. M., M. Khaire 2008. Creativity and the role of the leader. *Harvard Business Review* **October** 101-109.

Ancona, D. G., D. F. Caldwell 1992. Demography and design: Predictors of new product team performance. *Organization Science* **3** 321-341.

Audia, P. G., J. A. Goncalo. 2007. Past success and creativity over time: A study of inventors in the hard disk drive industry. *Management Science* **53** 1-15.

Baer, M. 2010. The strength of weak interactions perspective on creativity: A comprehensive examination and extension. *Journal of Applied Psychology* **95** 592-601.

Borgatti, S. P., R. Cross. 2003. A relational view of information seeking and learning in social networks. *Management Science* **49** 432-445.

Bowers, C., J. Pharmer, E. Salas. 2000. When member homogeneity is needed in work teams: A meta-analysis. *Small Groups Research* **3**1 305-327.

Brambor, T., W. R. Clark, M. Golder. 2005. Understanding interaction models: Improving empirical analyses. *Political Analysis* **14** 63-82.

Brewer, D. D. 2000. Forgetting in the recall-based elicitation of personal and social networks. *Social Networks* **22** 29-43.

Brewer, M. B. 1991. The social self: On being the same and different at the same time. *Personality and Social Psychology Bulletin* **17** 475-482.

Burt, R. S. 1992. *Structural Holes: The Social Structure of Competition*. Harvard University Press, Cambridge, MA.

Burt, R. S. 2004. Structural holes and good ideas. *American Journal of Sociology* **110** 349-399.

Burrows, P. 2006. The man behind Apple's design magic. *Business Week* 27-32.

Casciaro, T. 1998. Seeing things clearly: Social structure, personality, and accuracy in social network perception. *Social Networks* **20** 331-351.

Casciaro, T., K. Carley, D. Krackhardt.1999. Positive affectivity and accuracy in social network perception. *Motivation and Emotion* **23** 285-306.

Cattani, G., S. Ferriani. 2008. A core/periphery perspective on individual creative performance: Social networks and cinematic achievements in the Hollywood film industry. *Organization Science* **19** 824-844.

Cronin, M. A. 2004. A model of knowledge activation and insight problem solving. Complexity **9** 17-24.

Cross, R., J. N. Cummings. 2004. Tie and network correlates of individual performance in knowledge-intensive work. *Academy of Management Journal* **47** 928-937.

Cummings, J. N. 2004. Work groups, structural diversity, and knowledge sharing in a global organization. *Management Science* **50** 352-364.

Dane, E. 2010. Reconsidering the trade-off between expertise and flexibility: A cognitive entrenchment perspective. *Academy of Management Review* **35** 579-603.

De Dreu, C. K. W., D. van Knippenberg. 2005. The possessive self as barrier to conflict resolution: effects of mere ownership, process accountability, and self-concept clarity on competitive cognitions and behavior. *Journal of Personality and Social Psychology* **89** 345-357.

De Dreu, C. K. W., L. R. Weingart. 2003. Task versus relationship conflict, team performance, and team member satisfaction: A meta-analysis. *Journal of Applied Psychology* **88** 741-749.

Drazin, R., M. A. Glynn, R. K. Kazanjian. 1999. Multilevel theorizing about creativity in organizations: A sensemaking perspective. Academy of Management Review **24** 286-307.

Dugosh, K. L., P. B. Paulus, E. J. Roland, H-C. Yang. 2000. Cognitive stimulation in brainstorming. *Journal of Personality and Social Psychology* **79** 722-735.

Dunbar, K. 1997. How scientists think: On-line creativity and conceptual change in science. T. B. Ward, S. M. Smith, and J. Vaid, eds. *Creative thought: An Investigation of Conceptual Structures and Processes.* American Psychological Association, Washington, DC, 461-494.

Edmondson, A. C. 1999. Psychological safety and learning behavior in work teams. *Administrative Science Quarterly* **44** 350-383.

Ellis, A. P. J., J. R. Hollenback, D. R. Ilgen, C. O. L. H. Porter, B. J. West, H. Moon. 2003.Team learning: Collectively connecting the dots. *Journal of Applied Psychology* **88** 821-835.

