CARNEGIE MELLON UNIVERSITY

COGNITIVE STYLE DIVERSITY IN TEAMS

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Abstract

In this dissertation, I undertake the study of cognitive styles in teams in three papers. Cognitive styles are psychological dimensions that represent consistencies in how individuals acquire and process information, and guide their performance on information processing, decision making, problem solving, and creativity tasks. In addition, they distinguish between individuals from different educational and functional areas. They constitute an important, though largely underrepresented, area of team research. I investigate the relationship between cognitive style diversity and team performance on tasks that impose different demands on teams- execution and creativity. Across the three papers, I identify important processes such as strategic focus, strategic consensus, transactive memory, and learning that further explicate this relationship. The studies move the ongoing debate about whether and how diversity is beneficial and detrimental to team performance forward by exploring task contexts that benefit from diversity, and those that do not. In the final paper, I highlight one effective way to optimize the opposing forces that make diversity a challenging phenomenon to study, thus attempting to move the debate toward a resolution.

In the first paper, I investigate the effect of members' cognitive styles on team processes that affect errors in execution tasks. In two laboratory studies, I investigate how a team's composition (members' cognitive styles related to object and spatial visualization) affects the team's strategic focus and strategic consensus, and how those affect the team's commission of errors. Errors have crucial implications for many real-life organizational teams carrying out execution tasks. Study 1, conducted with 70 dyads performing a navigation and identification task, established that teams high in spatial visualization are more process-focused than teams

high in object visualization. Process focus, which pertains to a team's attention to the details of conducting a task, is associated with fewer errors. Study 2, conducted with 64 teams performing a building task, established that heterogeneity in cognitive style is negatively associated with the formation of a strategic consensus, which has a direct and mediating relationship with errors.

In the second paper, I investigate the effect of team members' cognitive style composition, and related team processes, on creativity. Creativity encompasses the processes leading to the generation of novel and useful ideas. In a study with 112 graduate-student teams working on a semester-long project, I explore the effect of the team's cognitive style composition on its transactive memory and strategic consensus, and find that it influences both these processes. Furthermore, I find that team's transactive memory is positively related to two aspects of creativity: flexibility and fluency. Originality, the third aspect of creativity is influenced by the team's strategic consensus and strategic focus. The study provides a nuanced understanding of how diverse inputs, but integrating processes, benefit team creativity.

In the third paper I highlight that cognitive diversity in teams is associated with both benefits and costs, and increasing the benefits linked with having a greater wealth of human resources without increasing the associated coordination costs is a challenge. In this paper, I provide a new lens for looking at team composition in terms of this cost-benefit tradeoff, and propose one way to optimize it. I study how cognitive resources are distributed in teams, emphasizing both breadth and depth, and investigate the influence of versatile team members, or members who encompass depth in a breadth of domains. In two studies, I find evidence for the proposition that the number of cognitively versatile members in the team is positively associated with team performance in execution tasks, explaining variance above and beyond standard and non-standard ways of capturing diversity. Interestingly, I find that while there is generally a curvilinear (inverted U-shaped) relationship between team size and team performance, there is a positive linear relationship between size and performance in teams that have cognitively versatile members. I also find that the positive impact of cognitively versatile members on performance in execution tasks is facilitated by process learning. I discuss the implications of this alternative way of viewing diversity.

Taken together, this dissertation explores team composition using deep-level diversity variables that directly relate to functional areas of individuals in organizations. The three papers contribute to an underrepresented area of organizational research, and establish the importance of the team's cognitive style composition to team performance. Also, by addressing many calls in the groups and teams research literature, this dissertation aims at providing a nuanced understanding of composition, processes and performance in teams, revealing the complexity of teamwork.

CHAPTER 1

Introduction

Groups and teams are important parts of organizations; experience, knowledge, and expertise needed to solve problems, make decisions, and perform organizational work frequently reside in groups and teams (Bunderson, 2003). As economic and technological changes continue to place demands on organizations, it is not surprising that teams are now used extensively in organizations (Devine, Clayton, Philips, Dunford, & Melner, 1999); a primary reason organizations use groups is to garner the benefits of the unique knowledge and information—or cognitive resources—that group members might bring to the table (e.g. Schneider & Northcraft, 1999). And, the use of multi-disciplinary and cross-functional teams has risen steeply in organizations because such teams are thought to have the resources required to solve important multi-faceted problems (Bunderson & Sutcliffe, 2003; Hackman, 2002; Wuchty, Jones, & Uzzi, 2007). However, there is also evidence that teams that have a variety of cognitive resources are unable to capitalize on their resources because of process losses, such as coordination and communication problems. These opposing forces make team composition and diversity a challenging and interesting phenomenon to study, and lends to diversity being a double-edged sword (Milliken & Martins, 1996; Williams & O'Reilly, 1998).

There is an active debate in the diversity literature about the positive and negative effects of diversity on team performance and processes. An increasing number of reviews on work team diversity have emphasized that diversity has mixed effects on group performance (e.g., Joshi & Roh, 2009; Harrison & Klein, 2007; Jackson, Joshi, & Erhardt, 2003; Milliken & Martins, 1996; van Knippenberg & Schippers, 2007; Williams & O'Reilly, 1998). These include positive effects, such as increase in innovation, group performance, perceived group performance, group member morale, and innovative climate (e.g., Bantel & Jackson, 1989; Horwitz & Horwitz, 2007; Jehn, Northcraft, & Neale, 1999; Van der Vegt, Van de Vliert, & Huang, 2005) and negative effects such as conflict and communication problems, decrease in satisfaction and commitment, and decrease in information integration (e.g., O'Reilly, Caldwell, & Barnett, 1989; Pelled, 1996; Pelled, Eisenhardt & Xin, 1999; Zenger & Lawrence, 1989; Jehn, Northcraft, & Neale, 1999; Dahlin, Weingart & Hinds, 2005).

In this dissertation, I attempt to contribute to this active area of research in three ways: (i) studying cognitive styles, which are deep-level diversity characteristics that are extremely pertinent to organizations, yet understudied in the literature, to deepen our understanding of diversity that exists within organizational teams; (ii) forwarding the debate on the positive and negative effects of diversity further by studying cognitive style composition of the team under different task contexts with opposing demands; and, (iii) proposing one solution to maximize the positive aspects of diversity and minizime the negative effects.

Team Diversity: Cognitive Styles

The diverse nature of modern workforce and the emphasis on work groups and teams in organizations make the study of the effects of diversity on group performance important. Diversity is typically conceptualized as referring to differences between individuals on any attribute that may lead to the perception that another person is different from self (Jackson, 1992; Triandis et al., 1994; Williams & O’Reilly, 1998). Diversity, therefore, is not limited to one type and can be categorized in terms of race, ethnicity, gender, nationality, income-level, personality, education, beliefs, values, and any other factor that leads to individual differences. Because of these differences in types of diversity, diversity variables are generally divided into two broad categories: surface-level and deep-level (Harrison, Price, & Bell, 1998; Milliken & Martins, 1996; Moreland, Levine, & Wingert, 1996). Scholars have urged researchers to pay close attention to the type of diversity variable studied, since the effects of diversity variables are not all equal (Shin, Kim, Lee, & Bian, 2012; Harrison & Klein, 2007; Horwitz & Horwitz, 2007; Joshi & Roh, 2009).

Cognitive diversity in the group relates to differences in deep-level, or non-observable, (Harrison, Price, & Bell, 1998; Milliken & Martins, 1996; Moreland, Levine, & Wingert, 1996) characteristics of members including knowledge, perspectives, and information-processing styles (Williams & O'Reilly, 1998). There has been a call in the diversity literature to study deeper psychological mechanism underlying diversity (Mannix & Neale, 2005), and cognitive styles provide a way to capture the deep-rooted cognitive differences that exist in functionally-diverse organizational teams. Scholars have also emphasized the need to study cognitive styles in the context of cognitive diversity (Kirton, 1976; 1989; Kurtzberg & Amabile, 2001), providing further motivation to study their effect on teams.

Cognitive styles are psychological dimensions that represent consistency in information acquisition and processing in individuals (Bartlett, 1932; Paivio, 1971; Richardson, 1977; Ausburn & Ausburn, 1978; Messick, 1984). Three cognitive styles that are of particular interest because of their direct relation to functional specialties in organizations are *verbalization, spatial visualization*, and *object visualization* (Kozhevnikov, 2007). While individuals high on verbalization rely primarily on verbal analytical strategies, those high in visualization rely primarily on imagery when attempting to perform cognitive tasks. Within visualization, individuals high in object visualization use holistic processing and perform better on tasks that require identifying global properties of shapes, whereas those high in spatial visualization use analytic processing, using spatial relations to arrange and analyze components (Kozhevnikov, Kosslyn, & Shephard, 2005). When thinking of a building, an individual high in object visualization will usually form a clear and bright mental picture of the building, but an individual high in spatial visualization will usually imagine the building's blueprint (Blazenkova & Kozhevnikov, 2008).

Research in cognitive psychology and neuroscience demonstrates that these cognitive styles are associated with different parts of the brain (Kozhevnikov, Hegarty, & Mayer, 2002), and gifted children as young as the age of 11-13 years, who have not received any area-specific training, exhibit specialization in these cognitive styles (Kozhevnikov, Blazhenkova, & Becker, 2010). Cognitive styles not only guide an individual's performance on information processing, decision making, problem solving, and creativity tasks (Chabris, Jerde, Woolley, Hackman, & Kosslyn, 2006; Kozhevnikov et al., 2005; Woolley, Hackman, Jerde, Chabris, Bennett, & Kosslyn 2007), but also differentiate among individuals choosing to go into different professional and occupational areas (Blazenkova, Kozhevnikov, & Motes, 2006; Kozhevnikov, Kosslyn, & Shephard, 2005), making their study important for understanding cross-functional collaboration in the organizational context. For example, scientists score higher than visual artists and humanists on spatial visualization, whereas visual artists score higher than scientists and humanists on object visualization (Kozhevnikov et al., 2005; Blajenkova et al., 2006).

An individual's educational and/or professional area often determines where they are placed in the organization, the work that they conduct, the employees they interact with regularly, and the teams they are part of. Since occupational areas play a key role in how individuals navigate in an organization, it becomes even more important to study the effect of cognitive styles in the organizational context. Such an approach also heeds the call in the literature to explore the psychological mechanisms underlying diversity (Mannix & Neale, 2005, van Knippenberg & Schippers, 2007).

Forwarding the debate: The role of context

An increasing number of reviews on work team diversity indicate that diversity provides a team with task-relevant resources, but at the same time contributes toward suboptimal team processes (e.g., Joshi & Roh, 2009; Harrison & Klein, 2007; Jackson, Joshi, & Erhardt, 2003; Milliken & Martins, 1996; van Knippenberg & Schippers, 2007; Williams & O'Reilly, 1998). The two existing *cognitive* perspectives that guide our understanding of these mixed effects are the information processing perspective (van Knippenberg, De Dreu, & Homan, 2004; Hinz, Tindale, & Vollrath, 1997) and the shared mental models perspective (Rouse & Morris, 1986; Norman, 1983; Klimoski & Mohammed, 1994). Diversity research has traditionally focused on the social categorization theory and the similarity attraction theory (Williams & O'Reilly, 1998; van Knippenberg & Schippers, 2007) to explain the negative effects of surface- and deep-level diversity. However, these theories provide only implicit insight about how cognitive similarities or differences in the team affect its cognitive processes such as information sharing, knowledge transfer, formation of strategic foci and consensus, learning, etc. Therefore, I take a cognitive approach to aid our understanding of the opposing effects.

The information processing perspective highlights the cognitive resources (such as knowledge, skills, ideas, perspectives, information processing styles, etc.) associated with diversity, and argues that the more resources a team has, the better equipped it is to perform well on a task (van Knippenberg & Schippers, 2007; Williams & O'Reilly, 1998). Greater number of members with different perspectives indicates a greater likelihood of having the resources important for conducting tasks. According to this perspective, diversity is related to increased cognitive resources, and is largely thought to be positive (Hackman, 2011).

The shared mental model perspective highlights the variation (in cognitive resources) in the team associated with diversity and argues that this variance can lead to communication and coordination difficulties, which can offset the potential gains (Klimoski & Mohammed, 1994; Cannon-Bowers, Salas, & Converse, 1993; Mathieu et al., 2000, Mathieu et al., 2005; Rentsch and Klimoski, 2001). These differences may arise from inconsistencies between individuals' definitions of the team's problem (Cronin & Weingart, 2007), or between individuals' approach to solving a unanimously understood problem, etc. In accordance with this perspective, diversity is related to increased variance, which prevents team members from understanding the perspectives of those dissimilar to them, and is largely thought to be negative.

By integrating the two perspectives, one deduces that a diverse team is equipped with cognitive resources and cognitive variance. And depending on the task context or the type of task confronting the group (McGrath, 1984), and whether the task will benefit from divergent thinking or convergent thinking, cognitive resources and cognitive variance will differentially affect performance. For example, having both cognitive resources and cognitive variance may benefit creative tasks (van Knippenberg & Schippers, 2007) such as product development or advertising, since a wide variety of different ideas coming from different individuals might be helpful. In contrast, execution tasks, or tasks that require a high level of coordination and efficiency, such as manufacturing objects or flying an airplane, should benefit from cognitive resources, but not cognitive variance since the associated communication and coordination problems may result in catastrophic errors.

In the first two papers of my dissertation, I examine the effect of cognitive style diversity on execution and creativity tasks. In the first paper, I explore the effects of a team's cognitive style composition on performance on a task where errors are costly, and careful execution is critical to achieve a good outcome in a lab setting. The studies demonstrate that higher variance in cognitive styles is associated with lower strategic consensus, which translates into more errors in performance, and hence worse outcomes. In the second paper, I explore the effect of a team's cognitive style composition on performance on a creative task. The study, conducted with 112 graduate student teams working on a term-length project, demonstrates that cognitive style variance is positively associated with all three aspects of creativity: fluency, flexibility and originality. Transactive memory system and strategic consensus guide this relationship, and are shown to have a positive effect on different aspects of team creativity. These two papers help further our understanding of cognitive style diversity and related processes on team performance under different task contexts.

Diversity debate: Moving toward a resolution

Since adding members with different cognitive resources leads to an increase in the cognitive resources of the team and its cognitive variance, a high resource and high variance combination is easy to achieve in teams. This raises an important question: is it possible to maximize cognitive resources, without increasing the cognitive variance, which would be ideal for execution tasks that benefit from convergent thinking? I propose that it is possible. In the third paper, I propose a team compositional solution to this optimization puzzle, joining other scholars (Dierickx & Cool., 1989; Kogut & Zander, 1992; Teece et al., 1997; Bunderson & Sutcliffe, 2002; Gardner et al., 2012) in arguing that both the amount and configuration of resources in the team are important. In this paper, I introduce the concept of cognitively versatile individuals, or individuals who are dominant in more than one cognitive style, as a way to maximize cognitive style resources in the team without increasing the cognitive style variance. In two studies, I find that the number of cognitively versatile team members is positively associated with performance on execution tasks. I also find that this relationship is mediated by process learning between trials.

Taken together, these three studies contribute to an underrepresented, yet important, area of team research. They delve into the team processes affected by cognitive style diversity in different task contexts. The studies attempt to shed further light on the ongoing debate about whether and how diversity is beneficial and detrimental to team performance, and move it toward a resolution.

Overview of the Dissertation

The dissertation consists of three stand-alone papers, each of which addresses different research questions related to the effect of cognitive style diversity on team processes and performance, and has separate theoretical background, hypotheses, methods, results, and conclusions. Below is a general overview of each of the three papers.

Paper 1

This paper (co-authored with A. Woolley) explores the effects of team cognitive style diversity on performance on a task where errors are costly. Errors are unintentional deviations from rules and procedures that can potentially result in adverse organizational outcomes (Edmondson et al., 2011). Errors can result in negative consequences such as loss of time and faulty products, as well as positive consequences such as learning and innovation (van Dyck, Frese, Baer, & Sonnentag, 2005). While it is hard to conceive that errors in execution or *executional* errors can be beneficial for any organizational task, some contexts are more vulnerable to the adverse effects of errors than others. High reliability organizations, for instance, are those for whom errors are catastrophic, and take a variety of extraordinary steps in pursuit of error-free performance (Weick, Sutcliffe & Obstfeld, 2008; Weick, 1987; Roberts, 1990; Rochlin, 1993; Schulman, 1993a, 1993b; LaPorte, 1994). While a number of studies have examined the relationship between team process and errors (e.g., Edmondson, 1999; Pisano, Bohmer & Edmondson, 2001), there has been little systematic investigation of the effects of team composition on the commission of errors. Similarly, while there has been some recognition that cognitive processes are important in high reliability functioning, what has been missing from these accounts is a clear specification of the ways in which these processes interrelate to produce effective error detection (Weick, Sutcliffe & Obstfeld, 2008) and error reduction.

In investigating the relationship between cognitive style diversity and errors, I delve into the process variables of strategic focus and strategic consensus. A team's strategy is a framework for guiding member attention toward key priorities and activities to accomplish goals, as evidenced by a pattern in a stream of important decisions (Ericksen & Dyer, 2004; Hackman, 1987; Hambrick, 1981; Miles & Snow, 1978; Mintzberg, 1978). Levine, Higgins, & Choi (2000) posit that prior to developing a shared reality about the best solution to a problem a group must first develop a shared reality about the best means for solving this problem. These means, or strategic foci, are important for two reasons. First, they influence critical aspects of the problem-solving process, including what information is attended to, how this information is weighted and integrated, and which members exert influence, all of which affect the group's final solution. Second, to the extent they are internalized, they have long-lasting effects on how individual members and the group as a whole respond to subsequent problems (Levine et al., 2000).

For the successful execution of a task, the focus of a team's strategy is important, but also whether all members see the priorities of their work similarly (Gurtner, Tschan, Semmer, &

Nagele, 2007). Strategic consensus is the shared understanding of strategic priorities among members of an interacting group or organization (adapted from Floyd & Wooldridge, 1992; Kellermanns, Walter, Lechner, & Floyd, 2005). Strategic consensus—or agreement on the importance of task elements—has been shown to be important in top management teams (TMTs), which we argue is relevant to task performing teams as well.

Based on previous research and theory, I expected that the cognitive style composition of a team will influence the team's level of strategic focus and strategic consensus. Both strategic focus and strategic consensus in turn will influence teams' commission of errors, which will affect their performance. To test the hypotheses, two studies were conducted. In the first study, 70 dyads (30 heterogeneous), 20 homogenous and predominant in spatial visualization, and 20 homogeneous and predominant in object visualization were used. Their task consisted of a computer-based maze that was designed to make use of both object and spatial visualization skills. In the second study, 231 individuals from the general population were randomly assigned to 64 teams ranging from size 2-5. Their task was also designed to use both object and spatial visualization skills, and consisted of using a set of building blocks to build a house, garage, and swimming pool based on a complex payoff criteria. In both the tasks teams incurred large penalties for errors in performance.

In this paper, I explored both whether cognitive style diversity mattered in teams, and how it mattered in a task where errors are costly. The studies indicated that it did matter; team composition based on members' cognitive style influenced both the strategic focus that a team formed, as well as strategic consensus. The relationship between levels of spatial and object visualization in teams and strategic focus that was established in Study 1 was highlighted in Study 2 as well. This finding underscored the importance of team composition on the strategic focus a team achieves. Study 2 additionally established the importance of strategic consensus, in that cognitive style diversity made strategic consensus more difficult to achieve. Both strategic focus and strategic consensus, in turn, impacted team performance through their effect on errors, elucidating how this diversity mattered.

