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Bradley R. Staats
Francesca Gino
Gary P. Pisano

Working Paper

10-016

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Bradley R. Staats[1]

Francesca Gino[1]

Gary P. Pisano[2]

[1]*Kenan-Flagler Business School, University of North Carolina at Chapel Hill*

[2]*Harvard Business School*

Acknowledgments

Our analyses and insights in this paper have been shaped by many conversations with Rob Huckman. We thank Melissa Schilling for sharing research materials, James Paci for research assistance, and Amy Edmondson, Dave Hofmann, Lamar Pierce, Ella Miron Spektor, and Melissa Valentine for helpful comments on previous drafts. We are grateful to the Division of Research of Harvard Business School for generous funding. All errors remain our own.

Abstract

Prior work examining the relationship of varied experience (i.e., the concurrent completion of multiple tasks) and learning by groups finds inconsistent results. We hypothesize that team familiarity, i.e, individuals' prior shared work experience, may help explain this difference, as familiar teams may be more effective than unfamiliar teams at using the knowledge gained from the concurrent completion of multiple tasks. A sense of psychological safety may be one reason that team familiarity could aid in the process of team learning. In an experimental study, we find that familiar teams learn at a faster rate than unfamiliar teams. Additionally, we find that team familiarity leads to the development of psychological safety and that the relationship between team familiarity and team learning is mediated by psychological safety. By separately examining task variety, team familiarity, and psychological safety, our work offers new insights and direction for the study of learning in teams.

Key Words: Learning, Psychological Safety, Team familiarity, Varied experience

Varied Experience, Team Familiarity, and Learning:

The Mediating Role of Psychological Safety

Teams play a central role in the work of many knowledge-based organizations (Ancona and Bresman 2007; Mathieu et al. 2008; Edmondson and Nembhard 2009). In many areas, ranging from new product development to consulting to investment banking, organizational performance is strongly affected by the ability of teams to learn (Argote 1999; Pisano, Bohmer and Edmondson 2001; Wilson, Goodman and Cronin 2007; Bresman 2010). In practice, organizations often employ widely different strategies to facilitate team learning. One such strategy involves the assignment of tasks to teams. Recent work on learning has challenged the assumption that repetition of a single task maximizes the rate at which a group learns (Schilling et al. 2003; Wiersma 2007; Clark and Huckman 2009). Drawing on psychological theory suggesting that the completion of related tasks helps individuals develop schema that can be used to improve the focal task (Schmidt 1975; Gick and Holyoak 1980), Schilling et al. (2003) find that experience with two related tasks ("varied experience") leads to faster learning than when groups complete only one task. While these recent studies suggest a positive relationship between varied experience and learning, prior work examining this linkage has found no effect (Darr, Argote and Epple 1995).

In this paper, we will examine one possible reason for this discrepancy in prior work. Varied experience may provide group members the *possibility* of better performance, as compared to their one-task compatriots (Schilling et al. 2003). However, without team familiarity (i.e., the prior experience of team members working together; Reagans, Argote and Brooks 2005; Espinosa et al. 2007; Huckman, Staats and Upton 2009), the potential benefits of multiple tasks may be lost. If individuals have little or no experience working together, they may be unable to use the knowledge gained from varied experience in order to solve complex problems (Faraj and Sproull 2000; Lewis, Lange and Gillis 2005). Therefore, in our study, we examine whether learning in teams that are completing multiple tasks is dependent on teams' prior experience working together.

Prior research finds that familiarity helps teams learn and perform better through the development of a transactive memory system (TMS; Wegner 1987; Liang, Moreland and Argote 1995; Moreland, Argote and Krishnan 1998; Lewis et al. 2005). For tasks that require coordination between individuals within a team, a TMS helps the team specialize roles, coordinate activities, and credibly communicate (Lewis 2003; Brandon and Hollingshead 2004; Lewis et al. 2007). In this paper, we are interested in another benefit of familiar teams that may be particularly salient in the context of knowledge work. We suggest that team learning varies based on the familiarity of individuals on the team and that the psychological safety among team members explains these differential effects. Psychological safety has been defined as the "belief that the team is safe for interpersonal risk taking" (Edmondson 1999: 354). A psychologically safe environment within a team can improve team learning behavior, increase knowledge sharing, and encourage experimentation (Edmondson 1999; Lee et al. 2004; Tucker 2007; Siemsen et al. 2009).

We examine the effects of varied experience, team familiarity, and psychological safety on learning at the team level in a controlled, laboratory setting. We find that familiar teams learn at a significantly faster rate than teams without experience working together. Additionally, we find that team familiarity is an antecedent to psychological safety and that the effect of team familiarity on team learning is fully mediated by psychological safety. The present research contributes to the literature on teams by advancing our understanding of the drivers of team learning. By introducing the contingency of team familiarity, we reconcile prior mixed results on the effect of varied experience on learning (Darr et al. 1995; Schilling et al. 2003). Additionally, we further unpack the positive benefits of team familiarity by empirically showing that team familiarity builds psychological safety, which drives team learning.

Task Variety, Team Familiarity, Psychological Safety, and Learning

The learning curve – the concept that increasing cumulative experience leads to improved performance – has served as a key pillar of the study of learning in organizations for many years (Wright

1936; Yelle 1979; Argote and Miron-Spektor 2010). We define learning as the improvement of performance through better knowledge over time (Fiol and Lyles 1985; Argote 1999; Edmondson 2002a). Prior work has established that the learning curve is not only an organizational phenomenon, but also holds for teams and individuals (Mazur and Hastie 1978; Argote 1993; Reagans et al. 2005). Empirical evidence has consistently shown that there is substantial variation in rates of learning across firms, organizational units (such as plants), teams, and individuals (Dutton and Thomas 1984; Hofmann, Jacobs and Gerras 1992; Darr et al. 1995; Pisano et al. 2001; Lapré and Tsikriktsis 2006). There are many explanations for these differences. For example, ex-ante structural choices, such as collocation of team members, team size, and work design, may enable improved learning (Adler 1990; Hackman 2002). Additionally, organizations commit different resources (in terms of quantity and quality) to improving processes with a resulting impact on learning (Hayes and Wheelwright 1984; Lieberman 1984; Adler and Clark 1991; Sinclair, Klepper and Cohen 2000). Finally, the variation in the relationship between experience and learning may arise from differences in how production units acquire, transfer, and retain the knowledge that comes from experience (Nelson and Winter 1982; Argote 1999; Lapré, Mukherjee and Wassenhove 2000; Argote, McEvily and Reagans 2003; Huckman and Pisano 2006).