Finke, R. A., Ward, T. B., Smith, S. M. 1992. *Creative cognition: Theory, research, and applications*. Cambridge, MA: The MIT Press.

Fleming, L., M. Marx. 2006. Managing creativity in small worlds. *California Management Review* **48** 6-27.

Fleming, L., S. Mingo, S., D. Chen. 2007. Collaborative brokerage, generative creativity, and creative success. *Administrative Science Quarterly* **52** 443-475.

George, J. M. 2007. Creativity in organizations. *Academy of Management Annals* **1** 439-477.

Gigone, D., R. Hastie. 1993. The common knowledge effect: Information sharing and group judgment. *Journal of Personality and Social Psychology* **65** 959-974.

Goncalo, J. A., B. M. Staw. 2006. Individualism-collectivism and group creativity. *Organizational Behavior and Human Decision Processes* **100** 96-109.

Granovetter, M. 1973. The strength of weak interactions. *American Journal of Sociology* **78** 1360-1380.

Greitemeyer, T., S. Schulz-Hardt. 2003. Preference-consistent evaluation of information in the hidden profile paradigm: Beyond group-level explanations for the dominance of shared information in group decisions. *Journal of Personality and Social Psychology* **84** 322-339.

Guimera, R., B. Uzzi, J. Spiro, L. A. N. Amaral. 2005. Team assembly mechanisms determine collaboration network structure and team performance. *Science* **308** 697-702.

Hansen, M. T. 1999. The search-transfer problem: The role of weak interactions in sharing knowledge across organizational subunits. *Administrative Science Quarterly* **44** 82-111.

Hargadon, A. B., B. A. Bechky. 2006. When collections of creatives become creative collectives: A field study of problem solving at work. *Organization Science* **17** 484-500.

Harrison, D. A., K. J. Klein. 2007. What's the difference? Diversity constructs as separation, variety, or disparity in organizations. *Academy of Management Review* **32** 1199-1228.

Heath, C., R. Gonzalez.1995. Interaction with others increases decision confidence but not decision quality: Evidence against information collection views of interactive decision-making. *Organizational Behavior and Human Decision Processes* **61** 305-326.

Hülsheger, U. R., N. Anderson, J. F. Salgado. 2009. Team-level predictors of innovation at work: A comprehensive meta-analysis spanning three decades of research. *Journal of Applied Psychology* **94** 1128-1145.

Ibarra, H. 1992. Similarity and differential returns: Sex differences in network structure and access in an advertising firm. *Administrative Science Quarterly* **37** 422-447.

Jehn, K. A., C. Bendersky. 2003. Intragroup conflict in organizations: A contingency perspective on the conflict-outcome relationship. R. M. Kramer and B. M. Staw eds. *Research in Organizational Behavior* **25**. Elseiver, New York, NY, 187-242.

Jehn, K. A., E. A. Mannix. 2001. The dynamic nature of conflict: A longitudinal study of intragroup conflict and group performance. *Academy of Management Journal* **44** 238-251.

Johnson, D. W., R. T. Johnson, D. Tjosvold. 2000. Constructive controversy: The Value of Intellectual Opposition. M. Deutsch and P. T. Coleman eds. *The Handbook of Conflict Resolution: Theory and Practice*. Jossey-Bas Publishers, San Francisco, CA, 65-85.

Keller, R. T. 2001. Cross-functional project groups in research and new product development: Diversity, communications, job stress, and outcomes. *Academy of Management Journal* **44** 547-555.

Kolb, D. A., R. Boyatzis, C. Mainemelis. 2001. Experiential learning theory: Previous research and new directions. In R. Sternberg and L. Zhang eds. *Perspectives on cognitive learning, and thinking styles*. Lawrence Erlbaum Associates, Mahwah, NJ, 227-247.

Krackhardt, D. 1990. Assessing the political landscape: Structure, cognition, and power in organizations. *Administrative Science Quarterly* **35** 342-369.

Labianca, G., D. J. Brass, B. Gray. 1998. Social networks and perceptions of intergroup conflict: The role of negative relationships and third party interactions. *Academy of Management Journal* **41** 55-67.