Paper 2

In this paper, I explore the effects of team cognitive style diversity on a task where creativity is important. Creativity encompasses the processes leading to the generation of new and valued ideas (West, 2002), and requires the ability to think divergently, see things from different perspectives, and combine previously unrelated processes, products, or materials into something new and better (Amabile, 1996). Creativity has been theorized to be a critical process necessary for groups faced with complex and interdependent work (Drazin, Glynn, & Kazanijan, 1999; Gilson & Shalley, 2004; Levine & Moreland, 2004). While a number of studies have explored the relationship between group composition and creativity, Shin et al (2012) posit that cognitive team diversity may be the most relevant diversity variable to study creativity because it provides the different perspectives, ideas, and thinking styles required for creative processes (Williams & O'Reilly, 1998). And, although existing work (e.g., Jackson, 1992) suggests positive relations between diversity and team creative decision making, how diversity relates to creativity is still not fully understood (Shin & Zhou, 2007). Specifically, the link between cognitive team diversity and creativity as an outcome has been studied sparsely, with a few exceptions (e.g., Van der Vegt & Janssen, 2003; Shin et al., 2012).

Organizational researchers have suggested that cognitive diversity in the group may enhance performance, especially on tasks requiring creativity (Austin, 1997; Bantel & Jackson, 1989; McLeod, Lobel, & Cox, 1996). The value-in-diversity argument highlights that exposure to differences in perspectives and approaches among team members may stimulate creativity-related cognitive processes (Perry-Smith, 2006; Perry-Smith & Shalley, 2003), and help the team create and consider different perspectives (West, 2002), which might be unlikely when there exists similarity in how each member sees the world. Differences in deep-level diversity variables, such as knowledge and abilities, can be beneficial to group creativity, because it brings non-redundancy in the group (Levine & Moreland, 2004). This can be extended to differences in cognitive styles as well, and lends to the prediction that cognitive style variance in the team will be associated with greater creativity. And, while a lot of research in the area group creativity looks at nominal brainstorming groups (Bartis, Symanski, & Harkins, 1988; Camacho & Paulus, 1995; Diehl & Stroebe, 1987), I focus on real groups that have a common shared goal of producing a useful end product.

In this paper, I argue that creativity necessitates the need for divergence in inputs, but also integrating processes. In exploring the relationship between the cognitive style composition of the team and its creativity, I analyze processes that should facilitate the integration of diverse inputs: transactive memory systems and strategic consensus. Transactive memory systems entail consensus on who knows what in the team, and strategic consensus entails shared understanding of strategic priorities in the team. Groups with strong transactive memory have good understanding of the knowledge and skills available to each individual member, and this has been found to facilitate both access to information and coordination. The development of TMS in cognitively diverse teams will relate to the accurate understanding of the information available to the group and where it is located in terms of member expertise (Mitchell & Nicholas, 2006).

Strategic consensus can be seen as an integrating process that might be essential for creativity in real-world groups that need to generate ideas that can be implemented. In fact, the ability to discuss opposing ideas, integrate divergent viewpoints, and reach consensus is vital for the creation of new ideas (Hülsheger, Anderson, & Salgado, 2009; Levine & Moreland, 2004). However, the impact of the consensus on performance may heavily depend on the *content* of the consensus. Consensus around a non-optimal strategic focus might be far from beneficial, and in fact may hurt team performance. Here I examine process focus (Woolley, 2009a; 2009b), which entails the amount of importance members place on identification of the specific tasks and subtasks that need to be completed, assigning tasks to members, and specifying how these activities will be coordinated across people and/or over time (Woolley, 2009a; 2009b; LePine, 2005; McGrath, 1984). While there can be many strategic foci that one could study, here I examine process focus because of its role in potentially undercutting creativity (Woolley, 2009a; 2009b; 2011.)

Based on research and theory, I expected that the cognitive style composition of a team will influence team creativity, through TMS, strategic consensus and strategic focus as mechanisms. To test the hypotheses I studied 112 graduate student teams working on a term-length project. Students were randomly assigned to teams; the measures of cognitive styles were collected at the beginning of the semester, the process measures in the middle of the semester, and their final product was evaluated at the end of the semester on three aspects of creativity: fluency, flexibility and originality. The team task consisted of developing a case about a senior manager, which entailed finding an interesting subject, conducting an interview, and generating a report that met some basic criteria, but was largely open-ended.

In this paper, I investigated whether cognitive style diversity matters in teams, and how it matters for performance on a task where creativity is important. I found that cognitive style diversity positively influenced team creativity, and the team's TMS as well at its strategic consensus. TMS positively influenced the team's fluency and flexibility, while strategic consensus interacted with process focus to influence originality. The findings illustrated the complexity of team creative performance.

Paper 3

Teams with diverse knowledge and expertise are increasingly the locus of important technological advances and scientific innovation (Hong & Page, 2004; van Knippenberg & Schippers, 2007; Wuchty, Jones & Uzzi, 2007). However, we also know that teams are often unable to capitalize on their cognitive resources (Hackman & Katz, 2010; Ilgen et al., 2005), and fail to achieve the outcomes they have the potential to achieve, because of process losses such as coordination and communication difficulties (Steiner 1972). These difficulties usually arise because members who have different bases of knowledge and skills are unable to understand one another or develop knowledge integration capability (Cronin & Weingart, 2007; Gardner, 2012; Gardner, Gino, & Staats, 2012). Hence the very reason why teams are created, i.e. variety of resources, is also one of the primary reasons why teams fail when members providing these resources cannot coordinate effectively. How, then, can a team have a variety of resources to tackle a task, without incurring the associated process losses? This is the puzzle I address in this paper.

In this paper (co-authored with M. Molinaro and A. Woolley) I provide a new lens for looking at team composition in terms of this cost-benefit tradeoff, and propose one way to optimize it. I study how cognitive resources are distributed in teams, emphasizing both breadth and depth, and investigate the influence of versatile team members, or members who encompass depth in a breadth of domains. I term individuals who are strong in multiple cognitive styles as cognitively versatile. At a team level, a team can have any number of cognitively versatile members. I expected that cognitively versatile team members will influence team inputs by increasing cognitive resources, while at the same time not increasing cognitive variance. The increased pool of cognitive resources they bring will be beneficial to the team in solving multi-faceted problems. In addition, since cognitively versatile team members add resources without adding to the variance that exists in a team when different members bring different resources, I contend that their presence will benefit integration and reduce coordination difficulties in the team, which should positively influence group performance on execution tasks.

I conducted two studies to test the hypotheses. The first study consisted of 49 groups of four to five participants (N= 200). The second study consisted of 105 groups of two to five participants (N= 348) as well as 55 individuals working independently. In both the studies the task entailed typing a complicated text on a shared document where team members could see each other's work in the online document with a slight delay. Such a task requires a high level of attention to detail and careful coordination among team members. In two studies, I found evidence that the number of cognitively versatile members in the team was positively associated with team performance on this execution task, explaining variance above and beyond standard and non-standard ways of capturing diversity. Interestingly, I found that while there is generally a curvilinear (inverted U-shaped) relationship between team size and team performance, there was a positive linear relationship between size and performance in teams that have cognitively versatile members. I also found that the positive impact of cognitively versatile members on performance in execution tasks was facilitated by process learning.

With these three papers, I undertake the study of cognitive style diversity in team. I investigate the relationship between two aspects of cognitive style diversity, resources and variance, and team performance on tasks that impose different demands. Across the three studies, I identify important processes such as strategic focus, strategic consensus, transactive memory, and process learning that further explicate this relationship. The studies attempt to move the ongoing debate about whether and how diversity is beneficial and detrimental to team performance further by exploring task contexts that benefit from diversity, and those that do not. The final paper highlights one effective way to optimize the opposing forces that make diversity a challenging phenomenon to study, thus attempting to move the debate toward a resolution.

CHAPTER 2 (Paper 1)

Do you see what I see?

The Effect of Members' Cognitive Styles on Team Processes and Errors in Task Execution

Abstract

Abstract

This research investigates the effect of members' cognitive styles on team processes that affect errors in execution tasks. In two laboratory studies, we investigated how a team's composition (members' cognitive styles related to object and spatial visualization) affects the team's strategic focus and strategic consensus, and how those affect the team's commission of errors. Study 1, conducted with 70 dyads performing a navigation and identification task, established that teams high in spatial visualization are more process-focused than teams high in object visualization. Process focus, which pertains to a team's attention to the details of conducting a task, is associated with fewer errors. Study 2, conducted with 64 teams performing a building task, established that heterogeneity in cognitive style is negatively associated with the formation of a strategic consensus, which has a direct and mediating relationship with errors.

Keywords: team performance, cognitive diversity, cognitive style, strategic focus, strategic consensus, errors

Do You See What I See?

The Effect of Members' Cognitive Styles on Team Processes and Errors in Task Execution

The use of multi-disciplinary and cross-functional teams has risen steeply in organizations because such teams are thought to have the resources required to solve important multi-faceted problems (Bunderson & Sutcliffe, 2003; Hackman, 2002; Wuchty, Jones, & Uzzi, 2007). However, these teams are also susceptible to communication and coordination difficulties and execution failures (Cronin & Weingart, 2007), which makes it important to appreciate the risks associated with such diversity. This is critical in the context of execution tasks, where errors are especially costly.

Recent work in cognitive neuroscience has identified the cognitive styles that characterize individuals working in different occupational and professional domains (Kozhevnikov, Kosslyn, & Shephard, 2005; Kozhevnikov, 2007). A cognitive style is a psychological dimension that represents consistencies in how someone acquires and processes information (Ausburn & Ausburn, 1978; Messick, 1984). Cognitive styles thus provide a way to capture the deep-rooted cognitive differences that exist in functionally-diverse organizational teams. Insights of this kind have been called for often in the groups and teams literature (e.g., Mannix & Neale, 2005; van Knippenberg & Schippers, 2007).

The two studies reported here focus on the implications of team composition and diversity, based on members' cognitive styles, for team process and the commission of errors. In the first study, we explored the effects of cognitive styles on the formation of team strategic focus, and the effect of strategic focus on errors. In the second study, we explored strategic consensus as a mediator of the relationship between team cognitive style diversity and errors. We wanted to understand *how* cognitive styles matter in teams performing execution tasks. To accomplish that goal, we drew on theory and research involving diversity, group processes, and even neuroscience.

Theoretical Background and Hypothesis Development

Task context and errors

Task characteristics clearly matter in determining the team processes that are critical for performance (Larson, 2009; McGrath, 1984; Steiner, 1972). McGrath's task circumplex (1984) identifies four task categories that reflect different sets of team interaction processes: generate, choose, negotiate and execute. Generate tasks include creativity tasks, such as brainstorming, that require idea generation. Choose tasks include intellective or problem-solving tasks that require choosing correct answers. Negotiate tasks involve resolving conflicting interests. Finally, execution tasks (such as object assembly) require a high level of coordination, physical movement, or dexterity. Although diverse teams are often good at tasks that benefit from divergent thinking, such as tasks involving the generation of new ideas (Brown & Paulus, 2002), diverse teams might face difficulties in performing execution tasks, which benefit from convergent thinking and require attention to detail.

In execution tasks, adhering to policies, or operating procedures and avoiding errors is often critical for performance. Errors are unintended deviations from rules, procedures, and policies that can potentially produce adverse organizational outcomes (Goodman et al., 2011). Errors merit research in their own right as an important phenomenon relevant to organizations. However, although references to errors regularly show up in organizational accounts of accidents and other major mishaps (e.g., Starbuck & Farjoun, 2005; Zohar, 2008), errors themselves are rarely the primary topic of interest (Goodman et al., 2011). We have thus chosen to study how group composition (based on cognitive styles) and associated group processes affect the commission of errors in execution tasks.

Group Composition and Cognitive Style

The information processing perspective argues that a broader range of task-relevant knowledge, skills, and abilities provides a team with a larger pool of resources for dealing with non-routine problems (van Knippenberg & Schippers, 2007; Williams & O'Reilly, 1998). Such resources generally pertain to the deep-level psychological characteristics of team members (Harrison, Price, & Bell, 1998; Jackson, May, & Whitney, 1995; Moreland & Levine, 1992a). These include, but are not limited to, perspectives, training, and cognitive styles. Psychologists have been engaged in research on cognitive styles and individual performance for many decades (Sternberg & Grigorenko, 1997), dating back to Jung (1923), and several different dimensions have been identified , including reflection-impulsivity (Kagan, 1958), field dependence-independence (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962), adaptation-innovation (Kirton, 1976), and verbalizers-visualizers. We focus on the verbalizer-visualizer cognitive style, which is closely associated with the educational and functional areas in which many people choose to specialize (Kozhevnikov, 2007).

Recent work on the verbalizer-visualizer distinction has further differentiated "visualizers" on the basis of two imagery subsystems—object and spatial—that are anatomically and neurologically distinct (Goodale & Milner, 1992; Kosslyn, Ganis, & Thompson, 2001; Levine, Warach, & Farah, 1985). Object imagery refers to representations of the literal appearance of individual objects, in terms of their precise form, size, shape, color and brightness. Spatial imagery refers to relatively abstract representations of the spatial relations among objects, parts of objects, locations of objects in space, movements of objects and object parts, and other complex spatial transformations (Kozhevnikov et al., 2005; Reisberg, Culver, Heuer, & Fischman, 1986). Individuals high in object visualization encode and process an image holistically, as a single perceptual unit, whereas individuals high in spatial visualization generate and process images analytically, part by part (Kozhevnikov et al., 2005).

When solving mathematical word problems, strong object visualizers rely on pictorial images of the objects themselves, rather than on the relations among the objects. In contrast, strong spatial visualizers rely on schematic diagrams that depict the spatial relations of objects to each other (Hegarty & Kozhevnikov, 1999). For example, when thinking of a building, an individual high in object visualization will usually form a clear and bright mental picture of the building, but an individual high in spatial visualization will usually imagine the building's blueprint (Blazenkova & Kozhevnikov, 2008). Kozhevnikov (2007) found that scientists tend to be stronger spatial visualizers, but artists tend to be stronger object visualizers.

Research on how diversity in members' cognitive styles can influence team performance has appeared in the teams' literature (see Caruso & Woolley, 2008, for a review), but has not yet fully examined the impact of cognitive styles on collaboration, much less the mechanisms by which they actually enhance or inhibit team performance. Because cognitive styles represent distinct ways in which individuals encode and process information, individuals with different cognitive styles are likely to approach work differently, influencing how teams go about their work.

Strategic Focus

A team's strategy is a framework for guiding members' attention to key priorities and activities. One can often infer a team's strategy by looking for patterns in important decisions (Ericksen & Dyer, 2004; Hackman, 1987; Hambrick, 1981). Levine, Higgins, and Choi (2000) argue that prior to developing a shared reality about the best solution to a problem a group must first develop a shared reality about the best means for solving that problem. These means, or strategic foci, influence critical aspects of the problem-solving process, including what information is attended to, how that information is weighted and integrated, and which members exert influence. All of these can affect the group's final solution. They can also have long-lasting effects on how individual members and the group as a whole respond to subsequent problems (Levine et al., 2000; Moreland & Levine, 1992b).

One dimension along which a team's strategic focus can be conceptualized is *process focus.* A team's level of process focus is determined by the importance that members place on identifying specific sub-tasks that need to be completed, the resources available for doing so, and the coordination of sub-tasks and resources among members and over time (Woolley, 2009a). Although process focus in teams can be manipulated situationally (e.g., Woolley, 2009a, 2009b), it can also be heavily influenced by the work style predilections of members, as shaped by their cognitive styles. As noted earlier, strong object visualizers process information holistically and identify global properties of objects, whereas strong spatial visualizers process information analytically and part by part, using spatial relations to arrange and analyze components (Kozhevnikov, 2007). By extension, we expect that strong spatial visualizers (as compared to strong object visualizers) will exhibit greater tendency toward the granular, detail-oriented thinking associated with process focus, leading to a higher level of process focus in the teams whose members are strong in spatial visualization.

Hypothesis 1: Spatial visualization will be a more positive predictor than object visualization of process focus in teams.

A process focus engenders attention to the details of conducting work on a task. Such attention should be especially beneficial in the context of execution tasks, which are heavily dependent on pre-specified standards, such as rules, procedures, and policies. Deviating from these standards (errors) will be more common in teams that are not attentive to details and process. So, we predict that the more process-focused a team is, the less likely it is to commit errors.

Hypothesis 2: Process focus in teams will be negatively associated with errors in an execution task.

Strategic Consensus

A team's strategic focus is important for the successful execution of a task, but so is whether team members see the priorities of their work similarly (Gurtner, Tschan, Semmer, & Nagele, 2007). Strategic consensus is the shared understanding of strategic priorities among members of an interacting group or organization (adapted from Floyd & Wooldridge, 1992; Kellermanns, Walter, Lechner, & Floyd, 2005). Strategic consensus reflects whether team members are "on the same page" about important task elements and about how work will be conducted. Strategic consensus is an important factor in top management teams, and should be important in other work teams as well.

Similarities among group members lead to higher levels of cohesiveness, conformity, and consensus (Kellermanns et al., 2005); even without much communication on a particular issue, individuals who share a common background and set of experiences may come to see things in similar ways (Hambrick & Mason, 1984). So, it is not surprising that diversity has a negative impact on strategic consensus (Knight et al., 1999; Priem, 1990), though the reasons for that impact are not well understood. We contend that heterogeneity in cognitive styles is an important factor influencing the difficulty of reaching strategic consensus. Individuals with different cognitive styles literally see the world differently, and thus start in different places with regard to the kinds of details they believe should be prioritized when planning work. Consequently, heterogeneity in cognitive style creates discrepancies in members' understanding of the team's strategic focus, resulting in weak strategic consensus.

Hypothesis 3: Team heterogeneity in members' cognitive styles will be negatively associated with strategic consensus.

Strategies can only be successfully executed when members are acting on a common set of priorities (Floyd & Wooldridge, 1992). Strategic consensus facilitates the implementation of a group's strategic decisions (Amason, 1996); higher degrees of strategic consensus are associated with greater coordination and cooperation in the implementation of strategy, and with better organizational performance (Kellermanns et al., 2005). Hence, for successful execution that involves fewer errors, teams must come to a shared understanding of what constitutes their final strategy.

It can be argued that consensus plays a different role in performance depending on what stage of the decision-making process a group is in (e.g., Mintzberg, Raisinghani, & Theore, 1976; Zeleny, 1982). Although consensus during the problem-framing and brainstorming phases might decrease the number of strategies a team considers, and weaken team creativity as a result, consensus during the execution stage will enable the group to coordinate members' activities so that they can perform as a single unit. In general, being on the same page about a poor strategy is likely to be detrimental. However, we argue that the coordination losses associated with low strategic consensus can be even worse, particularly in a context where execution is important and errors are costly. As hypothesized previously, we expect that a team process focus will be associated with fewer errors (H2) and further predict that greater consensus around process focus will result in fewer errors.

Hypothesis 4: Strategic consensus in teams will be negatively associated with errors in an execution task.

Strategic consensus is probably the main vehicle through which team heterogeneity in cognitive styles leads to errors. In other words, differences in members' cognitive styles lead to low strategic consensus, which in turn produces coordination lapses -- key details are missed, and errors are committed. Thus, we predict that strategic consensus will mediate the relationship between cognitive style heterogeneity and commission of errors.

Hypothesis 5: Strategic consensus will mediate the relationship between team heterogeneity in cognitive style and errors in an execution task.