Scholars in both the management and psychology literature have devoted significant effort to examining the positive benefits of knowledge gained from repeating the same task (Smith 1776; Thurstone 1919; Taylor 1979). As problem solvers gain experience, they gradually improve procedures, thus enhancing efficiency and reliability (Anzai and Simon 1979; Pisano 1994). By focusing on the same task repeatedly, an individual, team, or organization can learn about the underlying causal linkages in the process (Bohn and Jaikumar 1992) and thus eliminate circuitous pathways, choose better parameter values, and generally streamline the process (Simon 1981; March and Simon 1993; Adler et al. 2009). The benefit of repetition in experience has led to the widely held belief that focused operations outperform their less focused counterparts (Skinner 1974; Huckman and Zinner 2008; Huckman 2009).

Work on learning and task experience has traditionally examined the execution of a single task (such as the production of a specific product type). However, drawing on psychology and the study of learning more broadly, Schilling and her co-authors (2003) find that in some cases, related diversification, or varied experience, may result in faster learning in groups. There are several theoretical reasons why varied experience may aid learning. First, varied experience may help individuals within a group learn faster (Narayanan, Balasubramanian and Swaminathan 2009), which in turn may aid group learning. For example, when completing multiple related activities, the individuals in a group may recognize higher-order principles that apply to both (Schmidt 1975; Gick and Holyoak 1980). An example is analogical problem solving, whereby problem solvers transfer knowledge from a related setting to improve performance in the focal setting (Gick and Holyoak 1983; Gavetti, Levinthal and Rivkin 2005). Similarly, work in product development finds that to solve problems at low levels, it is often necessary to move up and restructure the approach at a higher level (Clark 1985). The knowledge needed to execute a successful high-level change may come from the experience gained across multiple related areas (Cohen and Levinthal 1990; March and Simon 1993).

Varied experience may also help groups to continue learning. The traditional formulation of the learning curve of $y = ax^{-b}$ assumes a decreasing return to volume. One reason for this is that, as noted above, over time the opportunities for improvement grow scarcer as reverse salients are addressed and processes are optimized (Hughes 1983; March and Simon 1993). Varied experience may permit problem-solving groups to connect knowledge that was hitherto thought to be unrelated (Fleming 2001; Schilling et al. 2003). An additional reason for decreasing returns is that problem-solving groups may find their performance satisfactory and fail to continue to seek ways to improve it (Imai 1986; Winter 2000). Switching between different activities may help keep the group in a state of active learning, thus preventing it from mechanically executing the same routines (Weick and Roberts 1993). For example, one of the stated benefits of the idea of *heijunka* in the Toyota Production System is that by switching between the production of different types of cars (i.e., varied experience), individuals remain actively engaged, and potential problems in processes are highlighted more quickly so they can be fixed and learning can continue (Spear 1999; Hino 2006).

While there are theoretical reasons to think that varied experience at a team level may help learning, empirical support for the relationship is mixed. For example, Darr, Argote, and Epple (1995) fail to find a significant relationship between varied experience and learning. The experimental study of Schilling et al. (2003) offers at least one clue to explain for this difference. In their design, teams were kept together over the course of the experiment (i.e., team familiarity – prior shared work experience – is gained). While Darr et al. (1995) do not find a relationship between varied experience and learning, team familiarity in their setting was quite low (they studied pizza stores with annual employee turnover of around 300%). Why then might team familiarity play a particularly important role in the capture of the benefits of varied experience?

To answer this question, we first start by examining why learning may be improved when team members gain familiarity with others in the group (Levine and Moreland 1991; Argote et al. 1995; Reagans et al. 2005; Espinosa et al. 2007). When individuals work repeatedly with the same team members, they may build social capital (Adler and Kwon 2002), thus improving the team's coordination (Faraj and Sproull 2000; Espinosa et al. 2007). Newly formed groups are often inefficient, as they spend time getting to know one another and developing processes for interaction (Steiner 1972; Harrison et al. 2003). Experience working together may also be an important source of learning, as it improves identification of expertise in a production group (Trotman, Yetton and Zimmer 1983; Littlepage, Robison and Reddington 1997; Bunderson 2003), aides in the transfer of knowledge among group members (Monteverde 1995; Szulanski 1996; Weber and Camerer 2003), and helps individuals to successfully apply newly acquired knowledge (Lewis et al. 2005; Reagans et al. 2005).

Prior work notes the great difficulty that many groups have identifying the knowledge and expertise that resides within the group members (Trotman et al. 1983; Littlepage et al. 1997; Van Der Vegt and Bunderson 2005; Haas and Cummings 2008). When individuals do not know what other members of the group know, then they are likely to rely on noisy and often incorrect signals of expertise (Bunderson 2003). As members work together, they develop a mental representation of the knowledge that resides in the group (Wegner 1987; Kozlowski and Ilgen 2006), which helps them better coordinate their activities. This idea has been captured by scholars in the concept of a transactive memory system ("TMS", Wegner 1987; Brandon and Hollingshead 2004). As a team works together, an idea of who knows what is captured within the TMS. The TMS in turn assists the team in specializing roles, assigning tasks to credible team members, and coordinating their activities (Austin 2003; Lewis 2003). As members gain experience working together, the TMS may evolve, creating a platform for ongoing learning (Lewis et al. 2005). However, even after individuals with the requisite knowledge are identified, it is still necessary to transfer the information to the team.

Transfer can be complicated by factors involving knowledge and motivation. In terms of the former, Szulanski (1996) finds that knowledge transfer within the firm is often thwarted because of a mismatch of knowledge between the sender and the receiver. Monteverde (1995) notes that differences in language can also limit the transfer of knowledge (von Hippel 1994; Weber and Camerer 2003). In addition to problems caused by knowledge-related factors, a mismatch of motivation may complicate the transfer process. Lacking work experience with other team members, an individual may not believe the climate will be accepting and safe for the sharing of information (Gruenfeld et al. 1996; Edmondson 1999; Hinds et al. 2000). This in turn may limit not only knowledge transfer, but also experimentation and risk taking within the team (Edmondson 2002a; Lee et al. 2004).