Lee, F. 1997. When the going gets tough, do the tough ask for help? Help seeking and power motivation in organizations. *Organizational Behavior and Human Decision Processes* **72** 336-363.

Lee, F., A. C. Edmondson, S. Thomke, M. Worline. 2004. The mixed effects of inconsistency on experimentation in organizations. *Organization Science* **15** 310-326.

Lee, G. K., R. E. Cole. 2003. From a firm-based to a community-based model of knowledge creation: The case of the Linux kernel development. *Organization Science* **14** 633-649.

Levin, D. Z., R. Cross. 2004. The strength of weak interactions you can trust: The mediating role of trust in effective knowledge transfer. *Management Science* **50** 1477-1490.

Lingo, E. L., S. O'Mahoney 2010. Nexus work: Brokerage on creative projects. *Administrative Science Quarterly* **55** 47-81.

Locke, K., K. Golden-Biddle, M. S. Feldman. 2008. Making doubt generative: Rethinking the role of doubt in the research process. *Organization Science* **19** 907-918.

Lovelace, K., D. L. Shapiro, L. R. Weingart 2001. Maximizing cross-functional new product teams' innovativeness and constraint adherence: A conflict communications perspective. *Academy of Management Journal* **44** 779-793.

Mannix, E. A., M. A. Neale. 2005. What differences make a difference? The promise and reality of diverse teams in organizations. *Psychological Science in the Public Interest* **6** 31-55.

March, J. G. 1991. Exploration and exploitation in organizational learning. *Organization Science* **2** 71-87.

Marsden, P. V., K. E. Campbell. 1984. Measuring tie strength. *Social Forces* **63** 482-501.

Mayer, R. C., J. H. Davis, F. D. Schoorman. 1995. An integrated model of organizational trust. *Academy of Management Review* **20** 709-734.

Mehra, A., M. Kilduff, D. J. Brass.1998. The social networks of high and low self-monitors: Implications for workplace performance. *Administrative Science Quarterly* **46** 121-146.

McAllister, D. J. 1995. Affect- and cognition-based trust as foundations for interpersonal cooperation in organizations. *Academy of Management Journal* **38** 24-39.

McGlynn, R. P., McGurk, D., V. S. Effland, N. L. Johll, D. J. Hardin. 2004. Brainstorming and task performance in groups constrained by evidence. *Organizational Behavior and Human Decision Processe*s **93** 75-87.

McFadyen, M. A., A. Cannella. 2004. Social capital and knowledge creation: Diminishing returns of the number and strength of exchange relationships. *Academy of Management Journal* **47** 735-746.

McPherson, M., L. Smith-Lovin, J. M. Cook. 2001. Birds of a feather: Similarity in social networks. *Annual Review of Sociology* **27** 415-444.

Mikulincer, M., D. Arad. 1999. Attachment working models and cognitive openness in close relationships: A test of chronic and temporary accessibility effects. *Journal of Personality and Social Psychology* **77** 710-725.

Nonaka, I. 1994. A dynamic theory of organizational knowledge creation. *Organization Science* **5** 14-37.

Obstfeld, D. 2005. Social networks, the tertius iungens orientation, and involvement in innovation. *Administrative Science Quarterly* **50** 100-130.

Owens, D. A., R. I. Sutton. 2001. Status contests in meetings: Negotiating the informal order. M. E. Turner ed. *Groups at work: Advances in theory and research*. Lawrence Erlbaum and Associates, Mahwah, NJ.

Paulus, P. B., H-C. Yang. 2000. Idea generation in groups: A basis for creativity in Organizations. *Organizational Behavior and Human Decision Processes* **82** 76-87.

Perry-Smith, J. E. 2006. Social yet creative: The role of social relationships in facilitating individual creativity. *Academy of Management Journal* **49** 85-101.

Perry-Smith, J. E., C. E. Shalley. 2003. The social side of creativity: A static and dynamic social network perspective. *Academy of Management Review* 28 89-106.

Reagans, R. E., B. McEvily. 2003. Network structure and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly* **48** 240-267.