Overview of Studies

The objectives of the first study were to test the effects of team members' cognitive styles on the level of process focus that teams develop, and the effects of process focus on errors (Hypotheses 1 and 2). Study 2 examines the effects of cognitive style heterogeneity on strategic consensus (Hypothesis 3) and the direct and mediating effects of strategic consensus on errors (Hypotheses 4 and 5).

Study 1

Method

Participants

The sample consisted of 70 dyads. Thirty dyads were diverse (one member was high in object visualization and low in spatial visualization, whereas the other member was high in spatial visualization and low in object visualization), 20 dyads were homogenous in one way (both members were high in spatial visualization and low in object visualization), and 20 dyads were homogeneous in the other way (both members were high in object visualization and low in spatial visualization).[1]

Individuals from the general population were recruited for the study through online and paper advertisements. An online pre-screening was conducted with 2,494 individuals who were asked to complete (1) the Visualizer-Verbalizer Cognitive Style Questionnaire (VVCSQ; Kozhevnikov, Hegarty, & Mayer, 2002; Lean & Clements, 1981), and (2) the Object-Spatial Imagery and Verbal Questionnaire (OSIVQ; Blazenkova & Kozhevnikov, 2008). The VVCSQ allowed us to classify each person as high in verbalization or visualization, based on the respondent's strategies for solving a series of math problems. The OSIVQ yields scores for the spatial visualization and object visualization cognitive styles, and these scores have been shown to correlate with spatial and object processing abilities (Blazenkova, Kozhevnikov, & Motes, 2006; Chabris et al., 2006; Kozhevnikov et al., 2005). The goal of the screening was to select individuals from the tails of the distributions for object visualization and spatial visualization, and choose individuals who were high only on one of the two visualization cognitive styles, and not both, in order to compose maximally diverse or homogenous teams. Of the 140 individuals who participated in the main study, half were strong spatial visualizers and the other half were strong object visualizers. Participants were not given feedback on how they scored. Among those who participated in the main study, 77% were Caucasian, 65% were female, and participant ages ranged from 18–60 with a median age of 24. Preliminary analyses revealed no significant effects of gender and age composition on group performance, so these variables were not incorporated into further analyses.

Task

The task was a navigation and identification task set in a computer-based maze. The maze consisted of a long, winding corridor with many hallways branching off. The hallways were populated by complex, unfamiliar objects called “greebles” (Brainard, 1997; Gauthier & Tarr, 1997). First person maze navigation is a prototypical task for testing spatial visualization. Greebles are objects that are difficult to distinguish from one another and thus are good stimuli for tapping into object visualization. In pretesting the task, strong spatial visualizers did well on the navigation component, but not well on greeble recognition, and the reverse was true for strong object visualizers. Thus, the task provided a context where both skills would be important resources for the dyads. Dyads viewed the virtual maze environment on a single monitor, and had access to just one keyboard and one joystick.

Each maze contained 12 greebles, including three pairs of identical greebles and six lone distractor greebles. The dyads were instructed to navigate through the entire maze and to find and tag as many of the identical greeble pairs as possible. Teams incurred penalties for tagging the wrong greebles. Teams earned a bonus for each correctly tagged greeble, lost money for each incorrectly tagged greeble, and earned a bonus for navigating enough of the maze to see all of the greebles. Participants were guaranteed a base pay, to which a bonus based on performance was added. The bonuses received ranged from $0 to $6.80, above the base pay promised.

Measures

Process Focus. Team level of process focus was measured using observational coding of the teams’ two-minute planning period (between Maze 1 and Maze 2). Two raters coded each team on the amount of discussion about details such as what each person should do, the order in which things should be done and how much to collaborate on work versus work independently. All of these evaluations were made on a 1 (low) to 3 (high) scale. Other topics teams discussed included clarifying the task instructions and scoring structure, coaching each other on how to use the equipment, and general performance. The process focus observational scale exhibited acceptable reliability across raters (M=1.84, SD= 0.77, Max=3, Min=1, *Cohen's kappa* = .86).

Errors. Errors in this context consisted of tagging greebles that should not have been tagged. Two factors affected the commission of errors—the degree to which the dyad navigated the maze well, so that each greeble that appeared on the screen was in a unique part of the maze, and the degree to which the dyad recognized whether a greeble had been seen before or not. Thus both object and spatial visualization influenced the number of errors committed. Our analyses focused on the percent of greebles incorrectly tagged.

Procedure

Participants were told that they would be participating in a group collaboration study. We manipulated dyad composition to create three conditions. In the diverse condition, the individual high in spatial visualization was given the role of the navigator, and the individual high in object visualization was assigned the role of a tagger. In the homogeneous conditions, these roles were randomly assigned. Once the participants were introduced and seated in their assigned positions, they viewed task instructions on the computer monitor and navigated two small practice mazes. During this practice period, dyads received feedback when they correctly tagged the greeble pair in each maze. Such feedback was not given later on in the study. Following the practice period, dyads navigated two mazes. We counterbalanced the order of presentation of the mazes such that within each condition, half of the teams saw Mazes 1 and 2 in each of the two possible orders. We later tested for order effects, but none were observed.

Participants were not allowed to communicate while working on Maze 1, but they were allowed to discuss the task freely for two minutes between Maze 1 and Maze 2. They could continue to communicate while working on Maze 2. The planning break was created to allow us to evaluate process focus. All dyads were videotaped, with the knowledge and consent of the participants. All participants were debriefed (in writing) at the conclusion of each session.

Results

Descriptive statistics for the various measures are displayed in Table 1.

Hypothesis 1 predicted that spatial visualization will be a more positive predictor than object visualization of process focus in teams. We ran a one-way ANOVA examining the effect of the three conditions on the team's level of process focus. This analysis yielded significant results, $F_{(2,67)}=8.40$, $p=.01$, $\eta^2=.20$. Pairwise contrast testing demonstrated that homogeneous teams predominant in spatial visualization had significantly higher levels of process focus ($M=2.25$, $SD=.85$) than did homogeneous teams predominant in object visualization ($M=1.35$, $SD=.59$), $t=3.89$, $p=.0001$ (Table 1), providing support for our hypothesis. Additional analyses showed that homogeneous teams predominant in object visualization had significantly lower levels of process focus ($M=1.35$, $SD=.59$) than did diverse teams ($M=1.90$, $SD=.66$), $t=3.08$, $p=.004$. Homogeneous teams predominant in spatial visualization did not have significantly different levels of process focus from diverse teams, $t=1.55$, $p=.13$.

Hypothesis 2 predicted that process focus would be negatively associated with errors. We ran a regression with process focus as the independent variable, two dummy coded variables for condition, and errors in Maze 1 as control variables, and errors in Maze 2 as the dependent variable. The analysis supported our hypothesis ($F_{(4,65)}=5.81$, $p<.001$, $R^2=.26$); we found that process focus was negatively associated with errors in Maze 2, $\beta=-.33$, $t(69)=-2.77$, $p=.007$ (Table 2, Column 2).

Conclusions

The research question we addressed in Study 1 was how cognitive styles affect team strategic focus and error commission during an execution task. The results demonstrated that the cognitive style composition of a team influenced the team's level of process focus. Teams that were high in spatial visualization were more process-focused than teams that were high in object visualization. Homogeneous teams high in spatial visualization did not have significantly different levels of process focus from diverse teams, suggesting that the presence of even one strong spatial visualizer helped a team to be process focused. In addition, the study demonstrated that process focus strongly affected the commission of errors in a team, which was an important aspect of performance. Keeping the errors committed by teams in the first maze constant, higher process focus was associated with more errors in the second maze. This study helped us understand the processes and task subcomponents most affected by a team's cognitive style composition. Given the number of situations in which teams are left to their own devices to determine a work strategy, the cognitive style composition of a team can have a significant influence on the team's strategic priorities and performance.

In Study 2, we relaxed some of the constraints employed in Study 1 to further explore these effects. First, the task used in Study 1 was specifically designed to incorporate components that tapped directly into the two cognitive styles that interested us. In the second study, we adapted a task that was not designed to tap into these cognitive styles, but should generally benefit from the skills associated with them (Woolley, 2009a). Second, rather than prescreening and selecting individuals from the tails of the distributions in cognitive style, we randomly assigned individuals to teams to allow for a broader distribution of cognitive style heterogeneity. Third, although dyads were necessary in Study 1 to insure equal representation of the different skills in the diverse condition, in Study 2 we employed larger teams, and controlled for team size. Finally, we added an examination of strategic consensus (in addition to strategic focus), to determine the effects of agreement among team members about strategic priorities on the team's commission of errors.

Study 2

Method

Participants

The study was conducted with 231 participants, who were randomly assigned into 64 teams of size two to five. Participants were paid for their participation. The mean age of the participants was 23.6 years and 53% of them were male. Preliminary analyses revealed no significant effects of gender or age composition on group performance. Thus, these variables were not incorporated into further analyses.

Task

Teams were asked to use a set of building blocks to build a housing complex that included a house, garage, and swimming pool (Woolley, 2009a). The structures were evaluated on the basis of their size, quality (e.g., whether they would hold together when lifted, flipped over, and/or dropped), and the inclusion of features that qualified for bonus points (such as parking spaces included in the garage). Several building codes were also specified. For example, the foundation of the house had to be built with cement/white bricks, and the swimming pool had to have a diving board. Teams could lose more points than they earned if they neglected these details or committed errors in execution. All requirements and associated payoffs were described in detail in an instructional video played before the teams began to work. This information was also available in reference materials that the teams could access during their work.[2]

Measures

Levels of cognitive style. The Object-Spatial Imagery and Verbal Questionnaire (OSIVQ) (Blazenkova & Kozhevnikov, 2008) was again used to measure object and spatial visualization among participants. For each participant, scores were calculated for both the object and spatial visualization scales (*M*=3.46, *SD*= 0.51, *Max*=4.73, *Min*=1.40 for the object scale, *M*=3.07, *SD*=0.60, *Max*=4.6, *Min*=1.2 for the spatial scale). Cronbach's α was 0.81 for the object scale and 0.85 for the spatial scale was 0.85. *Levels* of team object and spatial visualization were calculated as the mean level of each cognitive style across members.

Cognitive style heterogeneity. This was calculated as the within-group variance in team members' scores on object and spatial visualization.

Process focus**.** This was measured using a survey developed by Woolley (2009b). Participants were asked to indicate how important different issues were for their planning. These issues included how the team should divide its time among the various structures/parts of the task, and what each person would work on. Participants' judgments were made on 1 to 7 scales, where 1 was very uncertain, and 7 was very certain. The nine items on the scale exhibited acceptable reliability (*Cronbach's α* = .89; *M*=4.44, *SD*= 1.36, *Max*=7, *Min*=1), and were averaged to form a measure of process focus.

Strategic consensus. This was calculated using the within-group variance of the process focus measure. That index was reverse-scored to facilitate its interpretation as a consensus measure (Knight et al., 1999). Lower strategic consensus would indicate less agreement about the level of process focus in the team**.**

Errors**.** These were calculated by adding the penalties associated with deviations from the building codes for each structure (garage, house, and swimming pool), as specified in the task instructions.

Procedure

After participants arrived at the laboratory, they completed a consent form, followed by measures of cognitive style and other measures, such as individual intelligence (based on the Wonderlic Personnel Test). They were told that they would be participating in a group collaboration study. Cognitive styles and their relevance to the study were not mentioned. All teams were videotaped with the knowledge and consent of their members.

Every team watched an instructional video about the task. After the video, teams were given five minutes to plan their work. Following this planning period, team members completed the measures of process focus. Afterward, they began their 20-minute building period. A timer was displayed on a computer screen in the room throughout the task to indicate the amount of time remaining. All participants were debriefed (in writing) at the conclusion of the session.

Results

Descriptive statistics and the correlations among study measures are displayed in Table 3. Team size and mean level of intelligence were used as control variables in the analyses, because both variables have been shown to affect the performance of tasks like the one we used (Woolley, Chabris, Pentland, Hashmi, & Malone, 2010).

The data supported Hypothesis 1: spatial visualization was a more positive predictor than object visualization of process focus in teams. Higher process focus was associated with a higher level of spatial visualization, r=.22, p=.03, and a lower level of object visualization, r= -.26, p=.02 (Table 3). These correlations with process focus were also significantly different from one another, Z=2.56, p<.01 (Steiger, 1980). Spatial visualization and object visualization scores were not significantly correlated with each other at the individual level (r=-.07, $p>.05$), or at the team level (r=-.12, $p>.05$).

Hypothesis 3 predicted that team heterogeneity in cognitive style would be negatively related to a team's strategic consensus. As evident in Table 4 (Column 4), heterogeneity in object visualization was negatively associated with strategic consensus, ($F_{(6,57)}$ =1.90, p=.09, R^2 =.*17*), controlling for heterogeneity in spatial visualization and levels of object and spatial visualization. Heterogeneity in spatial visualization was unrelated to strategic consensus (t(63)=.34, p>.05) for reasons we will speculate about later on.

Hypothesis 4 predicted that strategic consensus would be negatively associated with errors. We ran a regression with strategic consensus as the independent variable, and errors as the dependent variable, controlling for heterogeneity and levels of object and spatial visualization. The analysis supported our hypothesis $F_{(8,54)}$= 5.02, p=.001, R^2 =.*43*, (Table 4, Column 8).

Hypothesis 5 predicted that strategic consensus would mediate the relationship between cognitive style heterogeneity and committed errors. Mediation analyses supported this hypothesis (Sobel test for mediation: t= 2.05, p =.001). After adding strategic consensus to the model, the significance of the effect for heterogeneity in object visualization on errors (β =.35, p<.01) became non-significant (β = .17, p>.05), indicating full mediation (Table 4, Columns 6-8; Figure 1).

Conclusions

The purpose of this study was to further investigate the effects of cognitive style composition and heterogeneity on error commission in teams, and to explore the role of team strategic consensus in performance. Consistent with Hypothesis 1, and the patterns observed in Study 1, we found that spatial visualization was a more positive predictor than object visualization of process focus in teams. Specifically, we found that a team's level of spatial visualization had a positive effect on its process focus, whereas a team’s level of object visualization had a negative effect. Also, consistent with Hypothesis 3, we found that heterogeneity in object visualization had a negative effect on a team’s strategic consensus. Integrating the two results, we saw that the level of object visualization in a team reduced process focus, and heterogeneity in object visualization reduced team's strategic consensus around process focus.

We did not find a similar negative effect of heterogeneity in spatial visualization on strategic consensus. However, heterogeneity in object visualization had a stronger negative effect than heterogeneity in spatial visualization on a team’s strategic consensus ($Z = -1.85$, $p < .05$, Steiger, 1980). We speculate that this is due to the asymmetric effects of negative versus positive influences in groups; factors that contribute to disagreement and reduced cooperation tend to be more influential than factors that contribute to agreement or increased cooperation (Johnson et al., 2006; Myatt & Wallace, 2008). Because heterogeneity in object visualization was *negatively* associated with strategic consensus, it was a factor that detracted from team agreement. Hence, it is not surprising that heterogeneity in object visualization had a stronger negative effect on the team’s strategic consensus than did heterogeneity in spatial visualization.

We also found that strategic consensus was negatively related to the errors committed by teams. At a given level of process focus, teams with more strategic consensus incurred fewer errors than did teams with less strategic consensus. Also, strategic consensus fully mediated the relationship between team heterogeneity in object visualization and errors, and thus was the main mechanism through which heterogeneity in object visualization affected errors.

Discussion

Our research provides an initial answer to the recent call in the diversity literature for research on the psychological mechanisms underlying the effects of diversity on team processes and performance (see Mannix & Neale, 2005, van Knippenberg & Schippers, 2007). We examined the effects of deep-rooted differences in how individuals process and represent information in a team setting. The cognitive styles we investigated have been shown to distinguish individuals working in different professional disciplines (such as science and the visual arts) that frequently experience difficulty in collaboration (Cronin & Weingart, 2007). This research is relevant to organizations because organizational teams are often the locus of cognitive diversity, but team members are generally unaware of such diversity, let alone its effects on team performance.

We were interested in exploring *how* cognitive style matters in teams. Our research indicated that team members' cognitive styles influence both the strategic focus that a team develops, as well as the team's strategic consensus. The positive relationship between spatial visualization in teams and process focus that was established in Study 1 was replicated in our second study. Study 2 established the importance of strategic consensus. Both strategic focus and strategic consensus, in turn, affected the errors committed by the teams.

Study 1 showed that one way of achieving process focus (and thus limiting errors) in teams is to have at least one member who is high in spatial visualization. The other desirable factor in relation to errors is strategic consensus, which can be attained by having cognitive style homogeneity in the team. If a task greatly benefits from both process focus and strategic consensus, then it will be beneficial to have team members who are high in spatial visualization. Future research can also investigate the role that individuals strong in more than one cognitive style may play in team performance.

Our focus in these studies was on execution tasks that required attention to detail and for which errors were costly. These conditions are similar to those faced by many real-world teams, especially in high reliability organizations where minimizing errors is crucial. Although our laboratory tasks were chosen because they allowed us to focus on the effects of cognitive styles on error commission, they resemble the tasks done by teams in other settings. For example, the task used in Study 1 involved navigation and object identification, which are often done by sports, police, military, search and rescue, and intelligence teams. In all these contexts, errors can be costly, with implications that range from losing a match to missing terrorist threats. The task used in Study 2 was modeled after complex R&D type problems, where trade-offs among multiple criteria must be managed. It is also similar to tasks that teams perform in architectural, engineering, construction, and design firms. In addition, the team processes necessitated by the tasks we used —such as coordination among members, operating in conditions where there is no clear expert, decision-making under time pressure, strategizing to maximize gains and/or minimize losses, and dividing work among members—are applicable to many organizational tasks and settings.

Admittedly errors may not be costly in all task contexts, and so heterogeneous team composition may not always be problematic. There are, for example, tasks where divergent thinking and creativity are as important as task execution, if not more important. In such contexts, a high level of process focus may lead a team to be less flexible in thinking about alternatives, and thereby hinder creative performance. Future work in this area will facilitate a broader understanding of the conditions under which cognitive style heterogeneity is an asset versus a liability.

We tested our hypotheses by manipulating team composition using individuals at the extremes of the cognitive style distribution (in Study 1), and by allowing cognitive style to vary by random assignment of individuals to teams (Study 2). We tried to address the issue of generalizability by recruiting people from the general population, and not just a student population. In addition, we tested these effects using two different kinds of tasks and teams of various sizes. These steps were taken in order to bolster the external validity of our research.

In spite of our efforts, it is not possible in a laboratory setting to simulate all the complexities faced by organizational teams. For example, our participants were briefed on a clear set of rules and the consequences of breaking those rules, but organizational team members may not be fully aware of what constitutes an error, the implications of errors for organizational outcomes, and the costs and benefits of different courses of action. To overcome such limitations, future research should complement our laboratory studies with field studies in high-reliability organizations. Another limitation of our first study was that we may have created more diverse teams than arise in nature, given the principle of homophily. However, our second study, where participants were recruited from the general population and randomly assigned to teams, supports our confidence in the generalizability of our findings.

Our findings have important implications for how team leaders can manage cognitively diverse teams in organizational settings. Although managers might not always be able to control the composition of a team, an understanding of the processes affected by team composition could help managers to identify interventions to counteract the negative effects of cognitive diversity. Our findings suggest that interventions that encourage the development of process focus (where appropriate), or that increase strategic consensus, should help to mitigate the dangers of cognitively diverse teams. Such interventions could take the form of facilitated discussions to get team members to make explicit agreements about strategic priorities. The inclusion of individuals who are strong in more than one cognitive style may also help to improve coordination and communication among team members with different cognitive styles. Failure to appreciate the importance of strategic consensus, and to facilitate such consensus in cognitively diverse groups, will lead teams to continue to perform well below their potential. We encourage both researchers and managers to be cognizant of these processes so that they can better understand teams and maximize their outcomes.