Together, these reasons suggest that team familiarity might activate learning opportunities in teams with varied experience. The challenge of turning knowledge into action is a key issue in organizational theory. Though it goes by many names, including the knowing-doing gap (Pfeffer and Sutton 2000), the idea-action problem (Obstfeld 2005), and the search-transfer problem (Hansen 1999), the finding that groups often know more than they are able to act upon is consistent. Without team familiarity, teams may be unable to effectively transfer knowledge, experiment with new ideas, and combine their findings to learn. For example, Harrison et al. (2003) and Lewis et al. (2005) both find that team familiarity aids learning when teams switch to a new task. We are interested in examining team familiarity's role when tasks stay the same over time, but are varied, since this may better capture what occurs in real organizations where employees are asked to work and gain experience on multiple tasks.

We posit that while varied experience may provide a group with the potential to learn, lack of team familiarity may prevent them from fully using this potential. Therefore, we hypothesize that:

HYPOTHESIS 1: When the task varies, *familiar teams will learn faster than unfamiliar teams.*

As discussed above, there are many potential reasons why team familiarity may aid in the process of team learning. We examine one reason, psychological safety, which is likely to be particularly valuable in the context of teams completing knowledge work. Psychological safety describes the interpersonal climate for risk taking within a team (Edmondson 1999). In teams involved in knowledge work, many of the manual routinicity benefits that come from improved coordination due to team familiarity are not relevant (since the teams are not physically acting upon a product). Instead, learning is driven by knowledge that is shared and built upon by team members (Argote et al. 2003; Edmondson, Dillon and Roloff 2007; Wilson et al. 2007).

We focus on psychological safety because team members' ability to openly discuss the risks and potential errors or problems they encounter in their work is critical to learning (Edmondson, 1999). If individuals are going to learn, they must be willing to engage in some risky behavior (Schein and Bennis 1965; Argyris and Schön 1978). For example, asking a question may make the questioner seem foolish, offering a critical but constructive comment to a group member may appear negative, and suggesting a new course of action may seem disruptive (Edmondson 2002b). Prior work establishes that experimentation plays a vital role in generating knowledge and learning (Thomke 1998), but a lack of psychological safety may eliminate the spark that leads to experimentation (Lee et al. 2004). Even if the argument is not taken to this extreme, a lack of psychological safety may at the very least prevent individuals from sharing the most controversial (and often insightful) information (Edmondson 1996; 2002a).

Team familiarity may play an important role in establishing psychological safety in a team. When individuals work together, the uncertainty of interactions is reduced (Hinds et al. 2000). First, when individuals interact repeatedly, they grow positively disposed toward one another (Festinger 1953; Zander and Havelin 1960; Byrne 1961). This positive disposition may aid in the interpretation of critical comments. Second, as individuals work together, they reveal their behavior to one another (Hinds et al. 2000). This reduction in uncertainty is valuable, whether or not the behavior encourages risk-taking. It is reasonable to assume that individuals in teams will be risk averse, since the risks of speaking up often dramatically outweigh the benefits (Edmondson 2002a; b). Therefore, with predictability, an individual on a team will likely engage in more risk-taking than she would have previously. Finally, prior work indicates that individuals are more likely to be receptive to the ideas and knowledge of other team members with whom they have prior experience, as opposed to new team members (Gruenfeld, Martorana and Fan 2000; Kane, Argote and Levine 2005). With this receptivity, individuals may be more likely to take the risk of sharing additional ideas and further building psychological safety.

Prior work has focused on the leader's role in building a psychologically safe environment (Edmondson 1996; Nembhard and Edmondson 2006). The previous arguments suggest that team familiarity may also be an antecedent to psychological safety. Team familiarity has been examined in the context of learning and psychological safety (e.g., Edmondson, Bohmer and Pisano 2001). However, in the Edmondson et al. (2001) study, team familiarity emerges as a factor, alongside psychological safety, that affects team learning. Here, we suggest that team familiarity is actually an antecedent to psychological safety and that the relationship between team familiarity and learning is mediated by psychological safety. We formalize our final two hypotheses as follows and present our research model in Figure 1:

HYPOTHESIS 2: When the task varies, *teams with team familiarity will have higher psychological safety than teams that lack familiarity*.

HYPOTHESIS 3: *When the task varies, psychological safety will mediate the relationship between team familiarity and team learning.*

Methods

We tested these hypotheses using a controlled, laboratory setting. Laboratory experiments allow researchers to directly measure group performance while controlling for other potential sources of variance and noise in the team, task, or learning setting (Argote 1993; Schilling et al. 2003). Our experimental design allows us to directly measure the effects of team familiarity and psychological safety on learning while controlling for varied experience and to attribute any difference in learning across conditions to our manipulations. In the experiment, participants played computer games repeatedly in teams of three members. We chose this problem-solving task because it has been used effectively in prior research by Schilling et al. (2003) to measure learning over time at the group level. In addition, this task simulates the type of problem-solving activities and processes characterizing group learning within knowledge-based organizations, including project and product development groups or consulting teams. In the experiment, we manipulated team familiarity while controlling for the number of tasks each team completed and task experience.

Participants

For our experiment, we recruited 72 students (54% female, Mean age = 21.3, SD = 3.6) from local universities in a city in the Northeastern United States to participate in a study on teamwork. Participants were divided into twenty four, three person teams with the teams divided equally between the familiar and unfamiliar conditions. Participants were screened to exclude those with experience playing the games used in the study. The study lasted eight hours and took place over two consecutive days (four hours each day). Participants received a $10 show-up fee and an additional $100 upon completion of the study. The fee was independent of the participants' performance during the study.

Tasks

Following the approach used by Schilling et al. (2003) in their work on team learning, we used Go and Reversi for our experiment. Both games represent problem-solving tasks that allow for learning over time and accurate performance feedback. The games also have an appropriate level of difficulty, and participants can play them against a computerized opponent.

The rules of Go, a strategic board game, are simple to understand, and an entire game only takes about 10 minutes. However, the game is difficult to master. The object of the game is to use one's stones to form territories by surrounding vacant areas of the 13x13 board grid. It is also possible to capture the opponent's stones by completely surrounding them. The two players take turns, placing one of their black or white stones on a vacant point on the board. Players gain points based on the amount of territory they control on the board grid.

Reversi is also a strategic board game, and it is considered similar to Go in appearance, objective, and ancestry (Parlett 1990; 1999). In Reversi, two players alternately place black and white stones on a square grid. As with Go, the objective is to conquer territory by placing one's stones in strategic places (e.g., to capture the opponent's stones), and points are awarded based on territory controlled.