Reagans, R., E. W. Zuckerman. 2001. Networks, diversity, and productivity: The social capital of corporate R&D teams. *Organization Science* **12** 502-517.

Rodan, S., C. Galunic. 2004. More than network structure: How knowledge heterogeneity influences managerial performance and innovativeness. *Strategic Management Journal* **25** 541-562.

Ruef, M. 2002. Strong interactions, weak interactions and islands: Structural and cultural predictors of organizational innovation. *Industrial and Corporate Change* **11** 427-449.

Russo, J. E., K. A. Carlson, M. G.Meloy. 2006. Choosing an inferior option. *Psychological Science* **17** 899-904.

Russo, J. E., M. G. Meloy, V. H. Medvec. 1996. The distortion of information during decisions. *Organizational Behavior and Human Decision Processes* **66** 102-110.

Russo, J. E., M. G. Meloy, T. J. Wilks. 2000. Predecisional distortion of information by auditors and salespersons. *Management Science* **46** 13-27.

Schulz-Hardt, S., F. C. Brodbeck, A. Mojzisch, R. Kerschreiter, D. Frey. 2006. Group decision making in hidden profile situations: Dissent as a facilitator for decision quality. *Journal of Personality and Social Psychology* **91** 1080-1093.

Sethi, R., D. C. Smith, D.C., C. W. Park.2001. Cross-functional product development teams, creativity, and the innovativeness of new consumer products. *Journal of Marketing Research* **38** 73-85.

Shane, S. 2000. Prior knowledge and the discovery of entrepreneurial opportunities. *Organization Science* **11** 448-469.

Simons, T., R. S. Peterson 2000. Task conflict and relationship conflict in top management teams: The pivotal role of intragroup trust. *Journal of Applied Psychology* **85** 102-111.

Simonton, D. K. 1997. Creative productivity: A predictive and explanatory model of career trajectories and landmarks. *Psychological Review* **104** 66-89.

Simonton, D. K. 2003. Scientific creativity as constrained stochastic behavior: The integration of product, person, and process perspectives. *Psychological Bulletin* **129** 475-494.

Smith, S. M. 2003. The constraining effects of initial ideas. P. B. Paulus and B. A. Nijstad, eds. *Group creativity: Innovation through collaboration*. Oxford University Press, United Kingdom, 15-31.

Sosa, M. E. 2011. Where do creative interactions come from? The role of tie content and social networks. *Organization Science* **22** 1-21.

Stasser, G., D. Stewart.1992. Discovery of hidden profiles by decision-making groups: Solving a problem versus making a judgment. *Journal of Personality and Social Psychology* **63** 426-434.

Sternberg, R. J., L. A. O'Hara. 2000. Intelligence and creativity. R. J. Sternberg ed., *Handbook of Intelligence*. Cambridge University Press, New York, NY, 609-628.

Suresh, S. 2011. Talking points on the National Science Foundation's innovation corps to strengthen the impact of scientific discoveries. **July** http://www.nsf.gov/news/speeches/suresh/11/ss110728_icorps.jsp

Sutton, R. I., A. B. Hargadon. 1996. Brainstorming groups in context: Effectiveness in a product design firm. *Administrative Science Quarterly* **41** 685-718.

Szulanski, G. 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal* **17** 27-43.

Taggar, S. 2002. Individual creativity and group ability to utilize individual creative resources: A multilevel model. *Academy of Management Journal* **45** 315-330.

Taylor, A., H. R. Greve. 2006. Superman of the fantastic four? Knowledge combination and experience in innovative teams. *Academy of Management Journal* **49** 723-740.

Tjosvold, D. 1982. Effects of approach to controversy on superiors' incorporation of subordinates' information in decision making. *Journal of Applied Psychology* **67** 189-193.

Tjosvold, D., D. K. Deemer. 1980. Effects of controversy within a cooperative or competitive context on organizational decision-making. *Journal of Applied Psychology* **65** 590-595.

Unsworth, K. 2001. Unpacking creativity. *Academy of Management Review* **26** 289-297.

Uzzi, B., J. Spiro. 2005. Collaboration and creativity: The small world problem. *American Journal of Sociology* **111** 447-504.

