Coordination in Teams: Evidence from a Simulated Management Game

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Keywords: coordination, teamwork, communication, shared cognition

Classification: research article

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3/22/2005

Draft 3.1.9
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ABSTRACT

Most research examining the influence of coordination on team performance has not distinguished between coordinating (the processes by which teams attempt to manage interdependencies among individuals) and the resultant state of coordination (the degree to which interdependencies are managed well). Similarly, most research has not distinguished between the state of coordination and the performance outcomes that are often influenced by coordination. We demonstrate the usefulness of these distinctions in a study of 50 teams engaged in a realistic 14-week management simulation. Results using a panel design show that two processes for coordinating (use of shared cognition about the distribution of expertise within the team, and working together for a longer time period) improved coordination. Shared cognition seemed to compensate for low levels of communication and lack of working together. The resulting coordination, in turn, directly influenced teams’ financial performance and external evaluations. All effects of the coordination processes, however, were indirect, and operated by helping the teams achieve a more coordinated state.
Groups are inherently different from individuals performing similar tasks because group members need to coordinate. Whenever the work of individuals is interdependent, they must manage these interdependencies to achieve success (Van de Ven et al., 1976). Malone and Crowston (1994) defined the process of coordination as the extra work individuals must complete when working in concert to accomplish some goal, over and above what they would need to do to accomplish the goal individually. To work together effectively, team members must coordinate their efforts in both broad and detailed ways. At the broad level, for example, a group developing a new product rollout must align goals. If the marketing manager is positioning a product as a prestige item, the engineering manager cannot skimp on quality. At a more detailed level, the team must assign tasks to the people most capable of doing them, hand off work products when others need them, and build components so that they interoperate, for example.

Although coordination has long been assumed by group and organizational scholars to be a component of group effectiveness, as Argote and McGrath (1993) note, there has been little systematic research examining the methods teams use to achieve coordination or the effects of coordination on performance. Recent research has started to fill this gap (Gittell, 2001, 2002; Hoegl & Gemuenden, 2001; Lewis, 2003), but this work has not clearly distinguished between two distinct aspects of coordination—the processes teams use to become coordinated and the resultant state of coordination. In addition, some work has failed to distinguish these two dimensions of coordination from the effects that the state of coordination has on team
performance and cohesion. This confusion may arise from the simple fact that the noun “coordination” is used in the vernacular to mean both “the act or action of coordinating” and “the harmonious function of parts for effective results” (*Merriam-Webster Online*, 2005), which often leads to misinterpretation in both reading and writing research about coordination.

These distinctions are important from a managerial point of view, because coordination processes are the levers teams can directly and indirectly manipulate in their attempts to improve coordination. Because coordination processes can be costly, teams should invest in them only if the resulting coordination results in higher performance. For example, in the management simulation we describe below, most teams met three to six hours per week to exchange analyses individual workers had conducted, plan work for the upcoming week, and set broad directions. These lengthy group meetings took time away from individuals’ analyses and writing, but the teams invested in them because they believed that they needed the resulting coordination to have coherent plans and presentations. If managers and organizational scholars do not distinguish among coordination processes, coordination as a state, and the production outcomes, they cannot make informed judgments about the types of investments that are valuable in setting up workgroups nor trace the mechanisms through which managerial decisions have their impact on production.

In this paper we attempt to clarify these distinctions, both conceptually and through confirmatory factor analyses. We then empirically examine several processes that teams in a managerial simulation used to achieve the state of coordination, concentrating on team communication, shared cognition, and tradeoffs between them. We show empirically that coordination as a state directly influences teams’ performance outcomes and that shared cognition can substitute for communication and experience working together in achieving
successful coordination.

Distinguishing coordination as a process, coordination as a state, and performance outcomes

Coordination as a process

When individuals are working together in a group, certain tasks can be carried out independently and therefore don’t need to be coordinated with those performed by other members. Other tasks are interdependent with the activities of other members, so teams must employ various coordination processes to manage these interdependencies (Malone et al., 1999). Managers and self-managed groups can avail themselves of a wide range of coordination processes when trying to manage interdependencies. Some, like the use of configuration management systems in software engineering or the employment of assembly lines in automotive manufacturing, are highly industry- and task-specific. Others, like communication and use of shared cognition, are quite general and can potentially be applied to many different types of groups performing different tasks. In this paper, we emphasize communication and shared cognition because of their generality. All teams use them in varying degrees to coordinate.

In terms of March and Simon’s classic distinction between mechanistic coordinating through planning and organic coordinating through mutual adjustment, unstructured interpersonal communication is an example of an organic coordination process (March & Simon, 1958). Individuals exchange information about their current states and adjust their behavior to others’ goals and actions (Thompson, 1967). When a bicyclist extends an arm to signal a left turn and catches a motorist’s eye to insure the signal was understood, they are coordinating through interpersonal communication. Groups can directly control how much they use
interpersonal communication as a coordination process. To increase interpersonal communication, they can schedule regular group meetings, locate team members in the same area to foster ad hoc meetings, and invest in telecommunication technology for communication at a distance (Olson & Olson, 2000).

In contrast, shared cognition is on the mechanistic end of the March and Simon continuum. Shared cognition is a belief held in common among members of a team about how each will behave. Like standard operating procedures and other pre-formed courses of action, shared cognition is a mechanism that allows members of a group to coordinate without explicit communication. Shared cognition is regularly used to coordinate in daily life. For example, motorists can move smoothly through an intersection with four-way stop signs if they all defer to the motorist on their right and believe that the others will do so as well. Similarly, visitors to Grand Central Station in New York can rendezvous with friends at the Biltmore clock without making explicit plans, if they believe the clock is a sensible landmark for meeting and think that their friends will believe this as well. Managers cannot mandate shared cognition in the same way that they can schedule group meetings. They can, however, make decisions to increase the likelihood that shared cognition will be available in a group, or to increase the degree to which it will develop. For example, they can select members with a common background (O'Leary et al., 2002; Ouchi, 1980), adopt personnel policies that discourage turnover (Katz, 1982), or invest in training regimes designed to foster common views, such as group training (Moreland et al., 1998) or cross-training (Volpe et al., 1996).

**Coordination as a state**

Although managers have some control over the coordination processes used in their organizations, they have less control over the resultant state of coordination—that is, the extent
Coordination in Teams

Coordination can be more or less successfully achieved. For example, in concurrent development projects, failures of coordination can consume up to 50% of the engineering capacity and up to one-third of the development budget (Terwiesch et al., 2002).

One can think of coordination in this sense as an index of group efficiency. When coordination is high, a unit of individual work translates into more or better team output. In contrast, when coordination is low, the same quality and quantity of individual work results in less or poorer group output, because of what Steiner (1972) terms process losses. Failures of coordination are characterized by redundant work, delays in production, and incompatibilities between intermediate outputs that will need to be redone before they can be integrated.

Research from the classic contingency theory tradition in organizational behavior demonstrates that identical coordination mechanisms can have different consequences depending upon the uncertainty of the task to which they are applied (Katz & Tushman, 1979). Although most of the early contingency research examined the direct link between coordination mechanisms and performance outcomes (Argote, 1982), it is likely that this link is mediated in part by the state of coordination the group has achieved (Gittell, 2002).

Performance outcomes

As the preceding paragraphs imply, effective coordination in a group should lead to better task performance, all else being equal. As Gittell notes, “Well-coordinated work processes are expected to produce higher quality outcomes, and to do so more efficiently” (Gittell, 2002, p. 1408). As Van de Ven and his colleagues argue (Van de Ven et al., 1976), members of an organization need to coordinate their work whenever their tasks are interdependent. In contrast, when tasks are not interdependent, the effort expended to coordinate is wasteful, and
coordination as a state should not lead to better performance. In the realistic management simulation we describe below, activities of individual team members are highly interdependent, and coordination is necessary for successful performance. For example, some sales organizations ran out of stock because the production manager failed to take into account sales estimates from the marketing manager. This is a failure of coordination. Coordination is not synonymous, however, with successful performance. Teams can fail if their members have insufficient skill, if they do not work hard enough, or if they pursue the wrong objectives, even if they successfully manage interdependencies. For example, in the simulation described below other teams ran out of stock because the marketing manager under-estimated consumer demand. This is a failure of individual decision-making, not of coordination.