Like Schilling et al. (2003), we evaluate group performance using the game of Go. Given the difficulty of the game, it more accurately matches real-world work, where the right answer is often unclear and discovering the causal logic between subsequent steps is difficult. Therefore, Go offers teams an opportunity to continue to learn throughout the entire exercise.

Design and Procedure

At the beginning of the study, participants filled out an initial questionnaire with general demographic questions and questions measuring their experience playing games and their enjoyment in doing so. Next, the experimenter informed participants that they would be working in teams of three members each and that they would be playing computer games throughout the study. They were told that the study was about learning and that their objective was to become as good at the games as possible. Stressing the team nature of the study, the experimenter asked participants to play games as a team by discussing strategies together and not delegating game-playing among team members. The experimenter told team members that talking within teams was encouraged, but that talking across teams was not allowed.

The study employed one between-subjects factor: half of the teams received a familiarity manipulation and half did not. At the time of each session, participants were divided into teams of three members each, and teams were assigned to one of the two experimental conditions. To avoid contamination across conditions, only one condition was run each session. In each condition, the teams repeatedly played computer games against a computer opponent for four hours a day for two consecutive days. This procedure allowed us to collect data over multiple rounds. Teams alternated between playing four games of Go and four games of Reversi. This procedure for varied experience, previously used by Schilling et al. (2003), accounts for the fact that learners get confused when tasks are varied too quickly and are unable to transfer their learning across tasks (Graydon and Griffin 1996).

Each team played games in a different break-out room. The break-out rooms were large enough for team members to sit comfortably, discuss their strategies in detail (e.g., they could use a white board) without being heard by other teams, and play games as a team. Teams played games throughout the study at their own speed. They received a packet with the game(s) instructions. In addition, participants received a score sheet to record their score in each game and the time spent playing each game.

In the familiar-team condition, members worked with the same team for all of Day 1 and Day 2; in the unfamiliar-team condition, members worked with different members after the first two hours of play in Day 1. We manipulated team familiarity by completely scrambling members in this condition. Since all individuals were inexperienced with the games before the start of the experiment, the initial two hours allowed each person the same amount of time with the task. After the two hours, half of the teams consisted of individuals with both task experience and experience working together; the other half consisted of individuals who only had task experience. Thus, our experimental design permits us to control for task experience and then examine the effect of team familiarity on learning.

Both observation and a questionnaire indicated that teams treated the task as a group activity; team members engaged in spirited debate as play progressed. At the end of the study, participants filled out a questionnaire with manipulation checks, questions about the involvement of group members (Schilling et al. 2003), and team process measures. Overall, individuals responded with a 5.2 out of 7 score, indicating that "all team members were equally involved with the game most or all of the time," a fairly high level of involvement.

Measures

We focused on two team processes: psychological safety and transactive memory systems.

Psychological safety. To measure psychological safety, we used Edmondson's (1999) seven-item Likert scale (e.g., "It is safe to take a risk on this team"), where one corresponded to strongly disagree and seven corresponded to strongly agree. To justify the aggregation of the individual responses to the team level, we used the within-team inter-rater agreement, r_{wg} (Hofmann 2002; Hofmann and Jones 2004). Our median r_{wg} for psychological safety was 0.78, above the conventionally acceptable level of 0.70 (Bliese 2000; Chen, Mathieu and Bliese 2004).

Transactive memory. We measured TMS using Lewis' (2003) fifteen-item scale. The scale includes five questions each about three different components: coordination (e.g., "Our team worked together in a well-coordinated fashion"), credibility (e.g., "I trusted that other members' knowledge about the project was credible"), and specialization (e.g., "Different team members are responsible for expertise in different areas"). As with psychological safety, participants used a seven-point Likert scale to respond to each item. We again used the within-team inter-rater agreement, r_{wg}, to justify the aggregation of individual responses to the team level and found that the median r_{wg} was above the acceptable level (Bliese 2000; Hofmann 2002; Chen et al. 2004; Hofmann and Jones 2004).

Overview of Analyses

As mentioned earlier, the standard learning curve formulation is $y = ax^{-b}$, where a log transformation of both sides of the equation permits the estimation of *b*, the learning coefficient or progress ratio, using linear regression (Dutton and Thomas 1984; Argote, Beckman and Epple 1990). The learning curve is typically used to estimate how increases in cumulative experience, *x*, are related to improvements in performance, *y*. In the case of our experiment, we expect increasing cumulative experience to result in increasing scores for the game of Go. Therefore, we estimate an equation such that an increase in *x* is related to an increase in *y*: $y = ax^{b}$ (Schilling et al. 2003).

Across our experimental conditions, we used score for the games of Go as the dependent variable. Scores for the game of Go ranged between 0 and 169, with a perfect score being a rare occurrence. As noted by Schilling et al. (2003), variability in learning in this game is likely to be higher than in production learning curves, as teams are likely to experiment with new strategies while playing the game, and these strategies might lead to lower scores even when prior strategies produced good results. While all teams had a fixed amount of time to play their specified games, not every team played the same number of games during that time. Different teams used different strategies, and some teams varied their strategies over the course of the experiment. Motivated by Darr et al. (1995), Schilling et al. (2003) averaged the scores of teams over a one-hour period to generate their dependent variable. We follow this same approach; when it is combined with controls for the games played per hour and the standard deviation during each hour, it is possible to compare our results across teams. By taking this approach, our analysis examines the effect of cumulative games played through the prior time period, $t - 1$, on the average scores from the time period, t.

Given that our data examines multiple observations of performance for the same teams over time, autocorrelation of errors is a concern. A Wooldridge (2002) test indicates that first-order autocorrelation is present within the data ($p<0.05$). Since failure to correct for autocorrelation will result in biased coefficients, we estimate all models using feasible generalized least squares with standard errors adjusted for heteroskedasticity and first-order autocorrelation. Table 1 details the variables used in our models.