Valacich, J. S., A. R. Dennis, T. Connolly.1994. Idea generation in computer-based groups: A new ending to an old story. *Organizational Behavior and Human Decision Processes* **57** 448-467.

Van Knippenberg, D., C. De Dreu, A. Homan. 2004. Work group diversity and group performance: An integrative model and research agenda. *Journal of Applied Psychology* **89** 1008-1022.

Von Krogh, G., E. von Hippel 2006. The promise of research on open source software. *Management Science* **52** 975-983.

Walker, G. 1985. Network position and cognition in a computer software firm. *Administrative Science Quarterly* **30** 103-130.

Weber, S., L. Donohue. 2001. Impact of highly and less job-related diversity on work group performance: A meta-analysis. *Journal of Management* **27** 141-162.

Woodman, R. W., J. E. Sawyer, R. W. Griffin. 1999. Toward a theory of organizational creativity. *Academy of Management Review* **18** 293-321.

Zhou, J., S. J. Shin, D. J. Brass, J. Choi, Z. X. Zhang. 2009. Social networks, personal values, and creativity: Evidence for curvilinear and interaction effects. *Journal of Applied Psychology* **94** 1544-1552.

Table 1: Descriptive Statistics and Correlations (N = 471)

Variable	M	SD	1	2	3	4	5	6	7
1. Gain New Insights	4.01	2.25							
2. Combine Info. for New Ideas	3.15	2.00	.64						
3. Age similarity	-1.24	10.37	-.13	-.31					
4. Gender similarity	0.46	0.50	-.16	-.24	-.01				
5. Position similarity	0.76	0.43	.01	.00	-.13	.04			
6. No. of Projects worked on together	0.68	1.21	.10	.30	-.12	-.04	.04		
7. Dyadic Network Cohesion	0.04	0.03	.20	.28	-.18	-.09	-.11	.11	
8. Discipline Similarity	0.87	0.33	.07	-.01	.04	.00	.04	-.07	.02
9. Competence-based Trust	4.65	1.70	.39	.49	-.25	-.13	.00	.19	.21
10. Open Critical Discussion	4.68	1.87	.34	.44	-.02	-.13	-.06	.20	.14

Variable	8	9
8. Discipline Similarity		
9. Competence-based Trust	-.01	
10. Open Critical Discussion	-.01	.54

Note. Correlations > |0.09| are significant at $p < 0.05$, and correlations > |0.12| are significant at $p < 0.01$.

Table 2: Linear Mixed Models Regression[1] on Gaining New Insights

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Age similarity (ego age minus alter age)	-0.02* (0.01)	-0.02* (0.01)	-0.00 (0.01)	-0.02* (0.01)	-0.00 (0.01)	-0.02* (0.01)	-0.01 (0.01)
Gender similarity (same gender = 0)	0.65** (0.20)	0.65** (0.20)	0.49* (0.19)	0.50* (0.19)	0.52** (0.19)	051** (0.19)	0.48* (0.19)
Position similarity (same position = 0)	-0.09 (0.24)	-0.07 (0.24)	-0.11 (0.23)	-0.16 (0.23)	-0.10 (0.22)	-0.16 (0.23)	-0.14 (0.22)
Number of Projects worked on Together	0.12 (0.08)	0.13 (0.08)	0.03 (0.08)	0.19 (0.08)	0.05 (0.08)	0.03 (0.08)	0.01 (0.08)
Dyadic Network Cohesion	10.39** (2.97)	10.22** (2.97)	7.16* (2.84)	8.39** (2.85)	7.12* (2.83)	8.26** (2.85)	6.84* (2.79)
Discipline Similarity (same discipline = 0)		-0.50 (0.30)			-0.55 (0.80)	-0.56 (0.30)	-0.57 (0.29)
Competence-based Trust			0.45*** (0.06)		0.76*** (0.16)		0.65*** (0.18)
Open critical discussion				0.36*** (0.05)		0.52*** (0.17)	0.24 (0.18)
Competence-based Trust x Discipline Similarity					-0.36* (0.17)		-0.38* (0.19)
Open critical discussion x Discipline Similarity						-0.18 (0.18)	-0.02 (0.19)
Restricted Log Likelihood	2074.29	2072.19	2024.18	2033.85	2019.44	2032.28	2011.45
Degrees of freedom	465	464	464	464	462	462	460

Note. N = 471.
Unstandardized coefficients shown with errors in parentheses
*p < 0.05; **p < .01; ***p < .001

[1] I used the linear mixed models function in SPSS to run this regression with the restricted maximum likelihood estimation option.