**Comparisons to recent literature**

The previous discussion suggests the simple causal model adopted by Gittell (2001, 2002, 2000), in which the use of appropriate coordination processes leads groups to be better coordinated, which, in turn, contributes to their successful performance. Although this model and the distinctions between coordination processes, coordination state, and performance outcomes appear obvious, they do not characterize much of the recent literature on coordination in groups. We contrast our approach to recent work by Hoegl and his colleagues on teamwork quality (Hoegl & Gemuenden, 2001; Hoegl et al., 2004) and by Lewis (2003, 2004) on transactive memory. We also show how it clarifies the concept of relational coordination introduced by Gittell (2001, 2002), with which it otherwise shares many similarities.

Hoegl and Gemuenden (2001) have elaborated the construct of “teamwork quality,” which they consider a group state that leads to efficient and effective group performance. They treat teamwork quality as a latent construct with six components: (1) communication among
team members, (2) coordination as a state, (3) effort, (4) balanced contributions among team members, (5) team cohesion and (6) mutual support. Unfortunately, their model conflates cause and effect in the traditional input-process-output model of group effectiveness (Hackman, 1987; McGrath, 1984). For example, their model does not distinguish coordination processes (e.g., “There was frequent communication within the group”) from the resulting state of coordination itself (e.g., “The work done on subtasks within the project was closely harmonized”). This model may be descriptively adequate, showing co-variation among group processes and outcomes. However, it is not adequate as a causal model, because it conflates factors under direct and indirect managerial control (e.g., communication and effort) with intervening states (e.g., coordination) and these factors with others, including cohesion and member support, that many group theorists consider to be group outcomes (Hackman, 1987).

Lewis’ development of a measure of transactive memory takes a similar approach in conflating coordination processes with the intervening states produced by these processes (Lewis, 2003). Transactive memory is individual knowledge that is dependent on what others know. Supervisors exhibit transactive memory, for example, when they are able to give a presentation on a topic they know little about, by relying upon subordinates to brief them or to prepare the presentation material. Transactive memory is one mechanism used by groups to achieve coordination. By knowing who in a group has specific knowledge or skills, group members can find information easily and assign tasks to those best able to carry them out (Moreland & Myaskovsky, 2000). Lewis, however, does not distinguish transactive memory and the processes leading to it from coordination as a state, which may be caused by it. Her second-order transactive memory scale, for example, consists of both items measuring specialization, which is a mechanism to achieve coordination (e.g., “Different team members are responsible for
expertise in different areas”), and those measuring the state of coordination (e.g., “Our team worked together in a well-coordinated fashion”).

Our approach is most similar to that of Gittell’s recent work on relational coordination (2001, 2002, 2000), which distinguishes processes for achieving coordination from the coordination itself and the effects that coordination has on production efficiency and effectiveness. Gittell defines relational coordination as the management of task interdependencies carried out in the context of relationships with other group members. Her definition of relational coordination and her theoretical treatment of it as a mediator between coordination mechanisms (such as supervisory span of control, routines, boundary spanners, and team meetings) and team production outcomes, suggest that she considers relational coordination to be the state in teams which have successfully achieved coordination. However, her operationalization focuses on coordination mechanisms themselves, including frequent and timely communication, common goals, and mutual knowledge. In addition to items assessing the state of coordination and processes leading to it, her measure also includes an element of team cohesion (i.e., mutual respect and help), which many theorists (Hackman, 1987; McGrath, 1984) would consider to be a type of group outcome, analogous to production efficiency.

While these prior approaches are useful in describing the specific constructs they address (e.g., teamwork quality, transactive memory), they have theoretical and practical limitations in their ability to help us understand coordination in teams. At the theoretical level, these prior approaches do not appropriately specify causal models of the way that coordination is achieved and its effects, and, as a result, don’t provide an accurate description of how teams translate the work of their members into group performance. At the practical level, these approaches give managers little guidance on how to improve teamwork quality. Our work builds upon this recent
research by making these important distinctions between coordination processes, states and performance outcomes.

**Coordination Processes and State in a Management Simulation**

Our empirical research is based on the simple model described previously and illustrated in Figure 1. In this model, differential use of coordination processes in teams influences the team’s state of coordination—that is, the extent to which task dependencies are effectively managed. Level of coordination in turn influences performance outcomes. We focus on communication and use of shared cognition as coordination processes in this research, although we also include the time a group has worked together (team history) as a control variable. As explained earlier, managers can control communication, time working together and shared cognition to different degrees, with the former being under more direct control than shared cognition. All three of these coordination processes are earlier in the causal chain than is the resulting level of coordination and therefore more under managerial control. We expect that use of each of these coordination processes individually will improve coordination. That is, teams will become better coordinated when their members communicate more, have developed shared views of each other, and have worked together for a longer period. In addition, we expect that these coordination processes will compensate for each other. That is, shared cognition will improve coordination most among teams who communicate least or who have not worked

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1 Keeping a team working together is a coordination mechanism under relatively direct managerial control. Doing so often improves various coordination processes, including shared cognition (Liang, 1995) and communication efficiency (Krauss & Fussell, 1990), which in turn should improve a team’s level of coordination. However, the time a team works together is confounded with any other variables that change over time. In addition, working together can influence production outcomes through other mediators than improving the team’s level of coordination (L. Argote *et al.*, 1995; Goodman & Leyden, 1991). Because of these considerations, we treat time working together as a control variable in our models, although it has some characteristics of a coordination process.
together. Similarly, explicit communication will be needed to achieve coordination early in a team’s history and if team members do not have shared views of each other. Finally, all else being equal, teams that have become coordinated, by whatever mechanism, should be more successful in meeting their production goals.

In the remainder of this initial discussion we describe in more detail our specific hypotheses regarding coordination processes and trade-offs among them, and the effects of level of coordination on performance. We then examine these hypotheses in the context of a realistic management simulation, in which teams of MBA students manage a simulated consumer products company over a multi-week time period. We end with a general discussion of the implications of our findings.

**Coordination Processes**

*Communication.* Unstructured, peer-to-peer communication is perhaps the most basic way that members of teams coordinate their activities. A large literature in the management and organizational sciences shows that team members must have a substantial amount of interpersonal communication to be successful when performing tasks involving interdependency and uncertainty—characteristic of the management simulation that we describe below (e.g., Pelz, and Andrews, 1966; Thompson, 1967; Van de Ven et al., 1976). For example, in a recent study, Cummings (Cummings, 2004) showed that senior managers evaluated teams in a multi-national corporation more highly when the members communicated more with each other. Conversely, Kiesler, Wholey and Carley (1994) showed that novice software engineering teams failed when
they didn’t communicate enough. Although little of this research explicitly considered the state of coordination as an intervening variable between coordination processes and group output, we posit that communication influences team outcomes by improving their level of coordination.

_Hypothesis 1: More frequent communication among team members will lead to higher levels of coordination._

*Use of shared cognition about team expertise.* Contemporary theorists have added shared cognition, shared mental models and transactive memory to the list of cognitive mechanisms that teams use to coordinate implicitly (e.g., Fiore et al., 2001). By shared cognition we mean the beliefs in common that team members have about such topics as each other’s abilities, the tasks they must perform, team procedures, and the external environment (e.g., Mohammed & Dumville, 2001). In this paper, we concentrate on shared cognition about transactive memory (Hollingshead, 2000; Liang, 1995; Moreland, 1999), beliefs about the distribution of expertise in a group—others’ skills, knowledge, and the like.