CHAPTER 3 (Paper 2)

Cognitive Style Diversity and Creativity: The Effect of Transactive Memory Systems and Strategic Consensus in Teams

Abstract

This research investigates the effect of team members' cognitive style composition, and related team processes, on creativity, above and beyond what is explained by the team's gender and ethnic diversity. Creativity encompasses the processes leading to the generation of novel and useful ideas. In a study with 112 graduate-student teams working on a semester-long project, I explore the effect of the team's cognitive style composition on its transactive memory and strategic consensus, and find that it influences both these processes. Furthermore, I find that team's transactive memory is positively related to two aspects of creativity: flexibility and fluency. Originality, the third aspect of creativity is influenced by the team's strategic consensus and strategic focus. The study provides a nuanced understanding of how diverse inputs, but integrating processes, benefit team creativity.

Keywords: team creativity, cognitive diversity, cognitive style, TMS, strategic focus, strategic consensus

Cognitive Style Diversity and Creativity: The Effect of Transactive Memory Systems and Strategic Consensus in Teams

In large, complex organizations, the most important work—including the critical work of generating new products and services—is done in teams, which is unlikely to change in the near future (Ancona & Bresman, 2008). In fact, teams play a critical role in many creative endeavors-from path-breaking scientific discoveries (Levine & Moreland, 2004) to industry-transforming consumer products in companies such as Motorola, Microsoft, BP, Merrill Lynch, Vale, Procter & Gamble, and Southwest Airlines (Ancona & Bresman, 2007). Developing creative ideas often means addressing ambiguous problems that benefit from divergent perspectives and cross-fertilization of ideas, something that diverse teams are uniquely positioned to provide (Kaplan, Brooks-Shesler, King, & Zacaro, 2009). The creative potential of a team is increased when it draws together individuals with diverse backgrounds and perspectives to work toward a shared creative purpose (e.g., Bantel & Jackson, 1989).

It has been argued that for creativity to occur teams must first have a variety of resources to draw from and second, they must combine those resources in novel ways (Nijstad & Stroebe, 2006). Creativity, thus, necessitates the need for divergence in inputs, but also integrating processes. In this paper, I study team inputs in the form of cognitive style variance and resources, which capture some of the deep-rooted differences that underlie functional diversity in organizations. Incorporating members into a team with different cognitive styles can result in more cognitive resources—skills, knowledge, training, or perspectives—for the team to draw upon, but also greater discrepancies within the team in how individuals process information. While greater differences in cognitive styles have been found to increase the prevalence of errors in task execution (Aggarwal & Woolley, in press), these differences might be beneficial for tasks requiring creativity, providing an interesting dynamic that warrants deeper exploration.

In exploring the relationship between the cognitive style composition of the team and its creativity, I analyze processes that should facilitate the integration of diverse inputs: Transactive memory system (TMS) and strategic consensus. TMSs entail consensus on who knows what in the team, and strategic consensus entails shared understanding of strategic priorities in the team. In the following sections, I develop theory around why these processes should be influenced by team composition, and also why they should influence team creativity.

Theoretical Background

Team Creativity

Creativity is becoming increasingly important for organizational effectiveness (Woodman, Sawyer, & Griffin, 1993; Kaplan, Brooks-Shesler, King, & Zacaro, 2009), and has been theorized to be a critical process necessary for groups faced with complex and interdependent work (Drazin, Glynn, & Kazanijan, 1999; Gilson & Shalley, 2004; Levine & Moreland, 2004). Team creativity is the production of novel and useful ideas concerning products, services, processes and procedures by a team working together (Shin & Zhou, 2007; Amabile, 1982; Shalley, Zhou, & Oldham, 2004; West, 2002), and requires the ability to see things from different perspectives, and combine previously unrelated processes, products, or materials into something new and better (Amabile, 1996). In organizations, it is pivotal that these ideas are not only novel, but also useful and appropriate, so that they can result in implementable products and services (Nijstad & Levine, 2007).

Creativity is generally conceptualized as having three aspects: fluency, flexibility, and originality (Guilford, 1967; 1977; Torrance, 1966), which form the most-well accepted criteria to understand creativity (Rietzschel, De Dreu, & Nijstad, 2009). *Fluency* relates to the number of ideas generated. *Flexibility* relates to use of different cognitive categories and perspectives, and the use of broad and inclusive cognitive categories (Amabile, 1996; Mednick, 1962; Rietzschel, De Dreu, & Nijstad, 2009). *Originality* refers to the uncommonness of the ideas, insights, problem solutions, or products generated (Amabile, 1996; Guilford, 1967; Paulus & Nijstad, 2003; Sternberg & Lubart, 1999; Torrance, 1966; Rietzschel, De Dreu, & Nijstad, 2009) that are both novel and appropriate (Amabile, 1983).

The relationship between some kinds of team diversity and creativity has been studied, and has yielded mixed findings (Jackson, Joshi, & Erhardt, 2003; van Knippenberg, De Dreu, & Homan, 2004; Williams & O'Reilly, 1998; Milliken, Bartel, & Kurtzberg, 2003), but the link between team cognitive diversity and creativity as an outcome has been studied sparsely, with a few exceptions (Van der Vegt & Janssen, 2003; Shin, Kim, Lee, & Bian, 2012). As a result, Shin et al. (2012) have urged researchers to pay close attention to the type of diversity variable studied, since the effects of diversity variables are not all equal (Harrison & Klein, 2007; Horwitz & Horwitz, 2007; Joshi & Roh, 2009), pointing out that cognitive diversity may be the most relevant diversity variable to study creativity.

Team Composition

Cognitive diversity in the group relates to differences in deep-level (Harrison, Price, & Bell, 1998; Milliken & Martins, 1996; Moreland, Levine, & Wingert, 1996) characteristics of members including knowledge, perspectives, and information-processing styles (Williams & O'Reilly, 1998). Scholars have emphasized the need to study cognitive styles in the context of cognitive diversity (Kirton, 1976; Kirton, 1989; Kurtzberg & Amabile, 2001), providing motivation to study cognitive style diversity.

Cognitive styles are psychological dimensions that represent consistency in information acquisition and processing in individuals (Bartlett, 1932; Paivio, 1971; Richardson, 1977; Ausburn & Ausburn, 1978; Messick, 1984). Three cognitive styles that are of particular interest because of their direct relation to functional specialties in organizations are *verbalization, spatial visualization,* and *object visualization* (Kozhevnikov, 2007). While individuals high on verbalization rely primarily on verbal analytical strategies, those high in visualization rely primarily on imagery when attempting to perform cognitive tasks. Within visualization, individuals high in object visualization use holistic processing and perform better on tasks that require identifying global properties of shapes, whereas those high in spatial visualization use analytic processing, using spatial relations to arrange and analyze components (Kozhevnikov, Kosslyn, & Shephard, 2005). Research in cognitive psychology and neuroscience demonstrates that these cognitive styles are associated with different parts of the brain (Kozhevnikov, Hegarty, & Mayer, 2002), and gifted children as young as the age of 11-13 years, who have not received any area-specific training, exhibit specialization in these cognitive styles (Kozhevnikov, Blazhenkova, & Becker, 2010).

These cognitive styles differentiate among individuals choosing to go into different professional and occupational areas (Blajenkova, Kozhevnikov, & Motes, 2006; Kozhevnikov, Kosslyn, & Shephard, 2005), making their study important for understanding cross-functional collaboration in the organizational context. Such an approach heeds the call in the teams' literature to explore the psychological mechanisms underlying diversity in organizational teams (Mannix & Neale, 2005; van Knippenberg & Schippers, 2007).

Team composition based on cognitive styles can be conceived of in terms of cognitive style variance and cognitive style resources. Cognitive style variance is what most research would title “diversity,” and implies differences among team members on a particular attribute. Another complementary way to look at team composition is in terms of “resources” or the team members’ strength in these attributes. In terms of cognitive styles, cognitive style variance refers to the differences in cognitive styles among members, while cognitive style resources refer to the strength or level of cognitive styles. Differences do not imply strength, and strength does not imply differences, and in this paper, cognitive style variance and resources will be treated as two distinct aspects of team composition.

Organizational researchers have suggested that cognitive diversity in the group may enhance performance, especially on tasks requiring creativity (Austin, 1997; Bantel & Jackson, 1989; McLeod, Lobel, & Cox, 1996). The value-in-diversity argument highlights that exposure to differences in perspectives and approaches among team members may stimulate creativity-related cognitive processes (Perry-Smith, 2006; Perry-Smith & Shalley, 2003), and help the team create and consider different perspectives (West, 2002), which might be unlikely when there exists similarity in how each member sees the world. Differences in deep-level diversity variables, such as knowledge and abilities, can be beneficial to group creativity, because it brings non-redundancy of ideas or perspectives in the group (Levine & Moreland, 2004). This can be extended to differences in cognitive styles as well, and lends to the prediction that cognitive style variance in the team will be associated with a greater creativity. And, while a lot of research in the area of group creativity looks at nominal brainstorming groups (Bartis, Szymanski, & Harkins, 1988; Camacho & Paulus, 1995; Diehl & Stroebe, 1987), I focus on real groups that have a common shared goal of producing a useful end product. In addition, because deep-level diversity is thought to influence task performance, while surface-level diversity is thought to influence social processes in teams (Van Knippenberg & Schippers, 2007), I predict that the cognitive style variance in the team will influence team creativity, above and beyond the effect of the team's gender and ethnic diversity, which are generally considered surface-level diversity variables.

Hypothesis 1: Cognitive style variance in the team will be positively associated with the team's creativity, controlling for the team's gender and ethnic diversity.

In understanding the team processes that should be affected by the cognitive style composition of the team, and also influence team creativity, I concentrate on the team's TMS and strategic consensus.

Transactive Memory System

A transactive memory system (TMS) refers to a shared system that individuals in groups develop to collectively encode, store, and retrieve information or knowledge in different domains (Lewis & Herndon, 2011; Wegner, 1987). Simply put, transactive memory refers to the knowledge of 'who knows what' (Argote & Ren, 2012). Groups with a well-developed TMS exhibit differentiation where different members specialize in learning, remembering and sharing different knowledge (Ren & Argote, 2011).

The latest review of the TMS literature has suggested that the link between creativity and TMS needs to be studied (Ren & Argote, 2011). Until now there is only one study that has examined the effects of TMS on creativity, which found that groups with well-developed transactive memories demonstrated a higher level of creativity in creating products than groups with less developed TMS (Gino, Argote, Miron-Spektor, & Todorova, 2010). The authors reported that development of TMS within teams allowed team members to create a common knowledge base which combined information, perspectives, and expertise of different team members- elements that are important antecedents of creativity.

Because groups with a well-developed TMS have knowledge of members’ expertise, they are in a better position to envision how members’ expertise can be combined in new ways to create new products and services than teams with a less developed TMS. Also, accurate expertise recognition improves team performance because it facilitates the division of cognitive labor among members, the search and location of required knowledge, the match of problems with the person with the requisite expertise to solve the problems, the coordination of group activities, and better decisions through the evaluation and integration of knowledge contributed by group members (Moreland, 1999; Ren & Argote, 2011). In addition, the potential to create novel ideas as a team is also dependent on team members’ ability to efficiently exchange knowledge and build on each other’s ideas (Hargadon & Beckhy, 2006; Monge, Cozens, & Contractor, 1992). The development of TMS for creative tasks will improve the coordination of knowledge exchange and use, as well as the capacity of team members to trust their teammates’ ideas (Gino et al, 2010), which will be important in facilitating team creativity. Based on this reasoning, I predict that:

Hypothesis 2: The team’s transactive memory system will be positively associated with team creativity.

While the relationship between surface-level diversity and TMS has been explored before in the context of gender and ethnic diversity (Hollingshead & Fraidin, 2003; Bunderson, 2003), and that between deep-level diversity and TMS has been studied in the context of personality traits (Pearsall & Ellis, 2006), not many scholars have studied the effect of cognitive diversity on

TMS. In fact, Peltokorpi (2008) concluded that future studies should examine more fully the influence of diversity on TMS (Argote & Ren, 2012).

Groups with strong transactive memory have good understanding of the knowledge and skills available to each individual member, and this has been found to facilitate both access to information and coordination. The development of a TMS in cognitively diverse teams will relate to the accurate understanding of the information available to the group and where it is located in terms of member expertise (Mitchell & Nicholas, 2006).

In a team where members are similar to each other on a set of attributes, it will be challenging for the team to decipher who is good at what, let alone have a shared understanding of it. However, in a team where members are different from each other on a set of attributes, differences will be more salient, and thus, the team will be more likely to recognize who is good at what, which may be a prerequisite to arriving at a shared understanding of how specialization is distributed in the team. Differences should allow team members to have a good opportunity to characterize individuals into different areas of expertise, which may facilitate cognitive interdependence that has been theorized as a critical prerequisite to the development of a TMS (Brandon & Hollingshead, 2004; Hollingshead, 2001). Having a common shared goal that needs to be fulfilled in a timely manner might be an important condition under which TMS is likely to form in natural groups. If the team does not care about the goal, or if there is no deadline associated with the goal, team members might be less motivated to come to a shared understanding of the division and specialization of labor and expertise.

Hypothesis 3a: Cognitive style variance in the team will be positively associated with the team's TMS.

But, what is likely to happen in teams where members care about the goal, but are relatively similar to each other? Understanding the interaction between cognitive style variance and resources gets at this question. For example, team members may be similar to each other (as will be seen in a team with low cognitive style variance), irrespective of whether team members are high in the three cognitive styles or low. I speculate that the strength in the cognitive styles of the team members is also likely to influence TMS.

One can imagine a team in which all members are similar to each other on the three cognitive styles, and all are also low in the cognitive styles; for example, in a hypothetical team in which all members have a low score of 1 in object visualization, spatial visualization, and verbalization (on a scale of 1-5). In such a team there exist fewer cognitive resources, which when combined with similarity, will yield a condition where it will be hard to distinguish between members. In contrast, one can also imagine a team in which members are similar to each other on the cognitive styles, but they are also high in them; for example in a hypothetical team in which all members have a high score of 5 in the three cognitive styles. In this case, the strength in the cognitive style resources will provide the factor that will help facilitate the understanding of who should specialize in what (even in this example where multiple team members will be suitable for the same job), and how work should be delegated in the team. Increasing the team's cognitive resources will give the teams a larger pool of resources, from which the select and assign work.

Hypothesis 3b: Cognitive style resources and cognitive style variance will have an interactive effect on the team's TMS, such that when teams have lower cognitive style variance, cognitive style resources will have a positive relationship with TMS.

Strategic consensus

Strategic consensus is the shared understanding of strategic priorities among members of an interacting group or organization (adapted from Floyd & Wooldridge, 1992; Kellermanns, Walter, Lechner, & Floyd, 2005), and is important in a group setting because it reflects whether group members are on the same page about the team's strategic priorities for the given task (Cronin & Weingart, 2007). Strategic consensus reveals how coordinated the group is in their understanding of the task elements, the distribution of work, and the understanding of what constitutes a successful outcome (Aggarwal & Woolley, in press).

Individuals who share a common background and set of experiences may come to see things in similar ways (Hambrick & Mason, 1984). In an attempt to understand the relationship between diversity and strategic consensus, Aggarwal and Woolley (in press) studied this relationship in the context of the team's cognitive style diversity. They found that there was a negative relationship between cognitive style variance and strategic consensus. When team members had different ways in which they encoded and processed information, and had different predilections to approach tasks, they started in different places with regard to the kinds of details they believed should be prioritized when planning work. Even after the team members had taken time to discuss what strategy the team would use to tackle the task, there was a strong negative relationship between cognitive style variance and strategic consensus, leading me to predict:

Hypothesis 4: Cognitive style variance will be negatively associated with the team's strategic consensus.

Strategic consensus can be seen as an integrating process that might be essential for creativity in real-world groups that need to generate ideas that can be implemented. In fact, the ability to discuss opposing ideas, integrate divergent viewpoints, and reach consensus is vital for the creation of new ideas (Hülsheger, Anderson, & Salgado, 2009; Levine & Moreland, 2004).

However, the impact of strategic consensus on performance may heavily depend on the *content* of the consensus. Consensus around a non-optimal strategic priority might be far from beneficial, and in fact may hurt team performance. While there can be many strategic foci that one could study, one that is relevant to this context, because of its expected sub-optimality, is process focus (Woolley, 2009a; 2009b).

Process Focus

Process focus entails the amount of importance members place on identification of the specific tasks and subtasks that need to be completed, assigning tasks to members, and specifying how these activities will be coordinated across people and/or over time (Woolley, 2009a; 2009b; LePine, 2005; McGrath, 1984). The level of process focus can be measured along a continuum, gauged by the degree to which these details take precedence in the team's decision making, allowing them to constrain other elements of the team's work (Woolley, 2009a).

When reduced errors and reliable output are highly desirable, well established procedural routines—associated with high levels of process focus—can significantly enhance team performance (Gersick & Hackman, 1990). However, a high level of process focus may not be as beneficial for tasks that benefit from the creation or combination of new ideas and knowledge (Woolley, 2009a), and is associated with less flexibility in thinking about alternative methods for carrying out work (Vallacher & Wegner, 1989). This leaves teams with high levels of process focus at a disadvantage in complex, changing environments where they might need to devise better ways to approach their task (Woolley, 2009b). Previous research (Woolley, 2009b) has demonstrated that high levels of process focus can have a negative effect on task performance in open-ended tasks.

I predict that a team's levels of strategic consensus, and process focus, will combine to influence creativity in teams. And, when the team's strategic consensus is high, indicating they are on the same page about all strategic priorities, and the level of process focus is low, indicating they are paying lesser attention to the means by which the task will be conducted, they will be the most creative.

Hypothesis 5: Process focus and strategic consensus will have an interactive effect on team creativity, such that when teams have higher strategic consensus, process focus will a negative relationship with team creativity.

The hypotheses are graphically displayed in Figure 1.

Method

Participants

Participants in the study consisted of 463 students randomly assigned to 112 teams as a part of an introductory MBA course. Students worked in four- to five -member teams to complete a semester-long project. Based on Dahlin, Weingart, and Hinds (2005), there are several advantages in using this sample: (1) highly motivated individuals whose grades depend upon team performance comprise the teams, (2) Team membership persists over two months, and (3) the teams have identical tasks, for which each receives the same background information.

Task

The team task consisted of developing a case about a senior manager, which entailed finding an interesting subject, conducting an interview, and generating a report that met some basic criteria, but was largely open-ended. As is the case in many organizational settings, this task was interdependent, complex and varied, providing an ideal task to study the effects of group composition on creativity (West, 2002). The task involved problem identification of the sort typical in management case studies; decision making, in activities such as generating options, products, or services or picking evaluation criteria and applying the criteria; seeking additional information, by, for instance, conducting research or seeking subject matter experts; critical thinking, as in critical evaluation of newspaper and research articles; building consensus on how best to handle problems; generating action plans; and generating reports (Taggar, 2002). Various types of case analysis tasks are often used to assess information use (Dahlin et al., 2005) and creativity (Taggar, 2002). The case report was the final product. The required visual displays (diagrams and figures) were evaluated for creativity since this was the major aspect of differentiation between reports among the teams. This task was especially pertinent in the context of cognitive styles, since the project overall encompassed significant visualization and verbalization components.