Table 3: Linear Mixed Models Regression[2] on Combining Knowledge for New Ideas

Variable	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
Age similarity (ego age minus alter age)	-0.05*** (0.01)	-0.05*** (0.01)	-0.03*** (0.01)	-0.05*** (0.01)	-0.03*** (0.01)	-0.05*** (0.01)	-0.04*** (0.01)
Gender similarity (same gender = 0)	0.86*** (0.16)	0.86*** (0.16)	0.70*** (0.15)	0.70*** (0.15)	0.71*** (0.15)	0.72*** (0.15)	0.67*** (0.15)
Position similarity (same position = 0)	0.05 (0.19)	0.05 (0.19)	0.03 (0.18)	-0.03 (0.18)	0.03 (0.18)	-0.05 (0.18)	-0.03 (0.17)
Number of Projects worked on Together	0.40*** (0.07)	0.40*** (0.07)	0.31*** (0.06)	0.29*** (0.06)	0.32*** (0.06)	0.29*** (0.06)	0.27*** (0.06)
Dyadic Network Cohesion	10.78*** (2.38)	10.75*** (2.39)	7.72** (2.22)	8.67*** (2.20)	7.74** (2.22)	8.70*** (2.19)	7.43** (2.15)
Discipline Similarity (same discipline = 0)		-0.09 (0.24)			-0.10 (0.23)	-0.21 (0.23)	-0.20 (0.22)
Competence-based Trust			0.43*** (0.05)		0.55*** (0.13)		0.32* (0.14)
Open critical discussion				0.38*** (0.04)		0.66*** (0.04)	0.52*** (0.14)
Competence-based Trust x Discipline Similarity					-0.14 (0.13)		-0.05 (0.14)
Open critical discussion x Discipline Similarity						-0.31* (0.14)	-0.30* (0.15)
Restricted Log Likelihood	1868.54	1849.39	1.795.53	1792.83	1797.72	1790.98	1770.01
Degrees of freedom	465	464	464	464	462	462	460

Note. N = 471.
Unstandardized coefficients shown with errors in parentheses
*p < 0.05; **p < .01; ***p < .001

[2] I used the linear mixed models function in SPSS to run this regression with the restricted maximum likelihood estimation option.

Figure 1: Effects of Competence-based Trust and Open Critical Discussion on the link between Discipline Similarity on Gaining New Insights and Combining Knowledge for New Ideas.