Scholars have identified a number of ways in which shared cognition about team members’ expertise can help coordinate their activities. Knowing each person’s strengths and weaknesses increases the efficiency and appropriateness of task assignments (Liang, 1995; Moreland et al., 1996), allows the team to distribute information more efficiently (Larson, 1996), and enables people to consult the appropriate individuals for advice and guidance (Olivera, 1999). Once we know another’s area of expertise we can communicate more efficiently within this domain, by using specialized vocabulary and argot (Isaacs & Clark, 1987). Depending on how detailed the knowledge is, shared cognition about expertise allows groups members to anticipate the actions of others and to make adjustments in their own behavior in anticipation of others’ reactions (Blickensderfer, 2000).
Hypothesis 2: Shared cognition about the distribution of expertise within the team will lead to higher levels of coordination.

Team History. By team history we mean the length of time members have worked together. The research literature strongly suggests that team history—having team members work together for longer periods—is a mechanism that can make coordination more successful, although most of the prior literature has treated team performance as a proxy for the state of coordination. Team performance typically increases as its members work together for longer periods, at least up to some limits (Katz & Tushman, 1979). Training members in the group in which they will ultimately perform improves later performance more than training them in other groups (e.g., Hollingshead, 2000; Moreland et al., 1998). Even brief periods of work history improve performance (Kanki & Foushee, 1989). There are multiple underlying mechanisms for the familiarity effect, including the development of routines (Gersick & Hackman, 1990), improved communication and the development of common ground (Krauss & Fussell, 1990), and the development of transactive memory and other shared cognition (Moreland & Myaskovsky, 2000). Although we will not be able to isolate the mechanisms in the empirical study below, we hypothesize that team history will have a positive effect on the team’s state of coordination:

Hypothesis 3: As groups work together longer, they will become better coordinated.

Trade-offs Among Coordination Mechanisms

Because communication, shared cognition, and team history can all lead to better coordination, it is likely that they can compensate for each other and that all do not need to be used for teams to become coordinated. Indeed, there is evidence that overuse of coordination mechanisms when they are not necessary can harm team performance by deterring from the
work itself (e.g., Argote, 1982). Phrased another way, each of these coordination mechanisms is likely to be more valuable when the others are not being used.

**Trade-offs between communication and shared cognition.** Classic contingency theory suggests that it is precisely when shared cognition and organizational routines are insufficient for coordination that communication becomes important (Katz & Tushman, 1979). There are at least two reasons why shared cognition could substitute for communication to achieve successful coordination. First, as suggested previously, shared knowledge of who knows what allows team members to assign tasks and to anticipate others' actions with minimal communication. Shared knowledge about other topics (e.g., organizational routines) allows team members to coordinate their activities without explicit discussions about who should be performing a particular task. Second, shared knowledge of others’ skills and expertise constitutes a type of mutual knowledge or common ground, which improves the efficiency of communication (Clark & Brennan, 1991).

**Hypothesis 4:** Shared cognition will improve coordination most when teams are communicating least.

**Trade-offs between communication and team history.** Assuming constant environment and task, the longer a team has been working together, the less communication it may need to coordinate. Often, teams need to communicate extensively early on to set direction, when their task is more uncertain, but can reduce their communication later on, when they are executing their plans. The reduced need for communication during task execution, however, is likely to depend upon the nature of the task. In software engineering, for example, requirements analysis and other direction-setting activities, which occur early in the development cycle, involve intense communication across multiple stakeholders. However, later in the cycle some bug fixing and redesign can often require intense communication (Curtis, 1988). In the managerial simulation
used for the site of the research reported here, the strategy-setting early in the simulation required
more communication than its execution. Teams spent substantial time early in their lifecycle
discussing the pros and cons of being a low-cost provider or a high-price, high-quality provider
of consumer goods. Once they made this decision, this set the direction that individual team
members followed (e.g., the VP for Research and Development searched for formulae that
allowed the team to produce products of acceptable quality with the least expensive ingredients).
In addition, over time, teams devise standard operating procedures or routines, such as weekly
meeting times or responsibilities for tasks, that allow them to handle recurrent problems without
explicit communication (Gersick & Hackman, 1990). Finally, as groups work together they
develop common ground that they can draw upon for more efficient communication (e.g., Isaacs

Hypothesis 5: Communication will improve coordination the most early in a team’s
history.

Trade-offs between shared cognition and team history. Although team members’ shared
cognition about each others’ knowledge and competencies is likely to grow over time (e.g.,
Gabarro, 1990; Orasanu & Salas, 1993), the need for this type of shared cognition is strongest
early in a team’s history, as they make decisions about task assignments. Later on, more
coordination can occur through the routinization of tasks and standard operating procedures that
develop as teams work together.

Hypothesis 6: Shared cognition about team member’s expertise will improve
coordination the most early in a team’s history.

Effects of Coordination on Performance Outcomes

If the state of coordination is the successful management of task interdependencies and is
one influence on a team’s efficiency, one would expect that better-coordinated teams would be more successful in their performance outcomes. Theory predicts that highly interdependent teams of the sort we are examining in this research need to coordinate to manage the interdependencies among their tasks (Van de Ven et al., 1976), and Gittell’s recent empirical research shows that successful coordination does increase performance for a variety of tasks (Gittell, 2001, 2002; Gittell et al., 2000). Although coordination is not the only factor leading to successful performance, all else being equal, one would expect that better coordination would improve a team’s overall performance.

_Hypothesis 7: Groups will be more successful in their primary, production tasks as their state of coordination improves._

**Method**

**Setting and participants**

We examined our hypotheses in the context of a realistic business simulation called the _Management Game_ (Cohen et al., 1964). Participants consisted of 277 MBA students, organized into 50 teams. Students had from zero to 27 years of prior work experience (M = 4.62; sd = 3.12). Approximately one-third were women.

Teams of 5 or 6 MBA students competed with each other in managing simulated consumer products companies over a 14-week period. During the first seven weeks, students organized teams and learned about the simulation, and during the second period they actually played the game and competed against each other. Students were placed on teams through a two-stage draft. First, students exchanged resumes describing skills, task preferences, and work experience. Based on a popular vote, the class as a whole elected 50 team presidents. These presidents subsequently selected members for their teams through a round-robin draft.
Students during a simulated two-year business period acted as the senior managers of a consumer products company based on Procter and Gamble. They made decisions regarding the nature, production, distribution, and financing of laundry detergents. For example, they decided what combinations of price, cleaning power, and environmental friendliness their detergents should have, what manufacturing capacity to maintain, how much to manufacture, where to market, whether to sell to the wholesale market, whether to offer stock dividends, and whether to settle or fight a class-action discrimination suit. They negotiated labor contracts with experienced union negotiators. During three separate reviews, each team presented its company’s strategies and accomplishments to its own board of directors, composed of local business executives. As individuals, all students participated in a stock market, trading shares of the other companies to amass personal wealth.

Except for the position of the president, teams had discretion on how to organize internally. Most adopted a functional division of labor, with different individuals responsible for the core functions of research and development, finance, marketing, production and the presidency. Each team member was responsible for finding, analyzing, and drawing conclusions from a large body of information, which had to be integrated with information gathered by members in other roles to make decisions. For example, early in the simulation, Vice Presidents for Marketing typically decided how much money to spend on market research about consumers’ preferences and interpreted the results. The Vice Presidents for Finance were responsible for managing debt and preparing financial projections for the board of directors.

Responsibilities for acquiring and analyzing other information were more diffuse. For example, most team members were involved in the basic strategic decision to produce a low cost/low quality product or a high cost/high quality one. In addition, most team members
examined publicly available financial data about other firms and sought out classroom gossip to assess their competitors’ strategies. Most business decisions they made were highly interdependent, requiring tight coordination among team members. For example, marketing decisions about consumer preferences had to be integrated with research and development information about product formulas and production decisions about plant capacities.