To build up to our final model, we first analyze the following two models:

$$\ln S_{it} = \beta_0 + \beta_1 G_{it} + \beta_2 SD_{it} + \beta_3 \ln Q_{it-1} + e_t \qquad (1)$$

$$\ln S_{it} = \beta_0 + \beta_1 G_{it} + \beta_2 SD_{it} + \beta_3 FA_i + \beta_4 \ln Q_{it-1} + e_t \qquad (2)$$

In model one, we examine coefficient β_3 for evidence of learning across both team conditions. Given that teams play the games at different speeds and might follow different strategies (e.g., taking a trial-and-error approach to the games), we include the control variables for games played per hour, G_{it}, and standard deviation, SD_{it} (Schilling et al. 2003). In model two, we add variable FA_i, an indicator for the familiar team condition. Finally, to test our hypotheses, we include separate learning terms for the familiar and unfamiliar team coefficients by interacting FA_i and UFA_i with the cumulative experience variable, Ln Q_{it-1}. This approach permits us to estimate individual learning curves for each of the two conditions (Lapré et al. 2000; Schilling et al. 2003). Altogether, this yields the following equation:

$$\ln S_{it} = \beta_0 + \beta_1 G_{it} + \beta_2 SD_{it} + \beta_3 FA_i + \beta_4 FA_i x \ln Q_{it-1} + \beta_5 UFA_i x \ln Q_{it-1} + e_t \qquad (3)$$

Hypothesis 1 predicts that familiar teams will learn at a faster rate than the unfamiliar teams. These rates are captured by coefficients β_4 and β_5; thus, if β_4 is greater than β_5 then Hypothesis 1 will be supported.

As for our other two hypotheses, Hypothesis 2 predicts that team familiarity positively influences psychological safety, and Hypothesis 3 predicts that psychological safety mediates the relationship between team familiarity and learning. We will test these hypotheses using independent sample t-tests and regression analyses, as reported below.

Results

Varied experience, team familiarity, and learning. Table 2 shows the results for the learning models. Column 1 shows that the overall learning rate is positive and significant; that is, on average across all conditions, teams performed better on Go as they played more games. In Column 2, we add the indicator for the study's experimental manipulation. The overall learning rate remains positive and significant. The coefficient on the variable for familiar teams is positive but not significant. In Column 3, we test the study's first hypothesis by adding terms to estimate the separate learning rates for the familiar- and unfamiliar-team conditions. Inspecting the coefficients, we see that the familiar team rate of learning is positive and significant while the unfamiliar team rate of learning is positive but not significant. A Wald test finds that this difference is statistically significant, providing support for Hypothesis 1. Figure 2, below, shows scatter plots of the data in the familiar- and unfamiliar-team conditions.

Psychological safety and team familiarity. Having established that teams learn faster in the familiar-team condition, we next turn to our second hypothesis – whether team familiarity leads to the development of psychological safety. Examining summary statistics, we see that psychological safety is higher in the familiar-team condition ($\mu = 5.61$, $\sigma=0.51$) than in the unfamiliar-team condition ($\mu = 4.83$, $\sigma=0.61$). To test for statistical significance, we use an independent sample t-test and find that the difference is significant ($t = -3.3715$, $p = 0.003$). Thus, the results provide support for Hypothesis 2, which predicted that team familiarity would positively influence psychological safety.

Mediation analyses. Our third hypothesis predicted that the relationship between team familiarity and team learning is mediated by psychological safety. To test for mediation, we used the multiple regression approach recommended by Baron and Kenny (1986; see also Kenny, Kashy and Bolger 1998). To capture the learning of teams, we used the team's average score in the final hour of the experiment (hour 8). This measure captures the realized benefits of learning that occurred over the course of the exercise (see the next section, Robustness Checks, for an alternative specification). Table 3, below, summarizes the results. First, we regressed the final hour score on the familiar-team indicator and found that the coefficient on the indicator was positive and significant ($b = 0.419$, $p<0.05$). Next we regressed psychological safety on the familiar-team indicator and found that it was positive and significant ($b = 0.584$, $p<0.01$). Together, these two results are consistent with the first two hypotheses of this paper and fulfill the first two requirements for mediation.

To meet the third requirement for mediation, we regressed the final hour score on the familiar-team indicator and psychological safety. Psychological safety was positively and significantly related to final hour score ($b = 0.579$, $p < 0.05$); the familiar-team indicator was positive but not significant at conventional levels ($b = 0.081$, $p=0.70$). We tested the mediation effect using Sobel's (1982) test and found that it was significant ($Z = 2.141$, $p < 0.05$). Thus, our experiment supports Hypothesis 3, which states that psychological safety fully mediates the effect of team familiarity on team learning.

Robustness checks. To examine the robustness of our results, we consider several additional models. First, we used a team's score in the final hour of the experiment as our measure of team learning. While this measure may capture the effects of learning (i.e., a team that learns more will have a higher score), it does not fully capture learning, since a team could also have a high final hour score by starting high and never improving. While we think this explanation is unlikely given the challenging nature of Go and individuals' lack of experience with the game, for the sake of robustness we check an alternative measure of learning. In particular, we ran the same regression model as in Table 2, Column 3; however, we replace the two learning terms with team-specific learning measures (i.e., we interact a team indicator with the log [cumulative] variable to estimate a learning coefficient for each team). We then use the estimated learning coefficient to repeat the analyses from above. As shown in Table 4, all results are consistent with Table 3: the familiar-team indicator predicts a team's rate of learning and team psychological safety, and psychological safety fully mediates the relationship between team familiarity and the rate of learning.

An additional question involves the effect of TMS in these models. Prior work shows a consistent and robust role for TMS on learning when tasks involve specialized roles and group coordination, particularly in manual assembly tasks (Lewis et al. 2005; Gino et al. 2010). Our expectation is that TMS will play less of a role in our particular context, given that there is little to no opportunity for specialized roles and that group coordination does not involve handing products from one person to the next. Rather, individuals in teams are involved in brainstorming and sharing ideas to create strategies and then working to improve their strategies. The decisions made as part of the game are mindful interactions between team members, similar to collective creativity, that cannot be attributed to any one member (Hargadon and Bechky 2006). Together this mirrors the processes followed in many knowledge-based industries. Despite these stipulations, we conduct robustness checks with TMS.

First, we examine whether TMS ($\mu = 4.343$, $\sigma = 0.581$) mediates the relationship between familiarity and learning, excluding psychological safety. In Tables 5 and 6 we see that familiarity is positively related to TMS (Step 2), but the effect of familiarity on either learning variable is not mediated by TMS (Step 3). In Step 3 for final hour score (Table 5), neither the familiar-team indicator nor TMS are significantly related to the dependent variable, while in Step 3 for learning rate (Table 6) the familiar-team indicator is positive and significantly related to the dependent variable, while TMS is not.