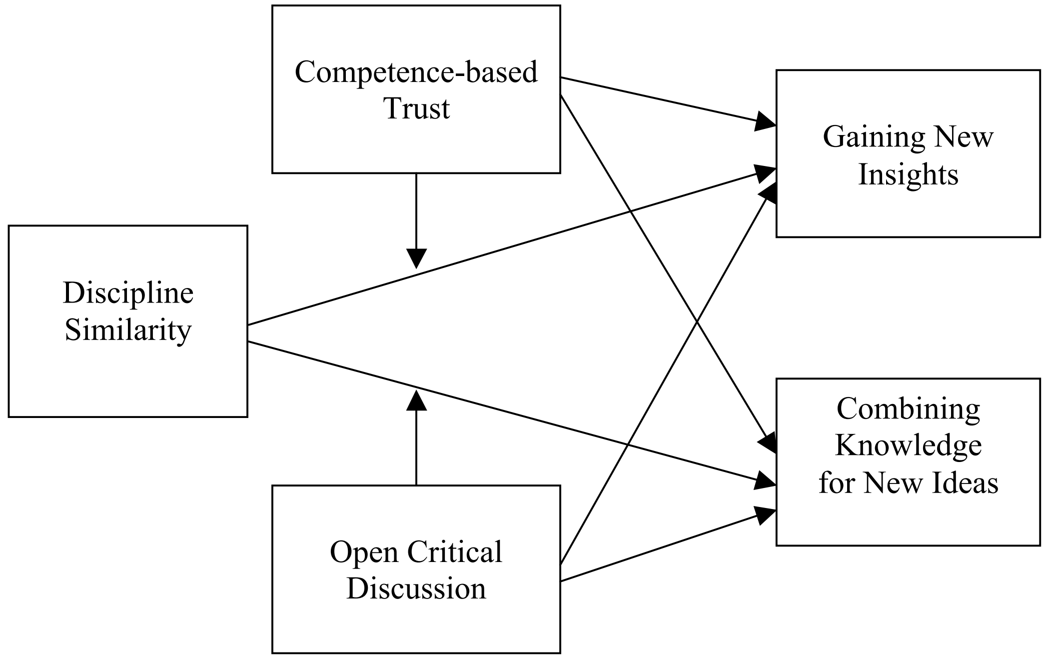

Figure 2: Two-way Interaction between Discipline Similarity and Competence-based Trust on Creativity as Gaining New Insights

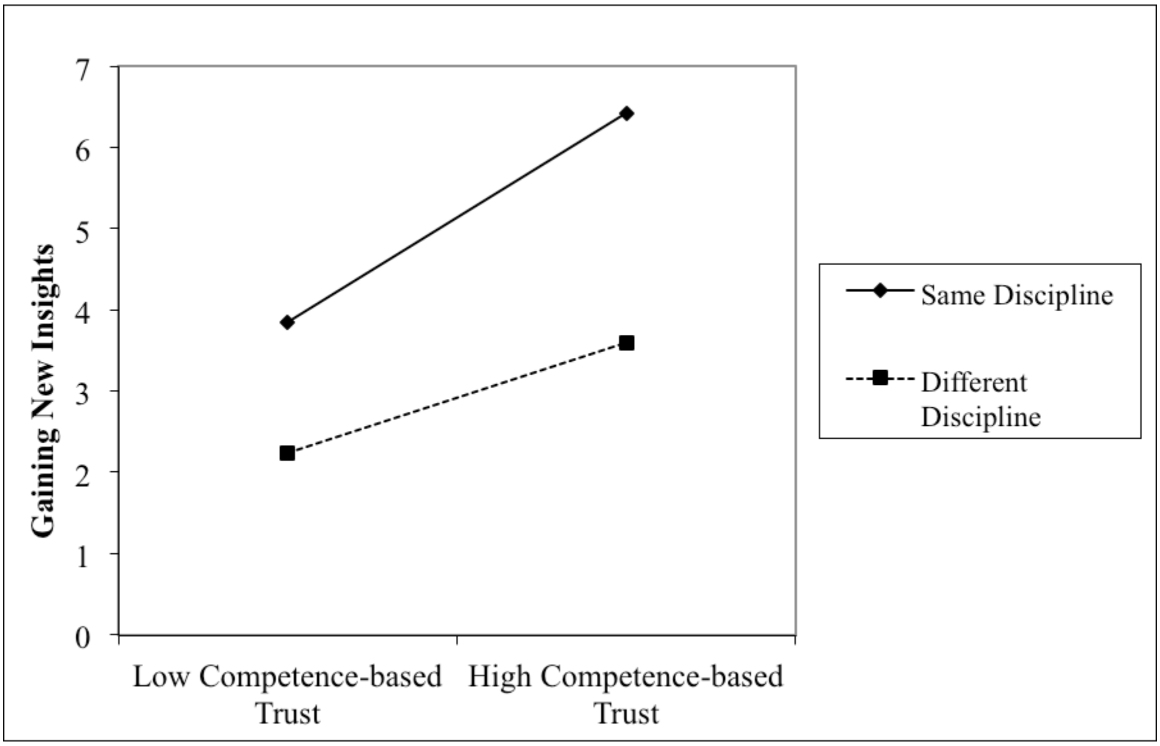

Figure 3: Two-way Interaction between Discipline Similarity and Open Critical Discussion on Creativity as Combining Knowledge to Generate New Ideas