Approximately twice a week teams made business decisions for that period (e.g., about spending on market research, the pricing of products in different markets, the attributes of products, the level of production in several factories, the sources of financing for their operations, etc.). The decisions made by competing teams were input to a computer simulation that provided feedback to students about their business performance—stock outages, costs, sales, market share, and profitability.

Each team met with its board of directors three times over a seven-week period. Each board of directors consisted of four or five business executives or managers. In preparation for each meeting, the teams wrote 15-25 page strategic plans and operational reviews, and they presented their plans and reviews to their boards during multi-hour, highly interactive meetings. The boards of directors approved major capital decisions and set compensation for the team. At the end of each meeting, they evaluated the team and its members on several Likert scales. These evaluations were a major component of students’ grades.

Team members communicated both synchronously (through scheduled face-to-face meetings, telephone calls, and impromptu discussions in corridors) and asynchronously (through email and file sharing). Because team members had different work and class schedules, teams worked in a distributed manner much of the time.
Measures

Because the teams prepared for and played the simulation over 14 weeks, we were able to collect longitudinal data, which allowed us to examine developmental processes and to test causal paths using panel designs and path analysis. Teams are the unit of analysis for this study. Some variables (e.g., a team’s profit or stock price) can only be measured at the team level. Other variables (e.g., team members’ assessments of coordination or board members’ evaluations of team performance) represent individual respondents’ assessments of the team as a whole. The data came from three sources: student surveys, board of directors’ assessments of team performance, and objective financial performance from simulation results.

Student Surveys. Participants completed voluntary surveys assessing their teams at three points during the simulation: at the end of the first 7-week period, halfway through the second 7-week period, and at the end of the simulation. The second survey preceded the teams’ second presentation to their boards of directors and the third followed the third board presentation. Of the 277 students, 74% completed the first survey, 77% completed the second, and 67% completed the third. We first conducted one-way analyses of variance to establish that teams explained variance in these assessments, and then calculated team-level measures by taking the mean of the individual members’ ratings. The interclass correlation was sufficiently high (p < .15) for all self-reported measures described below to justify analyzing the data at the team level (Kenny & Voie, 1985).

For each time period, we calculated team-level data from any team where at least 3 members filled out a survey. This represents 49 teams at time 1, 50 teams at time 2 and 47 teams

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2 We would have liked to have collected data more frequently, especially during the first few weeks of the teams’ existence, when teams were most rapidly developing plans and shared cognition, but this was operationally impossible.
at time 3. When teams had fewer than three responses, we imputed missing values for teams within time-period, using expectation-maximization techniques (SPSS, 1997). Although significance levels change slightly, none of the results that we present below changed qualitatively when we limited the analysis to teams with no missing values or when we included all teams with at least two non-missing surveys per time period. We included the following measures, based on self-reported survey data.

**Communication frequency.** Team members indicated the frequency with which they communicated with each member of their team using a 6-point scale, ranging from never to multiple times per day. Estimates were averaged across partners and then across respondents to compute an index of communication between the pairs within a team.

**Shared cognition about expertise.** Each member of a team rated him or herself and every other team member on four areas of knowledge relevant to the simulation: *strategy* (“understood how to position your team’s products in the regions”), *marketing* (“understood the relative impact of marketing decisions – e.g., advertising, sales force, pricing, etc.”), *finance* (“understood how to project cash flows under different scenarios”), and *production* (“understood how to increase the efficiency of production and distribution of products”). We calculated the average correlation between pairs of respondents judging the same target across the four knowledge dimensions. This is equivalent to estimating the reliability of judges’ assessments (Rosenthal, 1982). This metric represents overlap of beliefs about who knows what, and controls for biases in the use of rating scales (Cronbach, 1955). We used this correlational measure of shared cognition because we believed that coordination in a group would be influenced by members’ agreement about the relative expertise of each other on these four dimensions (e.g., who is most knowledgeable about finance or production). Relative judgments determine who
one would ask for help on a task or assign to a particular activity. We explicitly decided not to use R_{wg} (James et al., 1984), because the R_{wg} compares absolute judgments and penalizes groups whose members have different mean values when using a scale.

In general this shared cognition about expertise was moderately accurate, in the sense that the average Pearson correlation between group members' evaluation of a target's knowledge and the target's self-assessment was .44 (p<.001).

Coordination. The questionnaire included scales that previous investigators had developed to measure coordination (Cammann et al., 1983; Van de Ven et al., 1976). We also included new questions that we had constructed to assess the adequacy of the team’s ability to relate tasks and share information needed for decisions. An exploratory principal components analysis with varimax rotation of the individual level data from the first questionnaire administration showed that most of the 12 items originally intended to measure coordination loaded strongly on the first two factors, representing positively and negatively worded items. These factors explained 44% of the total variance. We eliminated 2 items which did not load at least .40 with either factor and whose communalities were below .40.

Confirmatory factor analysis using data from all three waves of the questionnaire showed that a solution with two correlated factors representing positively and negatively worded items was the best fit to the data (e.g., Comparative Fit Index = .93), with a similar factor structure across the three waves.

Table 1 represents the resulting 10-item coordination scale. It includes agreement with statements that tasks were coordinated, that goals, tasks and schedules were clear, and that members could get the right amount of information in a timely way, and disagreement with
statements that individuals duplicated work and disagreed over responsibilities and plans\textsuperscript{3}. We constructed the scale by reversing negatively worded items and taking the average.

Financial performance. Teams submitted decisions on approximately 70 different variables (e.g., the investment in automation they would make in their factories), and the game simulation used this data to calculate a number of financial indicators for each simulated quarter for each firm. We use profits as the primary measure of financial success, directly calculated by the simulation. Profits represents the gross income the team received from sales (price times quantity sold) minus the cost of goods sold and operating expenses, including salaries, transportation, research and development and marketing. Because profits are contingent on sales, we include sales (quantity sold) as a control variable when predicting profits in the analyses below.

The second financial outcome was the team’s stock price. Students traded shares of the companies in the game on a stock market, and a particular company’s share price was based on this market. Each student started the simulation with an equal number of shares in all firms with which they were not competing, and bought and sold shares over the 7 weeks during which the simulation was actively running. Thus, at any time, a firm’s stock price represented the collective judgment of participating students about how much the firm was worth, based on its past performance and future prospects.

\textsuperscript{3} A reviewer suggested that items 2 and 7 in Table 1 represent measures of conflict, rather than lack of coordination. We conducted a supplementary confirmatory factor analysis, to discover whether separating items 2 and 7 into their own factor improved model fit. Including a third factor reduced the comparative fit index from .93 to .85, (for the difference in $\chi^2$, p < .001). These results suggest that the all negatively word items cluster together, with the items mentioning conflict in goals and division of labor not being distinct from the item mentioning duplication of effort. We also conducted supplementary analyses, similar to those reported below, using an 8-item coordination scale, omitting questions 2 and 7. Results and conclusions are substantively the same using either the 8 or 10-item coordination scale.
Board Evaluations. Each team’s board of directors evaluated the team, based on their presentations and reports and the strategies they intended to use in the next period, as well as on objective performance data such as sales, market share, profitability, and stock price. Boards made their judgments by indicating their level of agreement with statements such as “The team is very likely to meet its financial and marketing objectives,” “The team has predicted the reactions of its competitors to its strategy,” and “Compared to other strategic plans and reports that I have read, this one is … [7-point Likert scale, with endpoints of ‘unacceptable’ to ‘outstanding’].” Principal components analysis identified only one dimension underlying their judgments, reflecting overall favorability of evaluation.