Procedure and Measures

Data on cognitive styles were collected in the beginning of the semester, data on group processes in the middle of the semester, and data on team performance at the end of the semester.

Cognitive Style. Team members completed the Object-Spatial Imagery and Verbal Questionnaire (OSIVQ) (Blazenkova & Kozhevnikov, 2008) in order to assess their cognitive styles.

Cognitive Style Resources were captured at the team level as the sum of the square-root of the team's mean on each cognitive style squared to capture both strength and range of the member cognitive styles in the team, $\left(\sqrt{OV\ mean} + \sqrt{SV\ mean} + \sqrt{V\ mean}\right)^2$ (as described in Aggarwal & Molinaro, 2013).

Cognitive Style Variance was captured as the sum of the within-team standard deviation in each cognitive style (as described in Aggarwal & Molinaro, 2013).

Gender Diversity was calculated using Blau's (1977) index since gender is a categorical construct, $(1 - \sum p_i\ ^2)$ where p_i is the fraction of group members with gender *i*.

Ethnic Diversity was calculated using Blau's (1977) $(1 - \sum p_i\ ^2)$ where p_i is the fraction of group members with ethnicity *i* [6 possible categories: White (Hispanic origin), White (not of Hispanic origin), Black (African-American), American Indian or Alaskan Native, Asian or Pacific Islander, Other/ Mixed heritage].

Transactive Memory System was measured using the scale developed by (Lewis, 2003). The scale contains 15 items (5 items per dimension) designed to assess team member specialization (e.g., ''Different team members were responsible for expertise in different areas"), credibility (e.g., ''I trusted that other members' knowledge about the task was credible"), and coordination (e.g.,''Our team worked together in a well-coordinated fashion"). Each item was scored on a 7-point Likert-type scale ranging from 1(strongly disagree) to 7 (strongly agree). The items were aggregated to form a single scale.

Process focus was measured using the scale developed by Woolley (2009b). Participants were asked to indicate how important different issues were in their planning such as "How the team should divide its time among the various structures/parts of the task," "What each person will work on" on a scale of 1 to 7.

Strategic consensus was calculated using the within-group SD among team members' evaluations of strategic priorities such as process and outcome focus (Woolley, 2009b). This index was reverse scored to facilitate its interpretation as a "consensus" measure (Knight, et al., 1999).

Team Creativity consisted of two objective measures, fluency and flexibility, and one subjective measure, originality. Fluency was captured by calculating the number of non-repetitive displays used by the team. Flexibility was captured by calculating the different categories from which the displays were used. Categories used included organizational charts, venn diagrams, bar charts, scatterplots, and timeline displays among others. Originality was computed on a detailed evaluation of the teams' final product on a scale adapted from Gino et al. (2010) (Appendix A). As is characteristic of the consensual assessment technique (Amabile, 1982; Hennessey & Amabile, 1999) where subjects are given some instruction for creating a product, and then experts independently assess the creativity of those artifacts (Baer, Kaufman, & Gentile, 2004), two independent coders evaluated the products and demonstrated high levels of interrater agreement; the inter-class correlation was .95. The scale demonstrated good reliability; the scale's Cronbach's alpha was .93.

Results

The independent variables were standardized for the year in which the data were collected. Dependent variables measuring creativity were left unstandardized. Control variables included year and team size. Descriptive statistics and intercorrelations among the study measures are displayed in Table 1.

As predicted in Hypothesis 1, cognitive style variance in teams had a positive effect on the team's creativity, above and beyond any effect explained by gender and ethnic diversity. The hypothesis was supported for all three dimensions of creativity (i) fluency, $F_{(5,106)}$ =4.66, p=.001, R^2 =*.18* (Table 2, Column 5) (ii) flexibility, $F_{(5,106)}$ =7.32, p<.001, R^2 =*.26* (Table 2, Column 9) (iii) originality, $F_{(5,106)}$ =6.17, p<.001, R^2 =*.23* (Table 2, Column 13).

Hypothesis 2 predicted that TMS will be positively associated with creativity. The data supported this hypothesis for two aspects of creativity– fluency, β = .26, t= 2.53, p=.01 (Table 2, Column 6) and flexibility, β = .26, t= 2.71, p=.008 (Table 2, Column 10) controlling for process focus, strategic consensus and their interaction, but not originality β = .13, t= 1.38, p=.18 (Table 2, Column 14).

Hypothesis 3a predicted that cognitive style variance will have a positive relationship with TMS. This hypothesis was supported, β = .23, t= 2.40, p=.02 (Table 2, Column 1).

Hypothesis 3b predicted that cognitive style resources and cognitive style variance will have an interactive effect on the team's TMS, such that when teams have lower cognitive style variance, cognitive style resources will have a positive relationship with TMS. The cross-product between cognitive style variance and cognitive style resources was significantly associated with TMS, β = -.23, t= -2.46, p=.02 (Table 2, Column 2). In doing a simple slope analysis to further understand this relationship (illustrated in Figure 2), the slope between cognitive style resources and TMS for teams 1 SD above the mean of cognitive style variance was -.10, at the mean was 0.14 and 1 SD below the mean was .38. This indicates a positive linear relationship between cognitive style resources and TMS when cognitive style variance was lower (1SD below mean), thus supporting the hypothesis.

Hypothesis 4 predicted that the team's cognitive style variance will be negatively associated with its strategic consensus. This hypothesis was supported, β = -.25, t= -2.63, p=.01 (Table 2, Column 3).

Hypothesis 5 predicted that process focus and strategic consensus will have an interactive effect on team creativity, such that when teams have higher strategic consensus, process focus will a negative relationship with team creativity. Results indicated that neither strategic consensus nor process focus had a significant main effect on any aspect of creativity. However, the cross-product term between strategic consensus and process focus had a significant effect on originality $\beta = -.17$, $t= -1.88$, $p=.06$ (Table 2, Column 14), but not on fluency $\beta = -.02$, $t= -.25$, $p>.05$ (Table 2, Column 6), nor flexibility $\beta = -.03$, $t= -.31$, $p>.05$ (Table 2, Column 10). In doing a simple slope analysis to further understand this relationship (illustrated in Figure 3) the slope between process focus and originality for teams 1 SD above the mean of cognitive style variance was -.35, at the mean was -.15 and 1 SD below the mean was .04. This indicates a negative linear relationship between process focus and originality when strategic consensus is higher (1 SD above the mean), supporting the hypothesis.

Discussion

This study aimed at exploring the effect of team composition based on cognitive styles on team creativity. I conceptualized team composition in terms of cognitive style variance and resources to provide a nuanced understanding of how the members' differences on cognitive styles, and their strength in them, influence team processes and creativity. Since diversity has been shown to have a beneficial effect on creativity, it was not surprising that the results demonstrated a positive effect of cognitive style variance on all three aspects (i) fluency (ii) flexibility, and (iii) originality. These effects hailed above and beyond the effects associated with gender and ethnic diversity. I focused on studying creativity of implemented ideas, which entails ideas that have been generated and selected for further development (Nijstad & Levine, 2007). Hence, these were the ideas that the teams thought were the most relevant to be included in the final product. It was interesting to see that there were differences between teams in the number and quality (novelty and usefulness) of these ideas, and that cognitive style variance explained why some of these differences existed.

The crucial question that was addressed from Hypothesis 2-5 pertained to the processes that affected this relationship. Scholars in the field have suggested that integrating processes related to consensus in the group are crucial for understanding team creativity (Levine & Moreland, 2004). I undertook the study of two such processes, TMS, and strategic consensus. As seen in the results, I found that both of these processes influenced different aspects of creativity, demonstrating that predicting a team's creative performance is characterized by complex mechanisms.

For example, TMS positively affected team fluency and flexibility. A TMS reduces the redundant overlaps in knowledge and clarifies who will specialize in what. Increased specialization leads to more efficient cognitive processing, as only the person assigned to a particular expertise attends to the relevant information and encodes it in memory. This frees up other individuals to concentrate on their own tasks. The improved information processing results in higher levels of creativity within the team, because members do not need to waste cognitive resources by encoding information relevant to subtasks to which other members are assigned (Gino et al., 2010). Because TMS entails specialization, coordination and credibility, it is not surprising that TMS influenced the number of implemented ideas, and also the number of categories these implemented ideas were from. Both fluency and flexibility are aspects of creativity that would especially benefit from specialization and coordination, as compared to originality that would benefit more from the cross fertilization of ideas. When the team members have a good understanding of who knows what, they are likely to delegate the tasks according to expertise, which would enable implementation of more ideas, and also ideas from non-redundant categories.

The third aspect of team creativity, originality, was influenced by the team’s strategic consensus, and the content of the consensus. As expected, teams that demonstrated consensus and were low in process focus had more original ideas than teams that demonstrated consensus but also had high process focus. As argued previously, being on the same page about the strategic foci is extremely important for the successful execution of a task, however what will determine whether being on the same page is beneficial or harmful will depend on the task context and the content of the consensus. Since process focus relates to the flexibility teams will have/employ in order to conduct the task, it was predicted that when teams are on the same page and high in process focus, they will be less flexible in approaching a task that would benefit from flexibility and cross fertilization of ideas, and hence be less creative. The originality aspect of creativity, which most benefits from cross fertilization, was gauged in terms of novelty and appropriateness. One reason why this pattern was not found for the other two aspects of creativity might have been because they pertain to volume, which would benefit from the specialization and credibility entailed by other team processes, i.e. TMS. This finding underscored the importance that the content of consensus has on the team’s creativity, and established that being on the same page about a suboptimal strategic priority hurts team creativity.

Given the above reasoning, it is not surprising that TMS affected fluency ($Z= 2.02$, $p<.05$) and flexibility ($Z= 2.24$, $p<.05$) more strongly than the interactive effect of strategic consensus and process focus. In contrast, the interactive effect of strategic consensus and process focus affected originality more strongly than TMS $Z= -2.38$, $p<.05$ (Steiger, 1980).

Another extremely relevant question that this paper addressed pertained to how these team processes naturally occur within the team without intervention, and the role of team composition in guiding this relationship. I had predicted that the team's composition based on members' cognitive styles will influence team processes through two configurations: variance and resources. Cognitive style variance is what most research would title "diversity," and implies differences among team members on a particular attribute. Another complementary way to look at team composition is in terms of "resources" or the team members' strength in these attributes. Differences do not imply strength, and strength does not imply differences. In line with previous research (Aggarwal & Woolley, in press), I found that differences in cognitive styles led to low strategic consensus. This is because when members differ from each other in how they process and encode information, and how they prioritize aspects of work, it is harder for them to be on the same page about the team's strategy, in the absence of an intervention.

I found that cognitive style variance was positively associated with the team's TMS. When team members were extremely different from each other, that was a sufficient condition for the team to decipher who was good at what, which may have served as a prerequisite to arriving at a shared understanding of who should take responsibility for different aspects of their work. I also found that cognitive style variance and resources interacted to influence a team's TMS. When cognitive style variance was low, and hence members were similar to each other in cognitive styles, having greater resources has a positive impact on TMS. This implies that when differences are low, strength in different cognitive styles is an important condition to establish expertise, which can help facilitate the team's understanding of how labor will be distributed. These results shed light on how different processes emerge in teams in their natural form.

This research addressed several calls in the groups and teams literature about studying (i) deeper-level mechanisms (Mannix & Neale, 2005), (ii) the relationship between cognitive diversity and creativity (Shin et al., 2012), especially diversity related to cognitive styles (Kirton, 1976; 1989; Kurtzberg & Amabile, 2001), (iii) the relationship between team composition and TMS (Argote & Ren, 2012), and (iv) the influence of TMS on creativity (Ren & Argote, 2011). In addition, this study provides a complement to the work on the cognitive style composition of the team and task execution (Aggarwal & Woolley, in press) by studying the implications of such composition in the context of creativity. Altogether, the study provides a nuanced understanding of composition, processes and creativity in teams, revealing the complexity of teamwork.

CHAPTER 4 (Paper 3)

Cognitive Versatility: A New Lens for Understanding Team Composition and Diversity

Abstract

Cognitive diversity in teams is associated with both benefits and costs, and increasing the benefits linked with having a greater wealth of human resources without increasing the associated coordination costs is a challenge. In this paper, we provide a new lens for looking at team composition in terms of this cost-benefit tradeoff, and propose one way to optimize it. We study how cognitive resources are distributed in teams, emphasizing both breadth and depth, and investigate the influence of versatile team members, or members who encompass depth in a breadth of domains. In two studies, we find evidence for the proposition that the number of cognitively versatile members in the team is positively associated with team performance in execution tasks, explaining variance above and beyond standard and non-standard ways of capturing diversity. Interestingly, we find that while there is generally a curvilinear (inverted U-shaped) relationship between team size and team performance, there is a positive linear relationship between size and performance in teams that have cognitively versatile members. We also find that the positive impact of cognitively versatile members on performance in execution tasks is facilitated by process learning. We discuss the implications of this alternative way of viewing diversity.

Keywords: teams, diversity, execution, cognitive styles, versatility, team size, learning

Cognitive Versatility: A New Lens for Understanding Team Composition and Diversity

Teams with diverse knowledge and expertise are increasingly the locus of important technological advances and scientific innovation (Hong & Page, 2004; van Knippenberg & Schippers, 2007; Wuchty, Jones & Uzzi, 2007). However, we also know that teams are often unable to capitalize on their cognitive resources (Hackman & Katz, 2010; Ilgen et al., 2005), and fail to achieve the outcomes they have the potential to achieve, because of process losses such as coordination and communication difficulties (Steiner 1972; Aggarwal & Woolley, in press). These difficulties usually arise because members who have different bases of knowledge and skills are unable to understand one another or develop knowledge integration capability (Cronin & Weingart, 2007; Gardner, 2012; Gardner, Gino, & Staats, 2012).

Hence the very reason why teams are created, i.e. variety of resources, is also one of the primary reasons why teams fail when members providing these resources cannot coordinate effectively. How, then, can a team have a variety of resources to tackle a task, without incurring the associated process losses? This is the puzzle we address in this paper.

Cognitive Resource-Variance Tradeoff

In the following sections, we adopt a new way to look at team composition and diversity, which relies on the insight that, depending on the task context, there are negative and positive aspects of team inputs that create a benefit-loss tradeoff. These beneficial and detrimental team inputs provide a dynamic that can be optimized. In this paper, we will look at team inputs in terms of cognitive resources and cognitive variance.

Cognitive resources in a team are often defined in terms of skills, knowledge, training, or perspectives that team members bring to the team. The information-processing perspective argues that the more resources a team has, the better equipped it is to perform well on a task (van

Knippenberg & Schippers, 2007; Williams & O'Reilly, 1998), making resources coveted for the team. One way of adding an array of cognitive resources in the team is by adding team members with specific resources.

However, a team where members cannot communicate or coordinate with each other, as a result of the differences in their knowledge, skills and perspectives, i.e. cognitive resources, will be unable to capitalize on the potential to utilize those resources. These differences, or cognitive variance, can lead to communication and coordination difficulties, which can offset the potential gains (Klimoski & Mohammed, 1994; Cannon-Bowers, Salas, & Converse, 1993; Mathieu et al., 2000, Mathieu et al., 2005; Rentsch and Klimoski, 2001). Cognitive variance may arise from representational gaps, i.e. inconsistencies between individuals' definitions of the team's problem (Cronin & Weingart, 2007), or between individuals' approach to solving a unanimously understood problem. Hence, by adding members with specific cognitive resources, cognitive variance is also introduced in the team.

Hence, adding different team members with different cognitive resources contributes to: (i) increased resources, and (ii) increased variance. Depending on the type of task confronting the group (McGrath, 1984), and whether the task will benefit from divergent thinking or convergent thinking, cognitive resources and cognitive variance will differentially affect performance. For example, having both cognitive resources and cognitive variance may benefit creative tasks (van Knippenberg & Schippers, 2007) such as product development or advertising, since a wide variety of different ideas coming from different individuals might be helpful. In contrast, execution tasks, or tasks that require a high level of coordination and efficiency, such as manufacturing objects or flying an airplane, typically benefit from cognitive resources, but not cognitive variance (Aggarwal & Woolley, in press).

Since adding members with different cognitive resources leads to an increase in both the cognitive resources of the team and its cognitive variance, a high resource and high variance combination is easy to achieve in teams. This raises an important question: is it possible to maximize cognitive resources, without increasing the cognitive variance, which would be ideal for execution tasks that benefit from convergent thinking? We propose that it is possible. And, in the following sections we generate a team compositional solution to this optimization puzzle, joining scholars (Dierickx & Cool., 1989; Kogut & Zander, 1992; Teece et al., 1997; Bunderson & Sutcliffe, 2002; Gardner et al., 2012) in arguing that both the amount and configuration of resources in the team is important.

Cognitive Resource Concentration

The concentration of different knowledge or perspectives within individual members of a group or community can be beneficial for the group as a whole. For example, scholars of racial diversity have appreciated the role of multi-racial individuals in integrating otherwise disparate communities of people for a number of decades (Bobo and Hutchings, 1996). However, research on other dimensions of diversity exploring the effects of individuals who encompass multiple attributes, which are generally assumed to reside in different people, is in its nascent stages.

In the teams' literature, Bunderson & Sutcliffe (2002) have demonstrated that intra-personal functional diversity affects team performance. Individuals with intrapersonal functional diversity are broad generalists whose work experiences span a range of functional domains, as opposed to narrow functional specialists with experience in a limited range of functions. Intra-personal functional diversity is important for organizational teams, making teams less susceptible to decision-making biases such as escalation of commitment and overconfidence (Burke and Steensma,1998), and enhancing information sharing and unit performance (Bunderson &

Sutcliffe, 2002). Furthermore, other work has shown that the distribution of relational resources, and concentration of experiential resources, is positively associated with a team's knowledge integration capability (Gardner et al., 2012).

However, most research on diversity overlooks depth in resources, and collapses resources and variance; it ignores that individuals may not only bring multiple resources (breadth), but also varying levels of each resource (depth). For example, the intra-personal functional diversity construct (Bunderson & Sutcliffe, 2002) takes into account how the proportion of functional experience is divided among different functional areas for each team member (i.e. it distinguishes between a person who has 2 years of experience in Area A and 4 years in Area B from a person who has 4 years of experience in Area A and 2 years in Area B), but does not capture the depth of the person's expertise in each area (e.g. it treats a person with 1 year of experience in Area A and 2 years of experience in Area B as similar to a person with 5 years of experience in Area A and 10 years of experience in Area B). While this missing account can be due to stronger interest in breadth of resources as a construct, we contend that the depth of cognitive resources encompassed by an individual, as well as the breadth of these resources, will affect team outcomes and processes.

Moreover, the call in the literature to understand deeper psychological mechanisms underlying diversity variables (Mannix & Neale, 2005) underscores the importance of understanding whether functional or educational diversity affects group performance, but also investigating the aspects of functional or educational diversity that matter. And, while proxies for expertise-relevant deep-level diversity, such as professional training and departmental affiliation, have been used in the organizational literature, we explore a set of constructs that drive differences underlying functional diversity, i.e., cognitive styles.

Cognitive Style Versatility

Cognitive styles are psychological dimensions that explain consistencies in how individuals acquire and process information (Ausburn & Ausburn, 1978; Messick, 1984). One framework of cognitive styles which is extremely relevant to organizational settings characterizes individuals along a continuum on Verbalization, Spatial Visualization and Object Visualization (Bartlett, 1932; Paivio, 1971; Richardson, 1977; Kozhevnikov, 2007; Woolley et al., 2007). While those strong in verbalization rely primarily on verbal analytical strategies, those strong in visualization rely primarily on visual imagery when attempting to perform cognitive tasks. Within visualization, those strong in object visualization use holistic processing and perform better on tasks that require identifying global properties of shapes, whereas those strong in spatial visualization use analytic processing, using spatial relations to arrange and analyze components (Kozhevnikov, Kosslyn, & Shephard, 2005).