Tables 7 and 8 below report comparable mediation results as Tables 3 and 4 with the addition of TMS as a control variable. While psychological safety and TMS are positively correlated ($r=0.480$, $p<.01$), TMS is not significantly related to any of the dependent variables in the regression models. Each of the results from the earlier analyses holds, with the exception of Step 1 in the model of final hour score on the familiar-team indicator and TMS. Previously, the familiar-team indicator had a positive and significant relationship with final hour score; now the relationship is positive but no longer significant (p=0.187). However, as noted by Kenny et al. (1998), the first step is not required to verify mediation, although it is implied by the relationships in the second and third steps. While future work should explore the relationship of TMS and psychological safety in more detail, these models increase our confidence in the findings of this study.

Limitations

As with all studies, this work has limitations that should be noted and that could be addressed by future research. First, these findings arise from the interactions of individuals in a laboratory setting. While experimental conditions are powerful for establishing causality and focusing on the aspects of interest to the researcher, they compromise on external validity for the benefit of internal validity. We believe that our task has characteristics that are comparable to operations within organizations, but these results should be explored in functioning organizations. Second, our study involves only one experiment. Prior work notes the difficulty of studying team familiarity and team learning curves in the laboratory, as both require significant investment of time and resources (Arrow and McGrath 1995; Littlepage et al. 1997). As with Schilling et al. (2003), we decided to use one longer study to combat these problems. By using a two-day, multi-hour per day study, we were able to give teams enough time to build familiarity (two hours, which is longer than many entire studies). Also, we were able to observe multiple periods of performance so we could trace learning curves over time. Nevertheless, future work should seek to replicate these findings both in the laboratory and in the field.

A third limitation is that our task is one of problem-solving, not execution. A large percentage of work in organizations involves both motor and cognitive skills. Examining how varied experience, team familiarity, and psychological safety affect ongoing, repetitive behavior that is both physical and mental will provide additional insights. For example, while we see a mediating role for psychological safety in our study, we do not find a significant effect for TMS. Future work should seek to understand the characteristics of tasks and teams that may lead to a complementary or substitutive relationship between these two factors.

Discussion and Conclusion

In the global economy, knowledge-based organizations (Drucker 1999; Cummings 2004; Haas and Hansen 2007) increasingly are turning to project teams to produce work (Ancona and Bresman 2007; Mathieu et al. 2008; Edmondson and Nembhard 2009). Given this increasing dependence on teams, organizational performance is strongly affected by the learning that occurs within teams (Argote 1999; Pisano et al. 2001; Wilson et al. 2007). Senge (1990: 236) goes so far as to state that teams are "the key learning unit in organizations." Our results help to unpack how teams learn under conditions of varied experience. Namely, we find that familiar teams learn at a faster rate than unfamiliar teams. Our findings may help to reconcile conflicting findings in the literature. When Schilling et al. (2003) studied familiar teams completing varied tasks, they found a significant rate of learning, but when Darr et al. (1995) studied largely unfamiliar teams completing varied tasks, they did not find a significant effect for task variety. Experience working together may improve a team's ability to learn (Reagans et al. 2005; Espinosa et al. 2007; Huckman et al. 2009), as the team is better able to identify, transfer, and apply knowledge (Szulanski 1996; Littlepage et al. 1997; Kane et al. 2005). This in turn may lead to better storage and subsequent creation of knowledge (Argote and Ingram 2000; Lewis et al. 2005; Reagans et al. 2005). These benefits may be particularly valuable when teams are working in highly complex cognitive situations, such as balancing multiple knowledge tasks (Kearney, Gebert and Voelpel 2009).

In addition to the effect of team familiarity on learning, under conditions of varied experience we are also interested in the role of psychological safety in this process. We find that team familiarity is an antecedent to psychological safety and that the effect of team familiarity on team learning is mediated by psychological safety. This result contributes both to theory and practice. The allocation of members to teams based on their experience sets has been a widely studied issue (Hinds et al. 2000; Argote and Miron-Spektor 2010; Huckman and Staats 2010). Recent work highlights that team familiarity is one dimension upon which managers should consider staffing teams (Reagans et al. 2005; Espinosa et al. 2007; Huckman et al. 2009). Unfortunately, even if managers wish to keep teams together, this may not be possible, due to factors such as turnover, promotions, or staff relocations (Ton and Huckman 2008;

Huckman et al. 2009). Our results suggest that there may be other ways to capture some of these benefits. Namely, other mechanisms such as leader inclusiveness or organizational climate have been shown to build team psychological safety (Edmondson et al. 2001; Baer and Frese 2003; Nembhard and Edmondson 2006; Tucker, Nembhard and Edmondson 2007). When familiarity is not an option, managers may be able to turn to these alternative approaches. Future work should explore the relationship between team familiarity, leader behavior, organizational climate, and psychological safety.

One additional result from our examination of team familiarity and team learning is worth discussing briefly. Namely, while we found that familiar teams learned at a faster rate than unfamiliar teams, the indicator variable for familiar teams in Column 3 in Table 3 is negative and significant. This suggests that unfamiliar teams initially outperformed familiar teams—that is, during the first hour after the teams were switched (i.e., hour three of the study). Prior work suggests that membership change, or turnover, may improve the creativity of teams (Ziller, Behringer and Goodchilds 1962; Choi and Thompson 2005; Gino et al. 2010). While turnover in team members may disrupt well-functioning, existing relationships and good routines (Leana and Buren 1999; Dess and Shaw 2001), it also creates the opportunity to introduce new knowledge into the group, spark learning, and disrupt maladapted routines (Dalton and Todor 1979; Gruenfeld et al. 2000; Argote and Ophir 2002).

When group membership is altered, group members have a “window of opportunity” to change existing routines (Tyre and Orlikowski 1994; Okhuysen 2001). When groups change completely (i.e., when a new group is constructed of individuals with similar task experience, as in this study), then the existing processes are no longer binding in the same way and individuals may draw on prior experience to create new, improved processes (see, Lewis et al. 2007, for an examination of the pathologies and solutions for partial group change). The new changes *may* overcome the process losses (Steiner 1972) of new group formation. Surprisingly, in our context, unfamiliar teams are initially able to capitalize on their differences; however, these advantages are short-lived, as familiar teams learn at a faster rate and quickly surpass them. Future work should explore the differences between short-term performance and learning over time in more detail (Druskat and Kayes 2000).