The board evaluation is the mean of multiple evaluation questions, averaged over board members. The average reliability of this measure across all judges for a team was high for all three time-periods (alpha = .80, .84 and .89 respectively).

The financial performance data were collected three times during the 7-week period in which teams were actively playing the simulation. For the first and second waves, measurement of the financial performance followed the team’s self-reported questionnaires and the evaluations by their boards of directors. For the third wave, financial performance was measured before the final board evaluation, at approximately the same time as students were completing their final surveys. The financial outcome variables were all moderately correlated (see Table 2).

Statistical techniques

The regression analyses we report below use the method recommended by Cohen and Cohen (1983) for dealing with analysis of change and were analyzed by an equation of the following form:
\[ Y_t = \text{Intercept} + Y_{t-1} + X_{at} + X_{bt} + X_{ct} + \ldots \]

This analysis examines the effects of predictor variables \((X_a - X_n)\) measured at one time period (e.g., team coordination as reported on the second questionnaire) on a dependent variable, \(Y_t\), measured at approximately the same time (e.g., board evaluations at second board meeting) while holding constant the value of the dependent variable, \(Y_{t-1}\), at the prior period (e.g., board evaluation at the first meeting). Because the lagged dependent variable is included among the regressors, the independent variables are predicting variance in the dependent variable that is not predictable from its value at the earlier time period. Therefore, this analysis is equivalent to an analysis of change scores on the dependent variable, controlling for regression towards the mean, unreliability, co-variation between the predictor variables and the outcome measured at an earlier time, and other statistical artifacts (Cohen & Cohen, 1983). In the example described in this paragraph, one can interpret the regression coefficient associated with coordination as an estimate of the extent to which teams’ current state of coordination predicted changes to its board evaluations from the last period (or more accurately, predicted variation in board evaluations at one period that was not predictable by evaluations a few weeks earlier).

Because we included a lagged variable in the analyses, each team contributed only two observations to this analysis (i.e., observations from \(T_2\) and \(T_3\)). Since the errors in these observations are not independent, violating assumptions of ordinary least squares regression, we analyzed data using the cross-sectional, time series regression procedure (\texttt{xtreg}) in the Stata statistical package (StatCorp, 2001), with a design that modeled teams as a random variable. This analysis accounts for the non-independence of the multiple observations per team.

We standardized continuous variables for the analyses. We included time as a control variable and as a proxy for team history. We coded time to be minus one for the first
questionnaire, zero for the second questionnaire and one for the third. All terms were centered prior to computing interactions, to reduce multicollinearity between main effects and interactions and to eliminate problems of scale invariance with second-order terms (Aiken & West, 1991.). The consequence of centering continuous variables and of coding for time this way is that the intercepts in the regression equations represent the mean value of the dependent variables at the second time period, when all independent variables are at their mean levels. The hypothesized substitution effects can be observed when these interaction variables are negative (i.e., when the value of one variable is small, the effect of the other variable is stronger).

Tables 3 and 4 present the results of these analyses. In Table 3, the coordination processes of communication, shared cognition, and time and their interactions were used to predict the coordination scale (i.e., the achieved state of coordination). Then, in Table 4, the state of coordination was added to the coordination processes to predict the performance outcomes. Figure 4 is a path analysis, summarizing the results relevant to our hypotheses. We constructed the path model from the standardized regression coefficients rather from a structural equation model, such as LISREL, because the small sample size of 50 teams did not allow estimation of both measurement and casual parameters in a single model.

Results

Preliminary analyses

Table 2 shows the means, standard deviations, and standard errors of the mean for all variables before standardization at the three time periods. It also shows their test-retest reliabilities and the cross-sectional correlations among the variables after being averaged across all time periods.
Coordination Mechanisms

The empirical goals of this research were to investigate the way in which different coordination processes influenced a team’s state of coordination and the way in which this state of coordination influenced performance outcomes. In the current section, we consider coordination processes predicting coordination as a state; in the next section we examine the effects of coordination as a state on team performance measures.

In Table 3, Model 1 shows the results for the main-effects analysis predicting coordination. As one would expect, coordination at one time period predicted coordination at the next ($\beta=.35$, $p<.001$).

Hypothesis 1, that frequent communication would lead to better coordination, was not supported. Teams whose members communicated extensively did not grow more coordinated than those who had substantially less communication ($\beta=.04$, ns). As we discuss in more detail below, however, communication did improve coordination among teams with little shared cognition.

Hypothesis 2, that shared cognition about the distribution of expertise within the team would lead to greater coordination, was supported. Coordination increased more among teams with more similar assessments of each other’s knowledge (in Model 1, $\beta=.24$, $p<.01$).

As predicted by Hypothesis 3, coordination increased as teams worked together longer (in Model 1, $\beta=.35$, $p<.025$). On average, teams increased their coordination approximately one-third of a standard deviation between administrations of the questionnaire, holding constant coordination during the prior period. This is a moderate effect size.
Model 2 in Table 3 adds the 2-way interactions, to examine trade-offs among coordination mechanisms. Consistent with Hypothesis 4, shared cognition and communication seem to be able to substitute for each other ($\beta = -.25, p < .025$). The interaction plot in Figure 2A shows that communication predicted changes in coordination among teams with low shared cognition, but did not predict changes in coordination among teams with high shared cognition.

There was no support for Hypothesis 5. Communication did not have stronger effects on coordination early in a team's history. However, consistent with Hypothesis 6, shared cognition did have stronger effects on level of coordination early in a team’s history ($\beta = -.55, p = .01$). The interaction plot in Figure 2B indicates that early in the teams’ history teams with high shared cognition were more coordinated than those with less shared cognition, but by the end of the simulation, low- and high-shared-cognition teams had equal coordination.

**Effects of Coordination on Team Performance**

Table 4 shows the effects of coordination and the processes that produce it on three measures of team performance. Because the performance measures are interdependent, in these analyses we include causally prior financial outcomes in the models of performance, as control variables. Profits depend, in part, on a firm’s sales. Investors rely upon a firm’s current profits to predict its future performance; therefore stock market price is dependent upon profits. Finally, boards of directors, representing shareholders’ interests, are influenced by these financial performance measures.

To summarize the major results to be reported in more detail below, performance
outcomes—profits, stock price and board evaluations—improved most during periods when the teams were more coordinated, holding constant previous performance and causally prior performance outcome variables. Neither frequency of communication nor shared cognition, however, directly influenced performance outcomes.

Insert Table 4 About Here

**Profits.** Model 3 shows profits as the dependent variable. Profits declined with time, as the game became more competitive ($\beta = -.31$, $p < .05$). Firms with larger sales were more profitable ($\beta = .68$, $p < .001$). Consistent with Hypothesis 7, more coordinated teams improved their profits more, even holding constant profits in the prior period and sales\(^4\) in the current period ($\beta = .33$, $p < .01$).

**Firm Price.** Model 4 shows a firm’s stock price as the dependent variable. Stock prices increased with time ($\beta = .57$, $p < .001$). In part this increase was driven by the law of supply and demand, as the amount of cash in the simulated economy increased over time while the number of stock shares remained constant. A company’s previous stock price was a good predictor of its subsequent stock price ($\beta = .69$, $p < .001$). In addition, firms that were more profitable had larger increases in their stock price ($\beta = .46$, $p < .001$). Holding these financial variables constant and consistent with Hypothesis 7, teams that were more coordinated had larger increases in their

\(^4\) A model treating sales as the dependent variable finds that only sales in the prior time period predict current sales ($\beta = .45$, $p < .01$). In particular, neither time, communication frequency, shared cognition nor their interactions predicted sales, once sales in the prior time period were controlled. [I know you mean the concept of “sales in the prior time period” but it’s too weird to have “sales” in the singular.]
stock prices ($\beta = .17, p < .05$). That is, classmates, whose bidding determined a firm’s stock price, seemed to value the coordination that a team exhibited, over and above the impact of that coordination on the teams’ profits.