These cognitive styles guide an individual's information processing, decision making, and problem solving (Chabris, et al., 2006; Kozhevnikov, Kosslyn, & Shephard, 2005; Woolley et al., 2007), and not only explain differences in individual performance on many important tasks (Kozhevnikov, Kosslyn, & Shephard, 2005), but also differences among individuals choosing to go into different professional and occupational areas (Blazenkova, Kozhevnikov, & Motes, 2006; Kozhevnikov, Kosslyn, & Shephard, 2005) and are apparent in children prior to their selection of an occupational field or discipline (Kozhevnikov, Blazhenkova, & Becker, 2010). Strong verbalizers are often found working in the humanities and writing intensive fields. Strong object visualizers are more commonly found in the visual arts and design, and strong spatial visualizers are dominant in engineering and science.

Consequently, cross-functional teams in organizational settings are typically composed of individuals who vary in these cognitive styles, and thus the strength and differences in these cognitive styles among team members captures the cognitive resources and variance that exist in such teams. Understanding these differences further suggests that the communication and coordination issues experienced by cross-functional teams are not easily remedied by simple rotational or cross-training programs, as individuals on these teams are hard-wired to literally "see" the world differently (Aggarwal & Woolley, in press).

The object and spatial visualization and verbalization cognitive styles are orthogonal and slightly negatively correlated with one another in most samples (Chabris et al., 2006; Kozhevnikov, 2007), leaving open the possibility that some individuals can express strength in more than one cognitive style. We term individuals who are strong in multiple cognitive styles as cognitively versatile. At a team level, a team can have any number of cognitively versatile members. We expect that cognitively versatile team members will influence team inputs by increasing cognitive resources, while at the same time not increasing cognitive variance. The increased pool of cognitive resources they bring will be beneficial to the team in solving multi-faceted problems. In addition, since cognitively versatile team members add resources without adding to the variance that exists in a team when different members bring different resources, we contend that their presence will benefit integration and reduce coordination difficulties in the team, which should positively influence group performance on execution tasks. There may be several ways in which versatile team members bolster integration.

First, as members dominant in multiple styles of processing information, versatile team members can facilitate translation in the group, which is extremely important in diverse teams since diversity in problem-solving styles of individual team members can lead to considerable difficulty in the absence of effective "translators" in the group (Kirton, 1976, 1989; Kurtzberg & Amabile, 2001). This translation is extremely important for coordination, and overlapping cognition makes coordination in the group easier and more efficient (Levesque, Wilson, & Wholey, 2001).

Second, cognitively versatile team members may facilitate creation of a common understanding in the team. Common understanding helps in coordination by providing a shared perspective on the whole task and how individuals' work fits within the whole. Common understanding of the task can be looked at in terms of the specific actions and strategies necessary to perform a task (Cannon-Bowers & Salas, 2001). It is important as an integrating condition because it enables team members to apply their effort towards a jointly held conception of the work or of the process to complete the work. Ongoing accomplishment of coordination in organizations relies on creating the integrating conditions to bring collective and interdependent work together (Okhuysen and Bechky, 2009).

Coordination remains a major source of process loss that teams incur, and is one of the main functions an organization must attend to in order to be effective (March and Simon, 1958; Georgopoulos, 1972). It involves fitting together the activities of organization members, and the need for it arises from the interdependent nature of the activities that organization members perform (Argote, 1982). More specifically in teams, coordination refers to the process of synchronizing or aligning the activities of the team members with respect to their sequence and timing (Marks, Mathieu, & Zaccaro, 2001; Wittenbaum, Vaughan, & Stasser, 1998; Malone & Crowston, 1994; for review see Okhuyen & Bechky, 2009), and is essential for task execution. Coordination is a process that largely benefits from convergent thinking, and differences in members' perspectives can limit the team's coordination.

Given the reasons stated above, we contend that versatile individuals will play a large coordinating role in teams. Furthermore, we believe that capturing the number of cognitively versatile members in the team will explain group performance above and beyond other existing metrics for capturing team diversity, well documented in Harrison & Klein's (2007) diversity taxonomy, of which separation—differences in position or opinion among unit members—is the most pertinent in the context of cognitive styles.

Hypothesis 1: The number of cognitively versatile members in the team will be positively associated with performance on an execution task, controlling for standard ways of capturing diversity.

Team Size

Generally as team size increases, coordination becomes more and more difficult. Process losses and coordination problems increase exponentially with the number of team members (Levesque, Wilson, & Wholey, 2001; Thompson, 2008). Even in tasks where adding members could have a positive effect on performance, there can be a curvilinear relationship between team size and performance (McGrath, 1984; Shaw, 1981). This is because up to a point, group performance tends to increase with size, owing to the added resources in the team, but past an optimal size, performance often decreases because of coordination costs (Keller, 1986). We contend that as team size increases, the presence of versatile individuals will become even more important in facilitating performance. In other words, in teams with versatile members, there will be a linear and positive relationship between team size and performance, because these members will help mitigate the coordination problems that would otherwise occur. This stands in contrast to the curvilinear relationship we would otherwise expect to see between team size and performance. Furthermore, we examine whether the benefits associated with cognitively versatile individuals come from their role in facilitating team performance, rather than due to a superior level of individual performance which contributes to the team overall.

Hypothesis 2: The presence of a cognitively versatile member will moderate the relationship between size and performance on an execution task, such that in teams without versatile members, there will be a curvilinear (inverted U-shaped) relationship between size and performance, whereas in teams even one versatile member, this relationship will be positive and linear.

Team Learning

There is mounting evidence that teams not only need to coordinate effectively to perform well, but that they need to learn and adapt to shifting performance contingencies over time (McGrath, Arrow, & Berdahl, 2000). One of the key contributors to sustained and increased performance over time is the team's ability to integrate knowledge, and adapt its strategy to changing conditions. While some groups are able to break routines and generate new solutions that enhance their effectiveness, other teams get stuck in previously adopted behaviors, unable to develop and change their conduct in fundamentally different ways (Argyris and Schon, 1978; Hedberg, 1981; Argote, 1999; Edmondson, 1999, 2002).

Team learning is defined in terms of both the process and the outcomes of group interaction, and is seen as the change in the team—which can manifest itself in changes in cognitions, routines, or performance—that occurs as a function of experience (Argote, Gruenfeld & Naquin, 2001; Argote & Miron-Spektor, 2011; Fiol & Lyles, 1985). We expect that versatile team members will play an important role in facilitating team learning, specifically updating the team's strategy over time. Cognitively versatile individuals should be able to understand the performance of the task from multiple perspectives because of their ability to understand and process information in multiple ways. This attribute should make them extremely valuable contributors when the team revises or updates its strategy about how to carry out a subsequent task. Research on functional generalists has found that teams composed of individuals who have worked in a number of different areas may be better prepared both to make sense of information and to integrate information related to different functional domains (Bunderson & Sutcliffe, 2002), and are more capable of recombining existing knowledge, skills, and abilities into novel combinations (Burke & Steensma, 1998; Weick, Sutcliffe, & Obstfeld, 1999).We focus on the revision of the strategy used to approach a task over time as the process indicator of adaptation and team learning, and contend that teams with cognitively versatile members should exhibit an ability to adapt their strategy as they work, which is a form of team learning.

Hypothesis 3: The number of cognitively versatile members in the team will be positively associated with team learning.

When a team is reflective about its strategy, it will witness improvement in performance over time (Hackman & Wageman, 2005; Okhuysen & Eisenhardt, 2002; Schippers et al. 2003). Groups that make use of opportunities to reflect on their work at the temporal midpoint or at other critical transition points generally outperform teams that do not (Gersick, 1988; Woolley, 1998). Building on prior experience to improve during subsequent performance periods is a hallmark of process learning (Pisano et al., 2001), and is a key means of reaching the highest levels of performance. We argue that this learning will provide one of the main mechanisms through which the presence of cognitively versatile members affects team performance. Groups containing versatile members will be better able to integrate the inputs of different members and translate them into an action plan that all can understand and follow (Okhuysen & Bechky, 2009).

Hypothesis 4: Process learning will mediate the relationship between the number of cognitively versatile members and subsequent team performance.

Study 1

In Study 1, we focus on primarily testing Hypothesis 1 regarding the effects of the number of cognitively versatile members on group performance.

Method

Participants

The sample consisted of 49 groups of four to five participants (N= 200). Participants were all students in a full-time MBA program in the Midwestern United States; 68% of the participants in the study were male. Participants received course credit for their participation.

Task

In this execution task, teams members were seated in front of a computer and shown a complicated text on one part of the screen, and they worked for five minutes to simultaneously type as much of the text as possible into a shared online document. Participants could see each other’s work in the online document with a slight delay. Teams were instructed to carefully coordinate their work to avoid typing over the work of other members or skipping whole sections. While the task drew on verbalization abilities (as it involved working with text), it involved a significant visualization component as well, as teams needed to orient around the arrangement of the paragraphs and set up the document in such a way that different sections could be adjoined appropriately.

Procedure

Participants were part of semester-long teams. In the beginning of the semester, they completed measures of cognitive style. In the middle of the semester, they worked on this task as a class exercise. Teams were shown an instructional video to explain the task. After the video, teams began their 5-minute typing period. A timer was displayed on a computer screen throughout the task to indicate the amount of time remaining. The team document was saved, and evaluated after the session.

Measures

Cognitive Style: The Object-Spatial Imagery and Verbal Questionnaire (OSIVQ) (Blazenkova & Kozhevnikov, 2008) was used to measure the level of object and spatial visualization, and verbalization of participants. For each participant, the 15 item ratings from each factor were summed to create object, spatial and verbal scores (M=49.68, SD= 8.11, Max=74, Min=29 for the object scale, M=49.22, SD=7.82, Max=69, Min=30 for the spatial scale, and M=46.60, SD= 7.64, Max= 71, Min= 23 for the verbal scale). The Internal reliability (Cronbach's α) for the object scale was 0.83, the spatial scale 0.76, and the verbal scale 0.79.

Cognitive Versatility was measured at the individual level as a categorical variable capturing dominance (or a score at or above 75th percentile of the entire sample for each cognitive style) in two or more cognitive styles. At the team level, cognitive versatility was calculated as the number of cognitively versatile people.

Separation was calculated as the within-team standard deviation on each cognitive style (Harrison & Klein, 2007).

Intra-personal diversity in terms of cognitive styles was calculated following Bunderson & Sutcliffe's (2002) formula at the individual level, $1 - \sum_{j=1}^{3} p_j^2$, where p_j denotes the individual's relative score on cognitive style j (e.g. p_1 is obtained by dividing the score in Object Visualization by the sum of the scores in Object Visualization, Spatial Visualization and

Verbalization). At the team level, the average member intra-personal diversity score was calculated (Bunderson & Sutcliffe, 2002).

Performance was captured as the number of words correctly typed by the team.

Results

Descriptive statistics and intercorrelations among the study measures are displayed in Table 1.

Hypothesis 1 predicted that the number of cognitively versatile members in the team will be positively associated with performance, controlling for standard ways of capturing diversity. As shown in Table 2 (Column 2), this prediction was supported, β= 0.41, t=2.06, p=.04, controlling for cognitive style means, separation and intra-personal diversity. And, adding the number of versatile team members to the model explained a significant amount of additional variance.

Conclusions

This study provided the first step in identifying the effects of cognitively versatile members in teams, and demonstrated that the number of cognitively versatile members was positively associated with performance in an execution task. These effects hailed above and beyond those explained by the most well-accepted way of capturing diversity for continuous variables, separation (Harrison & Klein, 2007) and even non-standard ways of capturing diversity such as intra-personal diversity (Bunderson & Sutcliffe, 2002), helping us establish the novelty and divergent validity for the construct of versatility.

This finding makes two important contributions. First, it illustrates that the presence of cognitively versatile members is important in teams, and hence, their role should be studied further. Second, it provides a new lens to look at team composition, one that is not captured in existing ways of looking at team composition and diversity, where the simultaneous existence of breadth and depth of cognitive resources in team members is considered. However, since this study only tested our first hypothesis, in the following study we address the remaining hypotheses.

Study 2

In this study, we build on the findings of Study 1 by investigating how groups perform over more than one trial of a task, allowing us to examine the mediating role of process learning. We also test how having versatile members in the team interacts with team size to influence performance.

Method

Participants

The sample consisted of 105 groups of two to five participants (N= 348) as well as 55 individuals working independently. Participants consisted of undergraduate and graduate students as well as individuals from the general population. The mean age of the participants was 23.6 years; 53% of the participants in the study were male. Participants were paid for their participation.

Tasks

A total of two execution tasks were given to the teams and individuals. They were structured identically to the task used in Study 1, except that the participants were allowed 10 minutes to type the text. This enabled teams a little more time to coordinate and enact their strategy for the task. In these tasks, it was not only important for team members to synchronize their activity in order to avoid overriding each other’s work, but also strategize effectively about what would be an achievable goal to target. Attempting to type too many sections could lead to large amounts of text left untyped and thus large penalties, while an under ambitious goal could lead to fewer sections typed and a lower score.

Procedure

When the participants arrived at the study, they were asked to read a consent form, and fill out survey measures individually, including measures of cognitive style. Later, each team worked in a private laboratory room on the task.

Teams were shown the instructional video to explain the task. After the video, teams were instructed to use the following 2 minutes to plan their work. After this planning period, teams began their 10-minute typing period. A timer was displayed on a computer screen in the room throughout the task to indicate the amount of time remaining. At the completion of the first typing task, they were given instructions for the second typing task (which was an identical task with a different text to type), followed by a two-minute planning period, and a ten-minute work period. The team documents were saved, and evaluated after the session. All participants were debriefed in writing and verbally queried about their observations regarding the experiment at the conclusion of each session. The exact same protocol was followed for the individuals doing the task independently as well.

Measures

Cognitive Style: Similar to Study 1, OSIVQ was used to measure the level of object and spatial visualization, and verbalization of participants (M=51.8, SD= 7.52, Max=71, Min=21 for the object scale, M=46.2, SD=8.77, Max=69, Min=22 for the spatial scale, and M=47.34, SD= 7.08 Max= 68, Min= 26 for the verbal scale). The Internal reliability (Cronbach's α) for the object scale was 0.81, the spatial scale 0.85, and the verbal scale 0.76.

Cognitive Versatility was measured as described in Study 1.

Separation was measured as described in Study 1.

Performance was measured by calculating the total score for the number of words typed, and subtracting typing errors and missing words for each task.

Process learning was measured as a change in the group's strategy, as reflected by a change in their goal in how much they aimed at typing in each task. This was captured by the farthest point in the document the group attempted to type between Task 1 and Task 2.

Results

Descriptive statistics and intercorrelations among the study measures are displayed in Table 3. At an individual level, versatility was not significantly correlated with intelligence r=-.005, p=0.91.

Hypothesis 1 predicted that the number of cognitively versatile members in the team will be positively associated with performance, controlling for standard ways of capturing diversity. As shown in Table 4, this prediction was supported for both tasks; Task 1, β= 0.22, t=1.90, p=.06 (Column 1), and Task 2: β= 0.39, t=3.09, p=.003 (Column 3). Adding the number of versatile team members to the model explained significant amount of additional variance.

Hypothesis 2, predicting that the presence of a versatile member will moderate the relationship between size and performance, was also supported. An ANCOVA analysis including the dichotomous categorical variable indicating whether or not a cognitively versatile member was present in the group, and size, which was a continuous variable, yielded a significant interaction in predicting performance on Task 1, $F_{(4,150)}$ =4.74, p=.001. This indicates that the slope of the equation relating size to performance differs depending on whether or not there is presence of a versatile member. Further analysis showed that in teams where there was at least one versatile member, increasing size was positively associated with performance β= 0.72,

t=7.88, p<.001. However, in teams where there was no versatile member, there was a negative quadratic relationship between size and performance β= -.82, t=-1.97, p=.05. Also, performance was not significantly different between versatile and non-versatile individuals who worked independently (i.e. size=1), $F_{(1,53)}$ =.691, p=.41 on the task (Figure 1), discounting the potential alternative explanation that versatile individuals contributed a higher level of task-specific ability to the team overall.

Hypothesis 3 predicted that the number of cognitively versatile members in the team will be positively associated with learning; this hypothesis was supported, $F_{(10,93)}$ =1.63, p=.10, R^2 =.15) (Table 4, Column 2). Hypothesis 4 predicted that team learning will mediate the relationship between the number of cognitively versatile members and team performance on subsequent trials, controlling for initial performance. This hypothesis was supported; Sobel test for mediation t=2.44, p=.01 (Figure 2). Learning partially mediated the relationship between number of cognitively versatile members and task performance (Table 4, Column 4).

Conclusions

The findings of Study 2 replicated those of Study 1 and allowed us to test additional hypotheses. First, we were able to establish that the number of cognitively versatile members was positively associated with performance in an execution task, controlling for standard ways of capturing diversity.

We also found that the presence of a versatile member moderated the relationship between size and performance. The curvilinear relationship between group size and performance is not surprising, and a pattern that has been established in the literature for many years. We had predicted, and found, that versatile team members will help break this pattern. We saw that in teams where even one versatile member was present, there was a positive and linear relationship between team size and performance. This suggests that versatile individuals play a major integration function in the team, which prevents process loss, and benefits performance in execution tasks. In addition, we were able to demonstrate that versatile individuals did not have any advantage in this task when working independently compared to non-versatile individuals. This helps discount the alternative explanation that versatile individuals are simply more skilled overall in performing this specific task.

We were interested in exploring the effect of versatile members in teams over time. We focused on the role they played in enhancing team learning, since learning is a main process that facilitates sustained team performance over time. We investigated process learning as manifest in a change or re-adjustment of strategy that occurs after acquiring experience with a task. A revision aimed at improving performance in the second task would suggest that the team was carrying knowledge, including information about factors leading to gains and losses, acquired from the first task, and applying it to the subsequent task. It reflects the team's adaptability, and is apparent in team process learning. We found that the number of versatile members in the team was associated with process learning, which further drove increased subsequent performance. We only found partial mediation, which indicated that there were other processes that versatile members affect, which should be studied in future research.

Discussion

In this paper, we proposed versatility as a solution to maximize the benefits of diversity, and minimize the associated costs. Versatility is a particularly important construct in situations involving diversity dimensions that are not easily acquired through experience or assignment. Notions of intra-personal diversity, and boundary spanning, also point to the role that individuals with a breadth of knowledge or experience can play in facilitating the processes and performance of a team. However, in addition to pointing at depth, we also point out that differences in cognitive style are even more difficult to bridge than differences stemming from organizational function or expertise, as they are hard-wired, and affect the very manner in which individuals acquire and process information. Cognitive versatility involves facility with multiple abilities (in our case, cognitive styles) that are not readily transmissible through learning or experience, and becomes a characteristic of an individual that is not situation-dependent. Thus, the concept of versatility adds to a growing body of literature that studies the nature of the differences that characterize a diverse team, and the skills and characteristics needed to bridge those differences.

We had theorized that versatile members may play a translational role that would help create common understanding in diverse teams. We found qualitative evidence for this in some interviews we conducted in conjunction with Study 1. For example, a versatile professional who was strong in all three cognitive styles mentioned that in the organizational teams that he was a part of, he was always the “writer” in the technical team, and the “technical guy” in the writing team, and often played the role of a translator in both teams. He mentioned that unless he helped them arrive at a common understanding, the team members could not or did not talk to each other in spite of the pressing deadlines and clear common goal. As posited in the literature, such translation is extremely important for coordination and execution, and overlapping cognition makes coordination in the group easier and more efficient (Levesque, Wilson, & Wholey, 2001).