Numerous scholars have called on managers to build learning organizations (e.g., Senge 1990; Garvin, Edmondson and Gino 2008). By explicitly examining varied experience, team familiarity, and psychological safety, we put an important operational lever into the hands of managers. Familiarity of workers is often not considered in staffing decisions, or else is decided informally by high-status individuals. Our results, in conjunction with recent work on team familiarity (Reagans et al. 2005; Espinosa et al. 2007; Huckman et al. 2009) highlight the need for organizations to actively manage familiarity. This will require the concurrent development of new heuristics and models for staffing, but may also create opportunities for organizations to achieve superior operational performance.

Tables

Table 1. Summary of variables used in study.

Variable	Label	Description
Score	S_{it}	Average score on Go in hour *t* for team *i*.
Games played	G_{it}	Count of the games of Go played during hour *t* by team *i*.
Standard deviation	SD_{it}	Standard deviation for the games of Go played during hour *t* by team *i*.
Cumulative games	Q_{it-1}	Count of the cumulative games of Go played since the beginning of hour 3 (when team composition was manipulated) until hour *t – 1*.
Familiar team condition	FA_i	An indicator set to one for team *i* if the team members were not switched (i.e., same team).
Unfamiliar team condition	UFA_i	An indicator set to one for team *i* if the team members were switched (i.e., different team).

Table 2. Results for the regression models examining varied experience, team familiarity, and learning.

	Dep Var: Log (Score)		
	(1)	(2)	(3)
Number of *Go* games played in hour *t*	-0.000 (0.003)	0.000 (0.003)	-0.000 (0.003)
Standard deviation of scores in hour *t*	-0.003** (0.001)	-0.003* (0.001)	-0.002 (0.002)
Log (Cumulative *Go* games at time *t* - 1)	0.033*** (0.006)	0.035*** (0.006)	
Familiar team indicator		0.021 (0.017)	-0.055** (0.027)
Familiar team × log (cumulative games)			0.052*** (0.008)
Unfamiliar team × log (cumulative games)			0.011 (0.009)
Constant	3.978*** (0.018)	3.959*** (0.023)	4.012*** (0.000)
Observations	144	144	144
Wald chi-squared	40.6005***	43.3115***	53.6692***

Notes: *, **, and *** denote signficance at the 10%, 5% and 1% levels, respectively.

Table 3. Mediation analyses with dependent variable of final hour score. Each mediation step contains a regression analysis. The table reports standardized coefficients (*n* =24).

	Dependent Variables				
	Psych Safety	Final Hour Score	F	R^2	ΔR^2
Mediation analysis, Step 1					
Familiar Team		0.419**	4.677**	0.175	
Mediation analysis, Step 2					
Familiar Team	0.584***		11.37***	0.341	
Mediation analysis, Step 3					
Familiar Team		0.081	6.888***	0.396	0.221***
Psychological Safety		0.579**			

Notes: *, **, and *** denote signficance at the 10%, 5% and 1% levels, respectively.

Table 4. Mediation analyses with dependent variable of learning rate. Each mediation step contains a regression analysis. The table reports standardized coefficients (*n* =24).

	Dependent Variables				
	Psych Safety	Team Learning	F	R^2	ΔR^2
Mediation analysis, Step 1					
Familiar Team		0.506**	7.569**	0.256	
Mediation analysis, Step 2					
Familiar Team	0.584***		11.37***	0.341	
Mediation analysis, Step 3					
Familiar Team		0.116	12.88***	0.551	0.295***
Psychological Safety		0.669***			

Notes: *, **, and *** denote signficance at the 10%, 5% and 1% levels, respectively.

Table 5. TMS mediation analyses with dependent variable of final hour score. Each mediation step contains a regression analysis. The table reports standardized coefficients (*n* =24).

	Dependent Variables				
	TMS	Final Hour Score	F	R^2	ΔR^2
Mediation analysis, Step 1					
Familiar Team		0.419**	4.677**	0.175	
Mediation analysis, Step 2					
Familiar Team	0.450**		5.586**	0.202	
Mediation analysis, Step 3					
Familiar Team		0.290	3.322*	0.240	0.065***
TMS		0.285			

Notes: *, **, and *** denote signficance at the 10%, 5% and 1% levels, respectively.

Table 6. TMS mediation analyses with dependent variable of learning rate. Each mediation step contains a regression analysis. The table reports standardized coefficients (*n* =24).

	Dependent Variables				
	TMS	**Team Learning**	**F**	**R^2**	**ΔR^2**
Mediation analysis, Step 1					
Familiar Team		0.506**	7.569**	0.256	
Mediation analysis, Step 2					
Familiar Team	0.450**		5.586**	0.202	
Mediation analysis, Step 3					
Familiar Team		0.447**	3.878**	0.270	0.014
TMS		0.131			

Notes: *, **, and *** denote signficance at the 10%, 5% and 1% levels, respectively.

Table 7. Mediation analyses with dependent variable of final hour score and controlling for TMS. Each mediation step contains a regression analysis. The table reports standardized coefficients (*n* =24).

	Dependent Variables				
	Psych Safety	**Final Hour Score**	**F**	**R^2**	**ΔR^2**
Mediation analysis, Step 1					
Familiar Team		0.290	3.322*	0.240	
TMS		0.285			
Mediation analysis, Step 2					
Familiar Team	0.461**		7.004***	0.400	
TMS	0.273				
Mediation analysis, Step 3					
Familiar Team		0.045	4.640**	0.410	0.17***
TMS		0.140			
Psychological Safety		0.532**			

Notes: *, **, and *** denote signficance at the 10%, 5% and 1% levels, respectively.

Table 8. Mediation analyses with dependent variable of learning rate and controlling for TMS. Each mediation step contains a regression analysis. The table reports standardized coefficients (*n* =24).

	Dependent Variables				
	Psych Safety	**Team Learning**	**F**	**R^2**	**ΔR^2**
Mediation analysis, Step 1					
Familiar Team		0.447**	3.878**	0.270	
TMS		0.131			
Mediation analysis, Step 2					
Familiar Team	0.461**		7.004***	0.400	
TMS	0.273				
Mediation analysis, Step 3					
Familiar Team		0.130	8.256***	0.553	0.283***
TMS		-0.057			
Psychological Safety		0.688***			

Notes: *, **, and *** denote signficance at the 10%, 5% and 1% levels, respectively.