*Board Evaluations.* Model 5 shows the board of directors’ evaluations of the team as the dependent variable. Board evaluations tended to be stable, with teams that received a high evaluation at one time tending to receive high evaluations at subsequent times ($\beta = .46, p < .001$). In addition, the boards were sensitive to objective measures of performance, giving higher ratings to teams with higher profits ($\beta = .31, p < .01$) and stock prices ($\beta = .19, p < .05$).

Consistent with Hypothesis 7, independent of past evaluations of the team and the team's objective performance, a team's current level of coordination predicted changes in boards' evaluations. Teams that reported themselves as more coordinated improved their evaluations more than less-coordinated teams ($\beta = .18, p = .01$).

*Mediation or indirect effects.* The coefficients shown in Tables 3 and 4 and summarized in Figure 3 represent a path analysis (Wright, 1921) of the hypothesized causal relationships among variables in this study. The path model shows that coordination processes—communication and shared cognition about expertise—influenced performance outcomes indirectly, by influencing coordination. A follow-up analysis to supplement those presented in Table 4 tested whether coordination mediated any direct relationship between coordination mechanisms and team performance (Baron & Kenny, 1986). This test examines whether the direct relationship between an independent and a dependent variable is significantly reduced when the presumptive mediator is entered into the equation. As seen in Table 1, neither communication nor shared cognition had a significant direct correlation with either profits or stock prices. Because there is no direct relationship, coordination cannot mediate it. However, as
seen in Table 1, shared beliefs about the distribution of expertise in a team was significantly correlated with the board’s evaluation of the team ($r=.27, p<.05$). Comparison of Model 6 in Table 4 with a similar model excluding coordination, however, shows no evidence of mediation. The relationship between shared beliefs and board evaluations, once communication, time and the financial performance variables were included in the equations, were small and non-significant and did not change reliably whether coordination was included in the equation ($\beta = -.07, p = .51$) or not ($\beta = -.01, p = .88$). Thus, variables measuring coordination mechanisms had indirect effects on a team’s performance outcomes, operating only through their influence on coordination.

**Discussion**

There are both theoretical and empirical conclusions to draw from this research. At the theoretical level, the research illustrates the value of differentiating processes producing coordination from the state of coordination itself. The coordination processes examined here—communication, use of shared cognition about expertise, and experience working together—were associated with teams becoming more coordinated. This state of coordination, in turn, influenced teams’ financial performance and the evaluations that boards of directors accorded them. In terms of task performance, the precise ways in which teams became coordinated were less important than the degree of coordination they ultimately achieved. That is, had we measured the extent to which teams developed routines (e.g., regular meeting times) or used technologies that should improve coordination (e.g., document repositories or shared websites that help them to identity and manage changes to documents), we believe these coordination techniques would have improved their coordination, and that the improved coordination would in turn have had positive consequences for their production outcomes.
Our conclusions at this level are similar to Gittell’s (Gittell, 2002): Coordination mechanisms have their influence on production efficiency and effectiveness by increasing the group’s abilities to manage task interdependencies. The main difference between this study and Gittell’s work is the way we operationalized the state of coordination. The highly reliable coordination scale we developed narrowly measures team members’ assessment of their success at managing dependencies (e.g., “People in this team were able to do their jobs without getting in each others' way”). In contrast, Gittell’s relational coordination scale is more diffuse, measuring communication (e.g., How often do you communicate with people in these groups?”) and shared cognition (e.g., How much do these groups know about your job?”), both of which we consider to be coordination mechanisms or processes that lead to coordination. It also measures team affect (“How much respect do you get from people in these groups?”), which we consider to be a relational outcome of team performance rather than the management of interdependencies. Thus, while we agree with Gittell’s theoretical stance, we disagree with the way she measured the state of coordination.

At the empirical level, the research illuminates two of the mechanisms that teams use to become coordinated and how these mechanisms compensate for each other. In particular, the research sheds new light on the role of shared cognition in influencing coordination, a concept about which there has been much theorizing but little empirical evidence. Shared cognition appears to allow groups to coordinate their activities with reduced communication and less experience working together.

**Coordination processes**

To summarize the empirical results concerning coordination processes, this research shows that teams became more coordinated when they had higher levels of agreement about the
distribution of expertise (i.e., shared cognition) and as they worked together longer. Shared cognition had larger effects on coordination during periods when communication among team members was low and early in the team’s history (i.e., during the second time period, when for the first time teams were playing the simulation competitively and formulating their strategies, rather than during the third period, when they were executing existing strategies). Contrary to our predictions, however, there was neither a main effect of communication frequency on coordination nor an interaction of communication frequency with a history of working together.

Although we measured shared cognition in the domain of transactive memory—agreement about the distribution of expertise—we are not certain how crucial the domain is to our results. Shared cognition about expertise probably facilitated task assignment, information distribution, advice-seeking, and the like. We expect that shared cognition about other relatively slowly changing aspects of a team’s internal environment besides expertise would operate in the same way and have similar influences on coordination. For example, shared cognition about the team’s strategies or about the appropriate analyses to apply to data could also have helped teams become more coordinated. We expect that the impact of shared cognition on coordination would have been stronger had we measured these beliefs earlier in the teams’ histories.

On the other hand, it is unclear how results obtained from examining shared cognition about expertise would generalize to shared cognition about more rapidly changing features of the internal team environment, such as others’ time availability (Perlow, 1999), or to shared cognition about the external environment, such as the behavior of competitors, which Endsley and her colleagues describe as situational awareness (Endsley, 1995, 2000; Jones & Endsley, 2002). We suspect that sharing rapidly changing situational awareness would be more important
for coordination than sharing transactive memory, but that the importance for shared situational awareness would not be concentrated early in a team’s history.

The failure to find a main effect of frequency of communication on coordination is in contrast to studies reviewed earlier, which demonstrated the value of communication for team performance. In our research, communication influenced coordination only when shared cognition was low. Although more communication is typically associated with better coordination and performance, this relationship is not inevitable. Because communication takes time and effort, which group members could use to perform their individual tasks (Perlow, 1999), excess communication could harm performance. Therefore we conducted a supplementary analysis to determine whether communication frequency had a curvilinear relationship with coordination. There was no increase in R-squared when the squared value of communication frequency was added to Model 2 in Table 3, and the coefficient for the curvilinear component of communication was not statistically significant. Thus there was no evidence from this study that lower-performing teams were communicating “too much.” We also conducted a supplementary analysis to determine whether lack of coordination led teams to increase their communication. We found that although communication increased between waves two and three ($\beta = .78(.19), p<.001$), coordination did not predict these changes in communication ($\beta = .02(-.07), p=.88$). This conclusion comes from a regression analysis predicting current communication from current coordination, controlling for communication, shared cognition and coordination in the prior period.

Perhaps the most interesting empirical results from this research involve the trade-offs among coordination mechanisms in producing coordination. Our data showed, for example, that shared cognition had larger effects on coordination early in a team’s history. These results are
consistent with prior research findings and theory that alternate methods of achieving coordination are substitutes for each other, at least to a degree. For example, in controlled laboratory experiments, Isaacs and Clark (1987) have demonstrated that similarity in expertise and a history of interaction substitute for each other in leading to efficient communication.

The statistical interaction between shared cognition and communication frequency on predicting a team’s level of coordination is interesting in its own right and may help explain the influence of communication on coordination. As Figure 2A illustrates, shared cognition improved coordination most when teams were communicating infrequently. This result is consistent with theorizing by Stout, Cannon-Bowers, Salas, & Milanovich (1999), that shared cognition should allow groups to coordinate with less explicit communication. An alternative way to frame the interaction is that heavy communication was most beneficial when teams had little shared cognition. That is, shared cognition and communication seem to be alternate ways of achieving coordination. Teams were relatively coordinated when they had adequate communication, or shared knowledge of each others’ expertise, but having both communication and shared cognition did not improve coordination further. It is important to understand more fully the developmental process by which shared cognition can substitute for other means of coordination. The research reported here collected data on teams over time. However, because we were unable to collect data immediately after the teams formed and we collected data at only three time periods, we do not have sufficient temporal resolution to determine in detail how these tradeoffs evolved.