An important boundary condition for the findings of this study relates to task characteristics. Our findings pertain specifically to performance on execution tasks, and we believe that our results will generalize broadly across tasks with similar characteristics. However, it remains to be explored whether these effects will generalize to tasks where creativity is important. It could be that the presence of versatile individuals is not as beneficial to performance in those tasks, and increased resources and increased variance –where different resources reside in different people--facilitates more varied perspectives, which may be beneficial to creativity. However, for innovation, which entails both idea generation and execution, versatile members could play an important role in facilitating the convergent processes that idea execution requires. This is a fruitful avenue for future research.

Our current research has important implications for the study of team diversity, and also managerial implications for group composition. We encourage researchers to look at the distribution of cognitive resources within a team to fully understand the impact of diversity on team processes and performance, and focus on both depth and breadth of resources. For practitioners, we encourage the inclusion of cognitively versatile members when composing teams as a way to bolster the positive aspects of diversity and minimize the negative effects. Including versatile members in teams may be a way of achieving the best of the two worlds-different perspectives without the communication and coordination costs.

CHAPTER 5

General discussion

In each of the three papers in this dissertation, I address a different research question and develop and test a set of relevant hypotheses. However, the papers combined together form a package that contributes to research on groups and teams in the following ways: (i) understanding whether, and how, the cognitive style composition of the team affects its performance (ii) forwarding the debate on the positive and negative effects of deep-level diversity further by studying cognitive style composition of the team under different task contexts with opposing demands and (iii) proposing one solution to maximize the positive aspects of deep-level diversity and minimize its negative effects. Below is a discussion of how each question is addressed by the dissertation.

Cognitive Styles: Do they matter in teams?

The first goal of my dissertation was to understand if the team's composition based on members' cognitive styles affected team performance, and simultaneously study the processes through which it affected team performance. In all three papers, I found that the team composition based on members' cognitive styles explained differences in performance between teams. This was true for lab-based tasks that were specifically designed to tap into the skills associated with the different cognitive styles, as well as managerial tasks that were not directly designed to test the effects of cognitive styles.

The papers also illustrated how cognitive style diversity affected team performance by laying out the processes that guided this relationship. In the first two papers, I found evidence that cognitive style variance influenced the team's strategic consensus, which was a powerful predictor of team performance on both creativity and execution tasks. I also observed effects of cognitive style diversity on team process focus, transactive memory, and learning. These processes were important in determining performance in different task contexts.

An understanding of whether and how cognitive styles affect team performance, and the associated gains and deficits, sheds light on the benefits and difficulties associated with functionally diverse teams in organizations, which constitute the fundamental way in which teams are composed in organizations.

Forwarding the debate

The dissertation was structured such that it explored the effect of cognitive style diversity in different task contexts to forward the debate about the opposing effects of diversity on team performance. Asking the question of whether diversity matters in team performance is important, but incomplete without addressing the boundary conditions under which it matters. To understand the effect of cognitive style diversity on team processes and performance, I studied teams under the task contexts of execution and creativity, which are characteristic of two broad categories in which tasks can be divided, i.e. those that benefit from convergent thinking and those that benefit from divergent thinking. The former requires teams to narrow options down to a set of solutions and execute those solutions, while the latter requires teams to generate many ideas that may then be implemented.

In understanding how cognitive style diversity affects performance under different task demands, I looked at two aspects of diversity: cognitive style resources and variance, and studied the processes that should affect execution and creativity. I found that strategic consensus was important, and beneficial, for both types of tasks. In addition, the second paper revealed that not only strategic consensus, but also the content of the consensus, is important in determining performance. Interestingly, process focus, which entails attention to the details of conducting the task, was beneficial for execution tasks while detrimental for creative tasks. The first paper demonstrated that in tasks where errors were costly, having a high degree of process focus facilitated performance by reducing the number of errors made. However, process focus was not beneficial for creativity, as evident in the second paper. This is because attention to low-level detail is associated with less flexibility in thinking about alternative methods for carrying out work (Vallacher & Wegner, 1989) which leaves process-focused teams at a disadvantage in complex, changing environments where they might need to devise better ways to approach their task (Woolley, 2009b; 2011). This finding highlighted how cognitive style diversity, through its effects on associated team processes, can differentially affect task performance in different contexts. I also found that TMS was a strong predictor of certain aspects of team creativity, i.e. flexibility and fluency, while strategic consensus and process focus predicted the originality aspect of creativity. This finding demonstrated that even within the same task context, different processes guide different aspects of performance.

There has been criticism in our field about the overabundance of variables under study (Pfeffer, 1993), and not enough detailed examination of a chosen set of variables. In this dissertation, I tried to forward the debate using a novel set of constructs, while at the same time trying to avoid this overabundance. I generated a general framework of cognitive style diversity in terms of resources and variance throughout the papers. The first two papers complemented each other in that both the studies explored similar inputs, and also similar processes under different task contexts. In addition, all of the process variables that I studied were borrowed from existing literature in order to further our understanding of those variables, and also provide a platform for consolidation and comparison of the findings of this research with existing research in the area of groups and teams.

Moving toward a resolution

In the dissertation, I adopted a nuanced view of cognitive style diversity and differentiated its two aspects-cognitive style variance and resources. This differentiation helps us understand which aspects of diversity are detrimental for some kinds of task performance and which aspects are beneficial. In the third paper of my dissertation, I attempted to move the diversity debate toward a resolution by proposing a way to maximize the universally beneficial aspects of diversity, while minimizing aspects that are detrimental in some situations. In order to reach such a solution, an understanding of what is a beneficial composition for different types of tasks is essential. Depending on the type of task confronting the group (McGrath, 1984), and whether the task will benefit from divergent thinking or convergent thinking, cognitive resources and cognitive variance will differentially affect performance.

From the first two papers, I was able to deduce that having both cognitive style resources, and variance was beneficial for creativity tasks. However, for execution tasks, cognitive style variance was detrimental as it was associated with an increase in execution errors. Increasing resources in the team by adding members with different strengths (and hence increasing variance), a compositional combination where both cognitive resources and variance are desired, is easy to achieve. But, the question that I undertook in the third paper pertained to increasing the cognitive style resources of the team without increasing its cognitive variance which is associated with process loss in execution tasks. I proposed that this can be achieved by adding team members who express strength in multiple domains, and the two associated studies demonstrated that such members played an essential coordination role that benefited team performance in execution tasks. In fact, adding such members to the team enabled a linear relationship between team size and performance, one that is non-monotonic otherwise.

Taken together, my dissertation explores team composition using deep-level diversity variables that directly relate to functional areas of individuals in organizations. The three papers contribute to an underrepresented, yet extremely relevant, area of organizational research, and establish the importance of the team's cognitive style composition to team performance. Also, by addressing many calls in the groups and teams research literature, the dissertation aims at providing a nuanced understanding of composition, processes and performance in teams, revealing the complexity of teamwork.

Future Directions

The research presented in this dissertation has initiated many questions for future research. First, in the ongoing pursuit of moving the diversity debate toward a resolution, a fruitful next step will be to understand the role that cognitively versatile team members play in tasks that benefit from divergent thinking. I suspect the magnitude of the impact will be lesser than it is for tasks that benefit from convergent thinking, but positive nonetheless. Second, in order to understand the effects of cognitive style diversity more comprehensively, these research questions should be tested in a virtual environment, and the findings should be compared and contrasted with the patterns found in the face-to-face teams in this dissertation. Since cognitive style diversity taps into hard-wired ways of encoding and relaying information, I expect the findings will hold in a virtual environment as well. It will be additionally interesting to see if cognitively versatile team members to have a similar effect on team coordination in a virtual setting. Third, in order to understand the implications of cognitive style diversity in real-world teams, these questions should be tested in the field. Some organizations, especially ones that are vulnerable to the adverse effects of errors, i.e. high-reliability organizations such as hospitals and manufacturing units, will be well suited to test some of the questions addressed in this dissertation. Other organizations, especially ones where organizational tasks benefit from divergent thinking, such as R&D units, will be great avenues to test these questions as well. Fourth, the intersection between cognitive style diversity and other forms of diversity, both surface level and deep level, such as functional and education diversity, will be an interesting avenue to explore to understand the effect of diversity on teams even further. Also, during the course of my dissertation, I have found some gaps in the literature pertaining to the measurement of team diversity. While many existing measures are able to capture diversity in continuous single-attribute variables and categorical variables—including standard deviation, Euclidean distance, Blau's index, and entropy—the literature lacks a measure of diversity for continuous multi-attribute variables such as cognitive styles. Future research should also look at devising measures of resources and variance for cognitive styles, which will be beneficial to study a broad array of other constructs.

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TABLES

CHAPTER 2

Table 1

Mean (and Standard Deviations) for Process Focus and Errors (Study 1)

Condition	N	Process Focus	Maze 1 Errors	Maze 2 Errors
Spatial-Object	30	1.90	50.85	44.68
		(0.66)	*(34.51)*	*(37.44)*
Spatial-Spatial	20	2.25	51.48	35.98
		(0.85)	*(28.89)*	*(31.90)*
Object-Object	20	1.35	56.69	46.87
		(0.59)	*(28.17)*	*(30.28)*
Minimum		1	0	0
Maximum		3	100	100
Mean		1.84	52.70	42.82
SD		0.77	30.91	33.79

Note. Homogeneous teams predominant in object visualization (object-object) are significantly different from homogeneous teams predominant in spatial visualization (spatial-spatial) in process focus; homogeneous teams predominant in object visualization (object-object) are significantly different from diverse teams (spatial-object) in process focus.

Table 2

Results Testing Hypothesis 2 using OLS Regression (Study 1)

	Maze 2 Errors	
	1	2
Spatial-Spatial^^	-.12	.06
Spatial-Object^^	.01	.12
Maze 1 Errors	.40**	.38**
R^2	.18	.26
F	4.71	5.81
ΔR^2		.08**

Note. Standardized regression coefficients ^^Dummy coded with object–object teams as the reference group.

^*p<.10*   * *p* < .05   ** *p* < .01

Table 3

Team Means, Intercorrelations and Internal Reliabilities for Cognitive Styles, Process Measures, and Errors (Study 2)

		1.	2.	3.	4.	5.	6.	7.	8.	9.
1.	Team Size	--								
2.	Average Member Intelligence	.12	--							
3.	Object Visualizer Variance	.32**	.40**	--						
4.	Object Visualizer Mean	.17^	-.003	-.19^	(0.81)					
5.	Spatial Visualizer Variance	.01	-.34**	.14	.32**	--				
6.	Spatial Visualizer Mean	-.03	-.27*	-.12	-.12	.09	(0.85)			
7.	Strategic Consensus	-.10	-.09	-.37**	.01	-.07	.22*	--		
8.	Process Focus	-.13	-.01	-.10	-.26*	-.10	.22*	.14	(0.89)	
9.	Errors	-.09	-.25*	.36**	-.22*	-.05	-.03	-.55**	-.02	--
	Minimum	2	15.75	5.30	41.50	2.00	30.00	-3.26	1.00	.00
	Maximum	5	32.50	160.33	62.00	312.50	55.50	.00	6.41	47200
	Mean	3.60	24.15	52.19	52.16	79.60	45.56	-.72	4.60	6257.86
	SD	1.15	3.67	35.79	4.37	74.73	4.66	.72	1.08	8588.46

Note. Zero-order correlations are shown for team size and average member intelligence. All other correlations are controlled for team size and average member intelligence. The values on the diagonals are the reliability coefficients for the corresponding measures.

^$p<.10$ * $p < .05$ ** $p < .01$ (one-tailed)

Table 4

Results of Hypotheses 3-5 using OLS Regression (Study 2)

	Process Focus		Strategic Consensus		Errors			
	1	2	3	4	5	6	7	8
Team Size	-.15	-.15	-.10	-.09	-.11	-.12	-.12	-.16
Average intelligence	-.25*	-.29*	-.08	-.19	-.30*	-.20	-.21	-.30*
Spatial Visualization Level	.24*	.22	.25	.18	-.05	-.02	.03	.11
Spatial Visualization Heterogeneity	-.05	-.02	-.14	-.05	.04	-.04	-.04	-.06
Object Visualization Level	-.24*	-.28*	.07	-.05	-.25*	-.14	-.16	-.17
Object Visualization Heterogeneity		-.13		-.36**		.35**	.34**	.17
Process Focus							-.04	-.01
Strategic Consensus								-.49**
R^2	.13	.14	.06	.17	.12	.22	.22	. 43
F	1.73	1.59	.69	1.90*	1.60	2.67*	2.27*	5.02**
ΔR^2		.01		.11**		10**	.00	.20**

Note. Standardized regression coefficients.

* p < .05 (one-tailed) ** p < .01 (one-tailed)

Table 1

Team Descriptives and Intercorrelations for Team composition, process variables, and creativity

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.	Year												
2.	Team Size	.09											
3.	Gender Diversity	.01	.21*										
4.	Ethnic Diversity	-.05	.04	.19*									
5.	Cognitive Style Variance	.06	.07	-.03	.16^								
6.	Cognitive Style Resources	.03	.04	-.10	.12	.01							
7.	TMS	.03	-.04	-.03	-.02	.22**	.16^						
8.	Strategic Consensus	-.07	-.03	.03	-.13	-.27**	.02	.15					
9.	Process Focus	.03	-.05	-.17^	.01	-.08	.06	.47**	.13				
10.	Fluency	-.34**	-.09	-.17^	-.01	.18*	.02	.19*	.01	-.01			
11.	Flexibility	-.43**	-.11	-.17^	-.01	.18^	.08	.21*	.01	.03	.85**		
12.	Originality	-.40**	-.08	-.14	.06	.19*	.06	.05	-.05	-.11	.49**	.58**	
	Minimum	0	4	0	0	-1.60	-2.59	-3.16	-3.34	-2.68	1	1	1
	Maximum	1	5	.75	.75	2.80	2.51	3.26	1.63	2.10	16	9	5
	Mean	.42	4.1	.30	.47	.02	-.02	-.02	.02	-.03	3.27	2.87	3.55
	SD	.49	.34	.22	.19	.97	.98	.98	.98	1.00	1.87	1.18	1.06

** $p<.01$ * $p<.05$ ^ $p<.10$

CHAPTER 3

Table 2

Results of OLS Regression testing Hypotheses 1-5

	TMS		Strategic Consensus	Fluency				Flexibility				Originality			
Column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Year				-.33**	-.34**	-.34**	-.34**	-.43**	-.44**	-.43**	-.44**	-.39**	-.41**	-.40**	-.40**
Team Size	-.05	-.05	-.02	-.02	-.04	-.05	-.02	-.04	-.06	-.07	-.05	-.02	-.04	-.03	-.01
Gender Diversity	-.003	.005	.04	-.16^	-.14		-.17^	-.16^	-.14		-.15	-.15	-.13		-.16^
Ethnic Diversity	-.05	-.09	-.10	.01	-.03		-.01	.003	-.03		-.03	.07	.03		.03
Cognitive Style Variance	.23*	.24**	-.25**		.21*		.14		.21*		.15		.21*		.16^
Cognitive Style Resources		.15					-.02				.06				.06
Cognitive Style Variance X Resources		-.23*					.02				.02				.06
TMS						.26**	.22*			.26**	.21*			.13	.09
Strategic Consensus						-.05	-.002			-.06	-.07			-.12	-.07
Process Focus						-.12	-.12			-.08	-.02			-.14	-.14
Strategic Consensus X Process Focus						-.02	-.03			-.03	-.04			-.17^	-.17^
R^2	.05	.13	.08	.14	.18	.17	.22	.22	.26	.25	.30	.18	.23	.22	.28
F	1.50	2.68*	2.37*	4.31**	4.66**	3.56**	2.49	7.35**	7.32**	5.79**	3.82**	5.98**	6.17**	4.95**	3.49**
ΔR^2		.08*			.04*				.04*				.05*		

**p<.01 *p<.05 ^p<.10

CHAPTER 4

Table 1

Team Descriptives and Intercorrelations in Study 1

	1	2	3	4	5	6	7	8	9	10
1.Team Size	--									
2.Object Visualization Mean	-.13	--								
3.Spatial Visualization Mean	.15	.01	--							
4.Verbalization Mean	.00	.24	-.02	--						
5.Object Visualization SD	-.05	-.11	-.05	-.09	--					
6.Spatial Visualization SD	.09	.23	-.16	.06	.20	--				
7.Verbalization SD	-.05	.03	-.12	-.09	.30*	.30*	--			
8.Intrapersonal Diversity	.07	.06	-.004	.28*	-.60**	-.38**	-.67**	--		
9.No. of cognitively versatile members	.02	.47**	.28*	.43**	.11	.35*	.07	-.02	--	
10 Performance	-.12	.20	-.09	.21	-.09	.01	-.28*	.12	.27^	--
Mean	4.08	49.65	49.23	46.6	7.18	7.41	6.93	.66	.69	830
SD	.28	3.96	3.23	3.84	3.89	3.51	3.22	.004	.84	241.78
Minimum	4	41.5	42.4	37.5	1.71	1.71	1.5	.65	0	300
Maximum	5	56.75	56.75	58.5	19.92	16.86	15.13	.67	3	1503

^ $p<.10$, * $p < .05$, ** $p < .01$

Table 2

Results of Study 1 Hypothesis Testing using OLS Regression (n=49)

Dependent Variable	Performance	
	1	2
Team Size	-.08	-.06
Object Visualization Mean	.16	.03
Spatial Visualization Mean	-.15	-.30^
Verbalization Mean	.22	.09
Object Visualization SD	-.13	-.21
Spatial Visualization SD	-.03	-.16
Verbalization SD	-.48*	-.53*
Intra-personal diversity	-.36	-.44^
Number of Versatile Members		.41*
R^2	.20	.28
F	1.28	1.70
ΔR^2		.08*

^ p<.10, * p < .05, ** p < .01

Table 3

Team Descriptives and Intercorrelations in Study 2

	1	2	3	4	5	6	7	8	9	10	11
1.Team Size	--										
2.Object Visualization Mean	-.05	--									
3.Spatial Visualization Mean	.18^	-.28**	--								
4.Verbalization Mean	-.15	.08	-.37**	--							
5.Object Visualization SD	.27**	-.27**	.08	.01	--						
6.Spatial Visualization SD	.26**	.23*	.15	-.19^	.13	--					
7.Verbalization SD	.26**	.03	-.03	-.12	.12	.13	--				
8.No. of cognitively versatile members	.27**	.48**	.13	.11	.07	.26**	.12	--			
9.Task 1 Performance	.43**	-.13	.16	-.24*	.11	.08	.06	.16^	--		
10.Process Learning	-.008	-.12	.03	-.10	.04	-.04	-.09	.09	.11	--	
11.Task 2 Performance	.24**	-.09	.22*	-.13	.07	.07	.02	.28**	.20*	.45**	--
Mean	3.41	51.92	45.95	47.54	6.38	7.65	6.29	.58	405.67	37.81	611.19
SD	1.14	4.20	4.96	3.63	3.24	4.09	3.23	.73	269.57	1404.5	1094.93
Minimum	2	41.5	30	36.5	0	.71	.71	0	33	-2348	29
Maximum	5	62	57	58.5	15.81	17.68	18.25	4	1993	4456	7404

^ $p<.10$, * $p < .05$, ** $p < .01$

Table 4

Results of Study 2 Hypothesis Testing using OLS Regression (n=105)