Figure 1. Research Model for Team Familiarity, Psychological Safety, and Learning

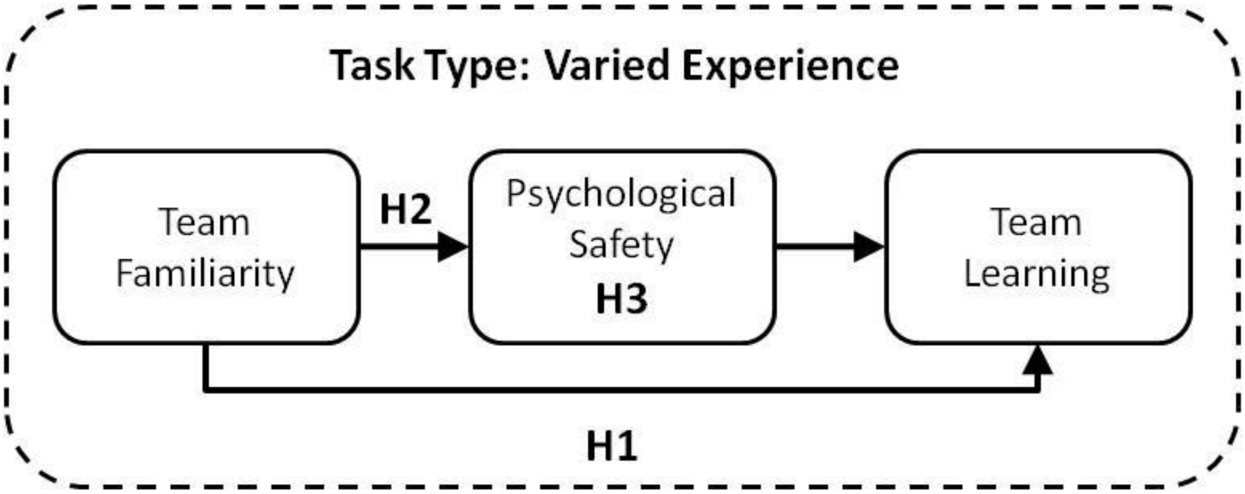
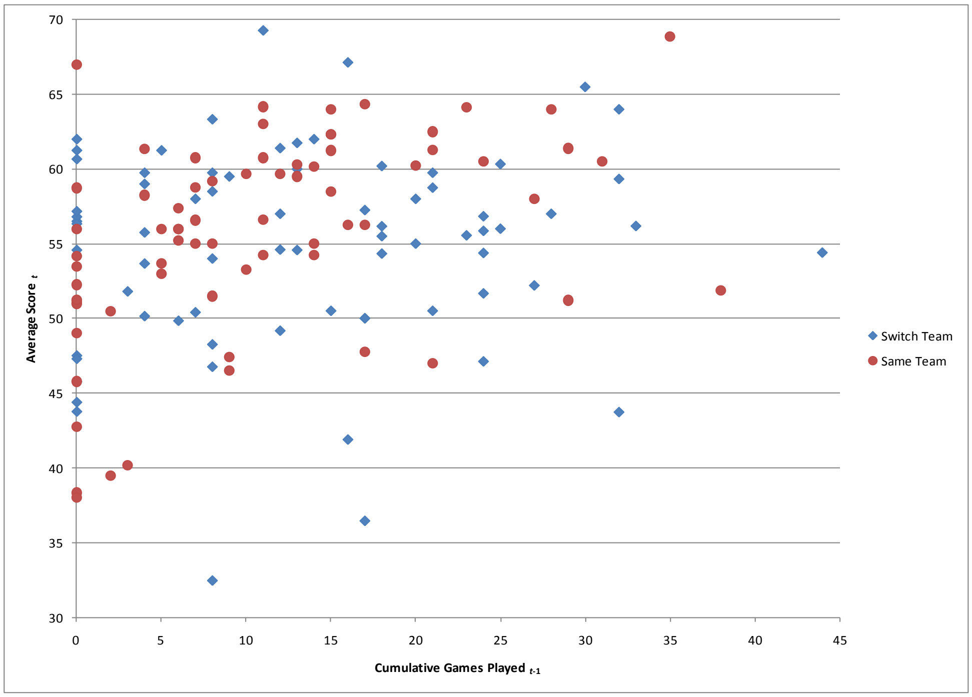
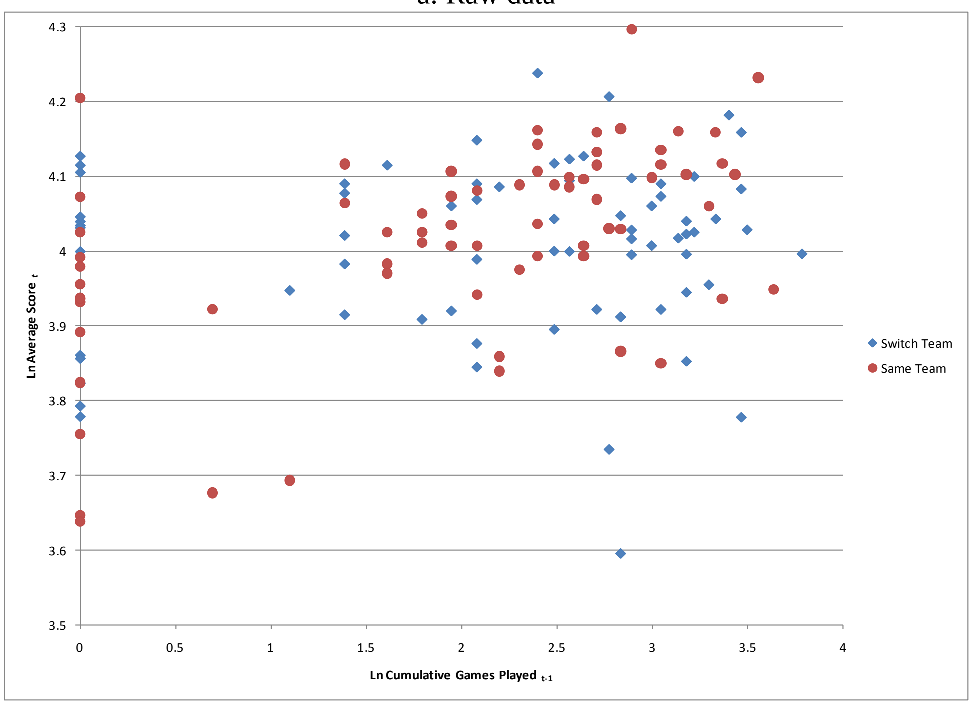


Figure 2. Scatter plot of average scores and cumulative games played.



a: Raw data



b: Log transformed data

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