We included time in our analyses as a control variable as well as a proxy for the effects of familiarity, efficient communication and routines, all of which develop as teams work together. As a result, we do not know the theoretical meaning of the time coefficients in our regression
models. The finding that time was associated with increases in coordination is consistent with Hypothesis 3, that teams improve performance as they work together, at least to some limit (Katz, 1982). It is possible, however, that the improvement in coordination over time may be caused by any number of other unmeasured factors that vary with time, such as the shifting nature of the tasks the teams needed to perform or the greater skill that team members develop in performing their individual assignments. Even under the assumption that work history and not time in general was responsible for improvement in coordination, there are multiple routes by which work history could improve coordination. Part of the improvement probably occurs because individuals perform better when they are more familiar with many features of their work environment, including tools, the physical environment, and the people they work with (Goodman & Leyden, 1991). Surprisingly, however, teams’ knowledge about the expertise of other members did not increase over time. Neither shared cognition (i.e., the average correlation among team members’ judgments) nor accuracy (i.e., the average correlation between team members’ judgments and a target’s self-assessment) increased over time ($r = -0.05$ and .12 respectively). These findings are reminiscent of Levesque, Wilson and Wholey’s findings (Levesque et al., 2001) that shared cognition about many aspects of a team’s environment does not necessarily increase with time, in part because the emerging division of labor in teams exposes team members to different environments. Alternately, it may be that shared cognition did not increase with time because we measured shared cognition too late in the team’s evolution, after it had already stabilized. The first questionnaire was collected after team members had practiced together for seven weeks of the 14-week simulation, but before the main activities of the simulation had occurred.
Part of the improvement in teams’ coordination with time probably occurs because groups become more efficient in communication as they work together (e.g., Kanki et al., 1991). In addition, we believe that part of the improvement occurs because groups develop standard operating procedures as they work together longer (Gersick & Hackman, 1990). One limitation of our research is that we did not directly measure efficiency of communication or the development of standard operating procedures, and therefore cannot definitively point to their role in improving coordination over time.

The negative interaction between shared cognition and time is consistent with suggestions by Moreland, Argote, and their colleagues that shared cognition about expertise has its impact on group performance primarily by facilitating task assignment (Liang, 1995; Moreland et al., 1996). Early in their history, when many tasks were new, teams need to understand each other’s skills and abilities in order to match team members to these tasks. For example, in the present simulation, team members needed to assess who was most knowledgeable about finance or production before assigning members to executive roles, and they needed to know who was most computer-savvy and could program spreadsheets in order to assign someone the task of uploading data. It is likely that later in their history, these assignments would have been routinized as part of the team’s standard operating procedures, and teams no longer needed to explicitly consider distribution of expertise.

**Coordination as State**

Consistent with Hypothesis 7, teams that were better coordinated had better performance outcomes for the measures of profits, stock price, and board evaluations. These measures are correlated, because they are causally linked to each other in ways consistent with standard economic theory. The effect of coordination on these outcomes remains even when relevant
economic precursors are controlled. For example, coordination improves profits, even after controlling for sales, which itself was a major determinant of a team’s profit. This finding suggests that teams can wring greater profits from a comparable level of sales when they are more coordinated. For example, more coordinated teams might charge more for their product in regions where consumers were relatively insensitive to price or where they particularly appreciated some product feature, like environmental friendliness. This type of decision-making, though, depends upon the different specialists within a team sharing information effectively and developing a common view of strategy. Similarly, more coordinated teams could react quickly to price changes by competitors, thereby retaining their own competitive position. They could control costs by avoiding stock outs, by selling their products in regions close to their factories to reduce transportation costs, by maintaining efficient plant capacity, or by advertising only in regions where consumers were sensitive to this type of marketing. Increasing revenues or reducing costs through these methods required decision-making and execution involving multiple team members. It appears that better-coordinated teams were able to integrate information across functional areas to make and execute these business decisions.

A team’s coordination influenced its stock price over and above its influence on the team’s sales and profits. Because stock price is a direct effect of fellow students’ buy and sell decisions on a team’s stock, it reflects these students’ assessment of the management team. These decisions could be influenced by direct observation and classroom scuttlebutt.

A team’s coordination influenced its board of directors’ evaluations over and above its influence on the team’s financial performance, as measured by sales, profits and stock prices. One reason is that by reading planning documents and observing meetings, board members had direct access to information about the team’s state of coordination. In particular, board members
could directly evaluate the quality of the management team, the coherence of their strategy, their future plans to deal with competitors and how well they supported each other during meetings. These signs are likely to be directly influenced by a team’s state of coordination.

Limitations and Future Directions

Inferring causation. Our theoretical model in Figure 1 and the summary of results in Figure 4 represent the relationships among variables as unidirectional. Methodologically, we have used panel data to infer the direction of causation. In general, self-reported measures of group process were collected before measures of group performance, although at Time 3 these variables were measured contemporaneously. Our analyses included lagged dependent variables, which further strengthen the causal claims we are making. By including lagged dependent variables, the analyses model the way an independent variable at one time period influences changes in the dependent variable from the preceding time period (J. Cohen & Cohen, 1983). The influence of the dependent variable at the prior period is partialled from both the dependent variable and from the independent variables in the current period.

While our methods demonstrate one of the causal paths, they do not exclude others. The relationships among the key variables in Figure 1 are likely to be bi-directional. As an example, consider the links between communication, shared cognition, and coordination. Our results suggest that communication and shared cognition trade off in causing coordination. However, alternative causal paths are also plausible. As research by Smith and his colleagues suggests, groups that are poorly coordinated at one period may subsequently increase their communication to get back on track (Smith, 1994). However, the supplementary analysis reported previously does not support these interpretations. Another possibility is that when one member of a team discovers that work assigned to another member is not being done in a timely way (a symptom of
poor coordination), this discovery may change assessments of the distribution of expertise in the group and may also cause the team to reassign tasks to resolve the problem. Both experimental research and observational research with a finer temporal granularity could help resolve some of these ambiguities about causal direction.

**Generalizability.** Although the results reported here are based on MBA student teams, we believe they can generalize to teams in business organizations. Almost all students in this simulation had work experience (an average of 4 years). The simulation was important to them, since it represented a capstone course in their MBA program. In contrast to the contextless ad hoc groups in the typical laboratory study, teams in the simulation made dynamic decisions in a competitive environment, were embedded in a market, and reported to business professionals who comprised their boards of directors. Unlike the typical laboratory experiment, teams in the Management Game worked together for an extended time (14 weeks). In a business setting, this work arrangement is analogous to an ad hoc task force, through which much organizational work is done (Cummings, 2004).

Despite the realism of the simulation, we recognize that generalizing from the results of a simulation involving students to teamwork in real business organizations requires a leap of faith. Generalization is also difficult because we examined coordination in only one setting and examined only a small set of coordination mechanisms. Therefore, we cannot be confident about the settings, teams, and tasks to which this research generalizes. Our research examined relatively flat, self-managed teams rather than ones with appointed managers embedded in a hierarchy. Team engaged in semi-structured managerial decision-making in a competitive environment, but not the highly repetitive physical work characteristic of assembly lines. Hierarchical management and the standard operating procedures of the assembly line themselves
are coordination mechanisms. Our theoretical distinctions between the processes leading to coordination, the state of coordination, and performance outcomes should apply to these different teams and tasks. However, it is not clear whether the empirical findings about the utility of shared cognition as a coordination mechanism or the nature of the trade-offs among different coordination mechanisms would apply to these or a range of other teams, tasks, and mechanisms.