	Task 1	Learning	Task 2	
	1	2	3	4
Team Size	.38**	.09	.12	.07
Object Visualization Mean	-.21^	-.30*	-.26*	-.15
Spatial Visualization Mean	-.08	-.11	.03	.07
Verbalization Mean	-.23*	-.20^	-.12	-.05
Object Visualization SD	-.04	-.01	-.05	-.05
Spatial Visualization SD	-.05	-.04	-.02	-.001
Verbalization SD	-.08	-.15	-.06	.01
Number of cognitively versatile members	.22^	.35**	.39**	.24*
Initial Goal		-.30*		.23*
Process Learning				.45**
Initial Performance			.03	-.06
R^2	.26	.15	.19	.36
F	4.12**	1.83^	2.38*	4.64**
ΔR^2				.17**

^ $p<.10$, * $p < .05$, ** $p < .01$

FIGURES

CHAPTER 2

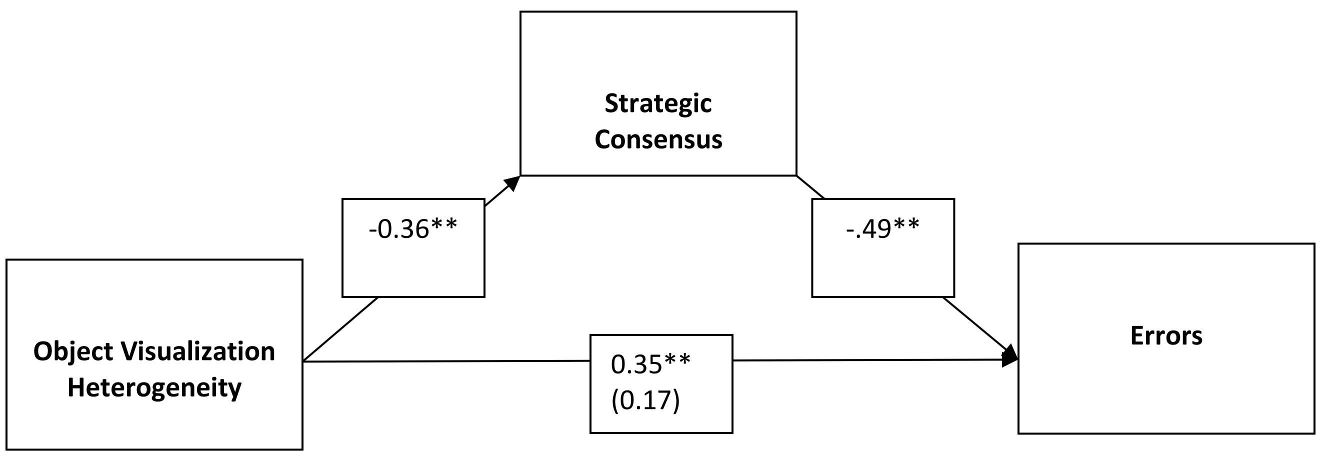

Figure 1. Mediation Model of Effects of Cognitive Style Heterogeneity on Errors through Strategic Consensus

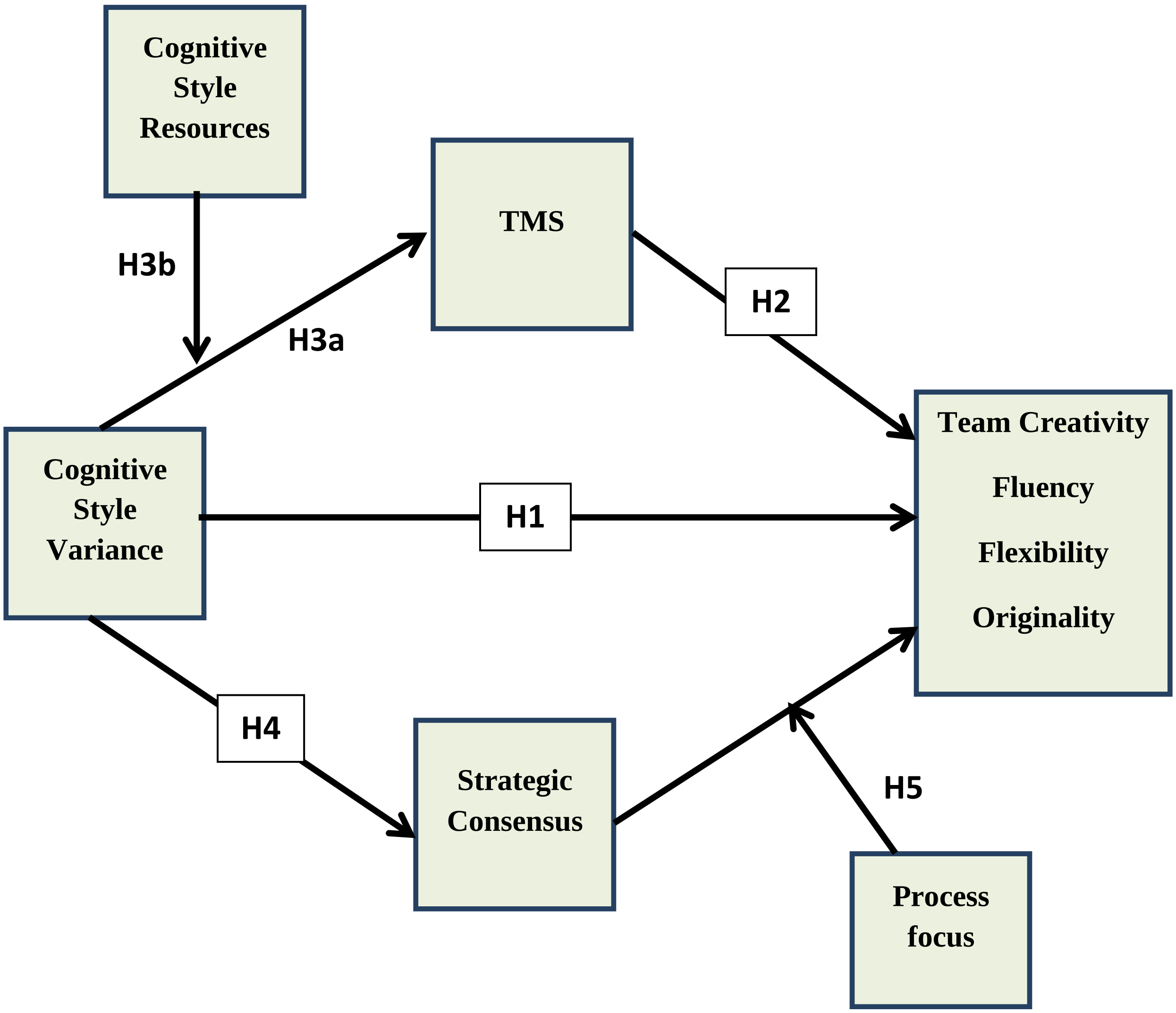

Figure 1. The Hypothesized Effects of Cognitive Style Diversity on Team Processes and Performance

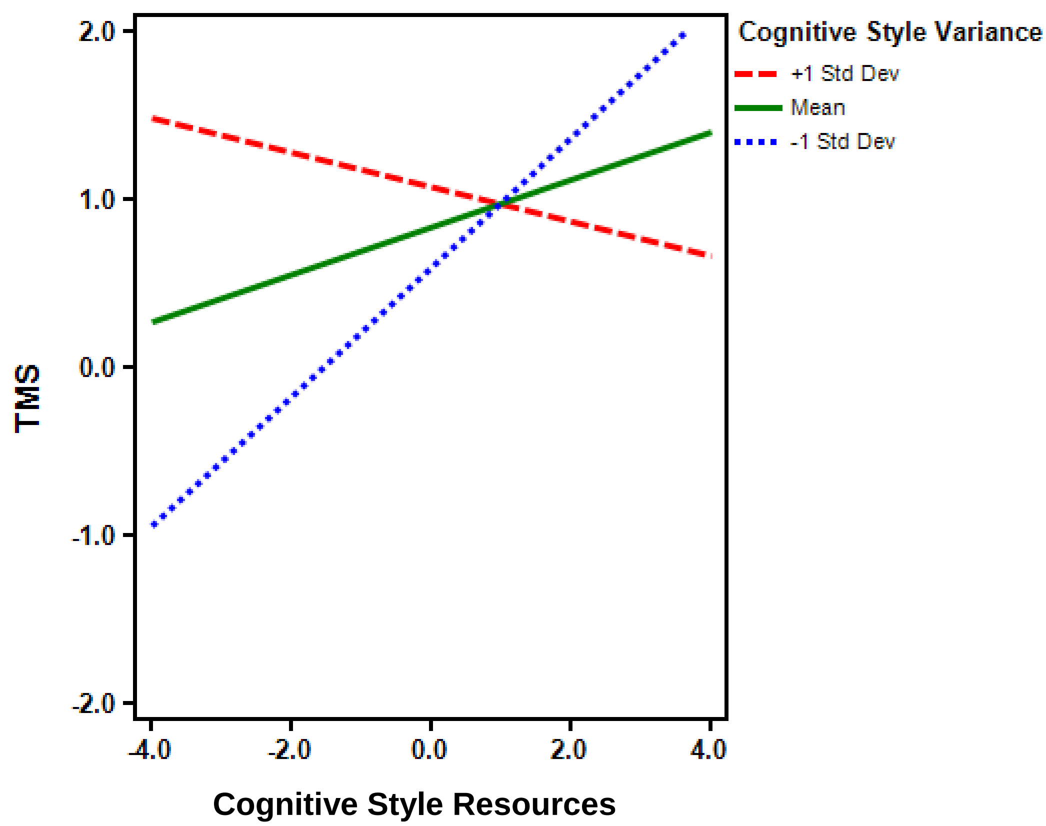

Figure 2. The Relationship between Cognitive Style Resources, Variance, and TMS

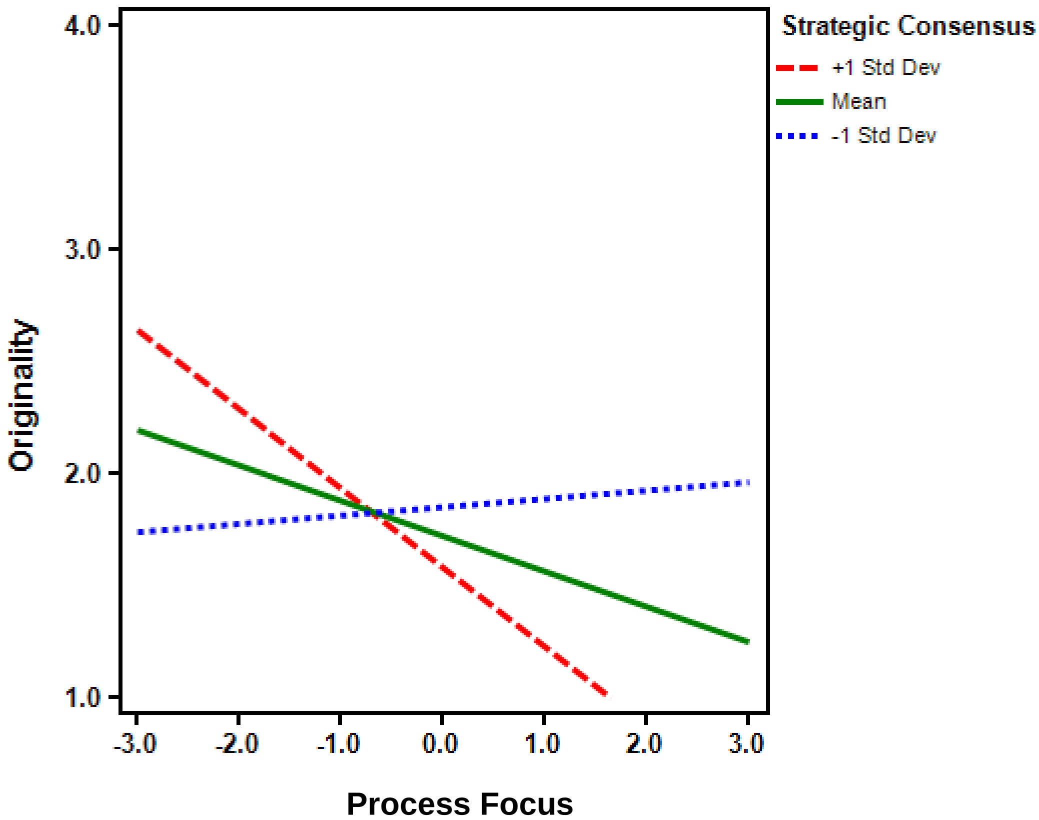

Figure 3. The Relationship between Strategic Consensus, Process Focus and Originality

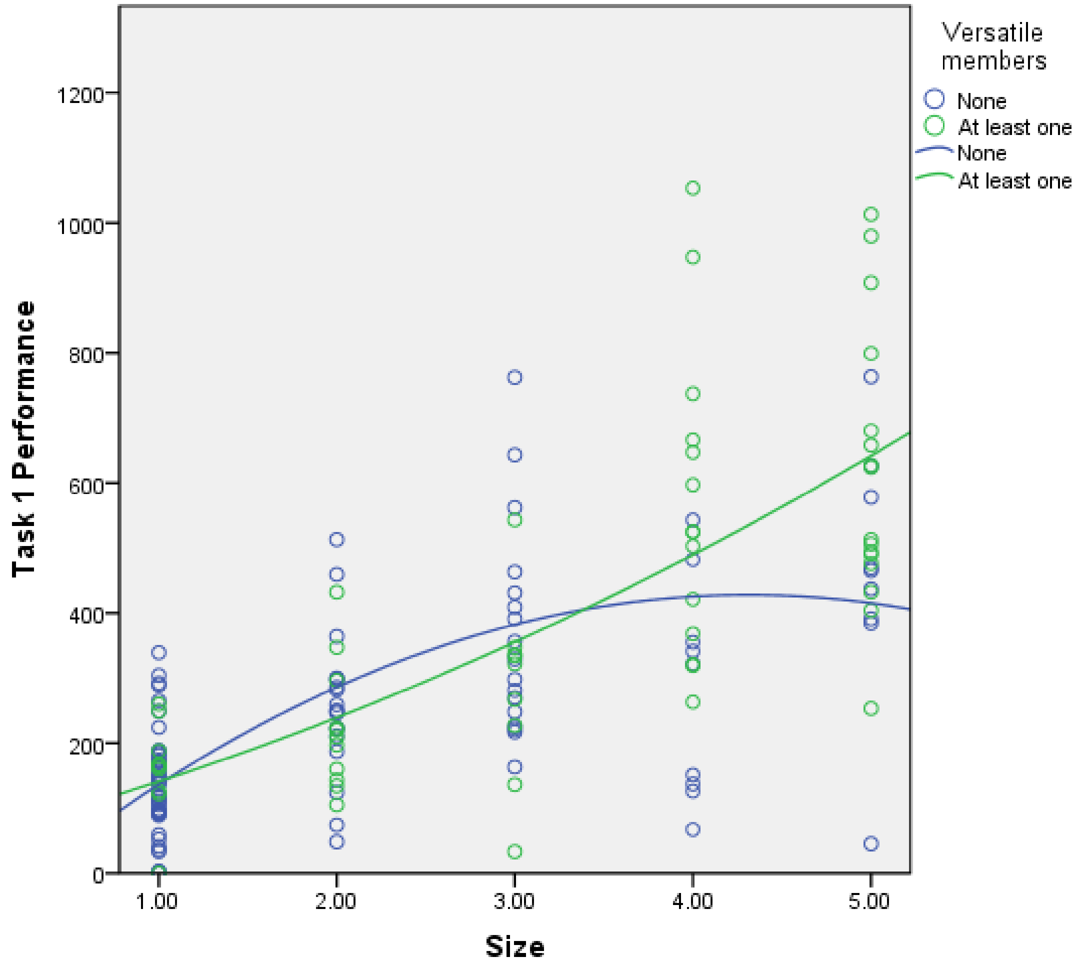

Figure 1. The Interactive Effect of Size of the Performing Unit and Versatility on Performance.

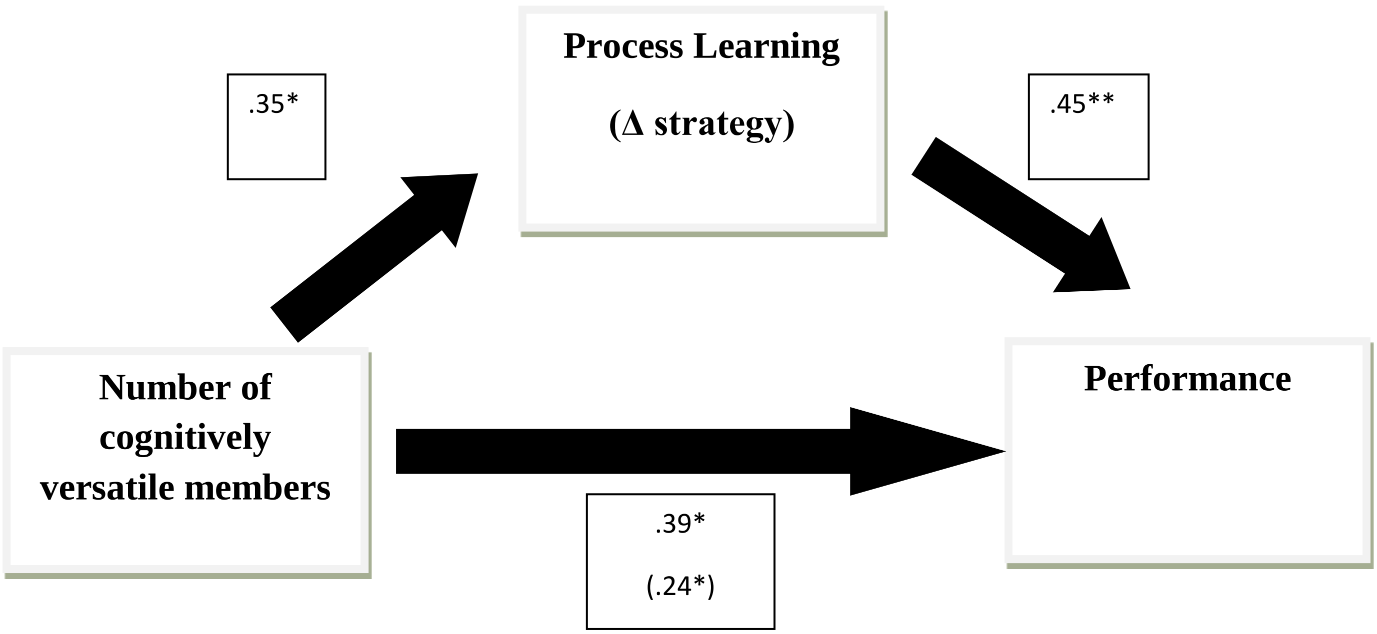

Figure 2. Mediation Model of the Effects of Versatility on Process Learning and Performance in Teams.

APPENDIX

CHAPTER 3

Appendix A

Originality Scale (Adapted from Gino, Argote, Miron-Spektor, & Todorova, 2010)

Rate each statement on a scale of 1-5 (5=definitely yes, 4= probably yes, 3= maybe, 2=probably not, 1=definitely not)

1. Is this a novel figure/diagram?
2. Does this diagram present the content in novel way?
3. Does this diagram make novel associations?
4. Is this an appropriate way of presenting the content?
5. Is the diagram explored in a detailed way?
6. Is the display complex (how good it would look in a power-point presentation)?