Conclusion

Our research has shown the usefulness of distinguishing between the processes leading to coordination and the state of coordination in predicting team performance. Empirically we have shown that more coordinated teams perform better regardless of how they achieve that coordination. In addition, we have demonstrated interesting tradeoffs among the processes that teams use to become coordinated. Shared cognition seems to improve coordination in teams and to compensate for low communication and short work history. Additional research is needed to understand the causal route by which shared cognition develops and through which it influences group process and outcomes more generally. Qualitative studies of the nature of teams’ communication could be especially valuable. In addition, there is a need for the development of detailed process models. We also believe that more empirical research is needed to identify the effects of different types of shared cognition.
### Table 1. Coordination scale.

1. It was very easy for me to get information from other team members when I needed it.
2. There were disagreements in my team about who should be doing what task.
3. Each member of my team had a clear idea of the team's goals.
4. I always received the information I needed from other group members on time.
5. I often found myself duplicating work that other team members had done.
6. People in this team were able to do their jobs without getting in each other’s way.
7. There were disagreements in my team on what plan to adopt for our company.
8. My team knew exactly what things it had to get done.
9. Tasks were clearly assigned. I knew what I was supposed to do.
10. Schedules were clear. I knew when I needed to have tasks completed.
Table 2. Means, standard deviations, and standard errors of the mean for variables used in regression equations.

<table>
<thead>
<tr>
<th>Variable (range in parentheses)</th>
<th>Time 1 Mean</th>
<th>Std. Dev</th>
<th>Time 2 Mean</th>
<th>Std. Dev</th>
<th>Time 3 Mean</th>
<th>Std. Dev</th>
<th>Test-retest reliability</th>
<th>Correlations&lt;sup&gt;a,b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Frequency of Communication (1-6)</td>
<td>3.14</td>
<td>.52</td>
<td>2.32</td>
<td>.51</td>
<td>2.43</td>
<td>.58</td>
<td>.28</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>2 Shared Cognition (-1.00-1.00)</td>
<td>.44</td>
<td>.15</td>
<td>.46</td>
<td>.19</td>
<td>.42</td>
<td>.24</td>
<td>.38</td>
<td>.17 .05</td>
</tr>
<tr>
<td>3 Coordination (1-5)</td>
<td>3.70</td>
<td>.36</td>
<td>3.75</td>
<td>.64</td>
<td>3.93</td>
<td>.48</td>
<td>.52</td>
<td>.03 .26</td>
</tr>
<tr>
<td>4 Sales ($15,039-$82,930)</td>
<td>35,349</td>
<td>8,045</td>
<td>37,961</td>
<td>9,346</td>
<td>37,488</td>
<td>12,893</td>
<td>.37</td>
<td>-.15 .16 .01</td>
</tr>
<tr>
<td>5 Profits (-$5,247 - $12,504)</td>
<td>2.295</td>
<td>2.526</td>
<td>1,828</td>
<td>3,151</td>
<td>1,178</td>
<td>3,224</td>
<td>.37</td>
<td>.07 .21 .41 .71</td>
</tr>
<tr>
<td>6 Stock Price per Share ($33.66-$192.61)</td>
<td>70.75</td>
<td>18.98</td>
<td>75.97</td>
<td>20.80</td>
<td>100.38</td>
<td>36.89</td>
<td>.55</td>
<td>.16 .19 .40 .62 .76</td>
</tr>
<tr>
<td>7 Board Evaluation (1-6)</td>
<td>4.66</td>
<td>.88</td>
<td>4.93</td>
<td>1.06</td>
<td>5.37</td>
<td>1.14</td>
<td>.70</td>
<td>.04 .28 .59 .42 .62 .65</td>
</tr>
</tbody>
</table>

Note: N=50 for all analyses.

<sup>a</sup>Data were collapsed across waves before computing correlations

<sup>b</sup>|r| >=.27, p <.05; |r|>=.36, p<.01
Table 3: Predicting the state of coordination

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1 Main Effects</th>
<th>Model 2 Main Effects + Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beta</td>
<td>SE</td>
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<tr>
<td>Intercept</td>
<td>-.483</td>
<td>.285</td>
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<tr>
<td>Lagged Coordination</td>
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<td>.102</td>
</tr>
<tr>
<td>Time (Team History)</td>
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<td>.170</td>
</tr>
<tr>
<td>Frequency of Communication</td>
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<td>.116</td>
</tr>
<tr>
<td>Shared Cognitions</td>
<td>.243</td>
<td>.095</td>
</tr>
<tr>
<td>Time X Communication Frequency</td>
<td></td>
<td></td>
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<tr>
<td>Time X Shared Cognition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication Frequency X Shared Cognition</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rsq | .328 | .401
df | 44   | 41
Change in Rsq |                      |        |
Wald Chi Square | 26.94 | 41.31
Difference in Chi Square |          | 14.37 | **

*Note: 2-tailed p-values*

\[ p <= .05, \quad * p <= .025, \quad ** p <= .01, \quad *** p <= .001 \]
Table 4: Predicting team performance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 3 Profits</th>
<th>Beta</th>
<th>SE</th>
<th>p-value</th>
<th>Model 4 Stock Price</th>
<th>Beta</th>
<th>SE</th>
<th>p-value</th>
<th>Model 5 Board Evaluation</th>
<th>Beta</th>
<th>SE</th>
<th>p-value</th>
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<td>.237</td>
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<td></td>
<td></td>
<td>-.036</td>
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<tr>
<td>Performance lagged</td>
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<td>.018</td>
<td>.075</td>
<td></td>
<td>.691</td>
<td>.115</td>
<td>***</td>
<td></td>
<td>.460</td>
<td>.089</td>
<td>***</td>
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</tr>
<tr>
<td>Time (Team History)</td>
<td></td>
<td>-.314</td>
<td>.139</td>
<td>*</td>
<td>.573</td>
<td>.169</td>
<td>***</td>
<td></td>
<td>.169</td>
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<tr>
<td>Frequency of Communication</td>
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<td>.076</td>
<td>*</td>
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<td>.181</td>
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<td>Communication Frequency X Shared Cognition</td>
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<tr>
<td>Stock price</td>
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<td>.086</td>
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</tr>
</tbody>
</table>

Note: Beta entries are standardized beta weights

* p < .05, ** p < .01, *** p < .001
Figure 1. Research framework.

Coordination processes
- Communication
- Shared cognition
- Time

Trade-offs
- Communication \( \times \) Shared cognition
- Time \( \times \) Shared cognition

Coordination state
- Coordination

Performance outcomes
- Profits
- Stock price
- Board evaluation

Coordination, Time, Communication, Shared cognition, and Trade-offs are interconnected within the framework, with Performance outcomes at the end.
Figure 2. Interactions of shared cognition and history and communication frequency on coordination.

*Note.* For illustration, interaction plots show level of coordination when (A) frequency of communication was a standard deviation above the mean (high communication) or below (low communication) or (B) when coordination was measured at the second questionnaire or the third questionnaire shared crossed with shared cognition when it was a standard deviation above the mean (high agreement) and below the mean (low agreement).
(A) Shared cognition x Communication

(B) Shared cognition x Time
Figure 3. Path model summarizing the relationships among time, communication, shared cognition, coordination, and performance outcomes.

Note: Numbers represent standardized beta weights. Only relationships where p < .05, 1-tailed, have been retained. Models control for the lagged dependent variable, but this link has not been shown, for simplicity’s sake. In addition, the signification direct paths between time and the performance measures of profit (beta=−.31), stock price (beta=.57), and board evaluation (beta=.17) have not been shown, for simplicity’s sake, because they are of no theoretical interest.
References


