Virtual Teams: Effects of Technological Mediation on Team Performance

James E. Driskell
Florida Maxima Corporation

Paul H. Radtke
Naval Air Warfare Center Training
Systems Division

Eduardo Salas
University of Central Florida

Recent advances in networking environments and telecommunications have led to the proliferation of teams that do not work face-to-face but interact over a computer-mediated communications network. Although some have asserted that virtual teams transcend boundaries of time or distance, others have claimed that working remotely in a mediated team environment differs in significant ways from working face-to-face. In this article, the authors examine the effects of technological mediation on team processes such as cohesiveness, status and authority relations, counternormative behavior, and communication. They discuss conditions under which distance matters in virtual team interaction.

Recent advances in networking environments and telecommunications have led to the proliferation of teams that do not work face-to-face but interact over a computer-mediated communications network. We use the term *virtual team* to refer to a team or group whose members are mediated by time, distance, or technology. Other closely related terms that have been used to describe this type of environment include *computer-mediated communications* and *computer-supported cooperative work.* Although there are differences in the type of technology used and the types of communication enabled in virtual team environments, for our purposes, the core feature of a virtual team is that it is one in which interdependent group members work together on a common task while they are spatially separated.

Cairncross (1997) has coined the phrase "the death of distance," suggesting that distance may no longer be a limiting factor in our ability to communicate and is quickly becoming irrelevant to the way people interact. Proponents of this view presume a future (or present) in which all time and space restrictions have been removed from the communication process and where "face-to-face communication can be done across oceans if video conferencing facilities are available" (Burgelman, 2000, p. 3). However, most researchers take issue with the view that the technology that mediates human interaction is seamless or transparent. For example, Olson and Olson (2000) argued that "distance matters" and that group members who are remotely located or distributed from one another are likely to face obstacles in coordinating group efforts. The general consensus is that the nature of interaction in virtual teams may differ in a number of important ways from "normal" face-to-face team interaction. However, if distance matters to how group members interact, then how does it matter? How does this phenomenon—that virtual team members must work interdependently but remotely in a com-

James E. Driskell, Florida Maxima Corporation, Winter Park, Florida; Paul H. Radtke, Naval Air Warfare Center Training Systems Division, Orlando, Florida; Eduardo Salas, Department of Psychology, University of Central Florida.

Correspondence concerning this article should be addressed to James E. Driskell, Florida Maxima Corporation, 507 North New York Avenue, R-1, Winter Park, Florida 32789. E-mail: james.driskell@rollins.edu

puter-mediated environment—impact the na-
ture of team interaction and performance?

The purpose of this article is to examine the
effects of technological mediation on team pro-
cesses such as cohesiveness, status and author-
ity relations, counternormative behavior, and
communication. We first present a model of the
effects of technological mediation on team per-
formance. We then examine how performing in
a virtual team environment may impact team
processes. Finally, we discuss factors, such as
the nature of the task, that may moderate the
effects of technological mediation on team
interaction.

Team Interaction in Computer-Mediated Environments

In face-to-face interaction, group members
share the same physical location, can see and
hear one another, receive messages in "real
time" as they are produced, and send and re-
ceive information simultaneously and in se-
quence. During face-to-face interaction, group
members can see another's nods and gestures;
they can observe eye contact, facial expressions,
and posture; they can hear the other's tone of
speech and dialect; they are aware of the timing
of speech and who responds to whom; and they
experience the immediacy of interacting and
being involved with a physically present team
member. These types of contextual cues provide
important information about the individual with
whom one is interacting (i.e., Does the speaker
give evidence of being competent or experi-
enced? Is the speaker a high-status or low-status
team member?), how the message is being con-
veyed (i.e., Is the speaker angry, tense, or con-
fident?), and whether the message is being con-
veyed successfully (i.e., Are others paying at-
tention? Do they look puzzled?). Groups whose
members are distributed apart from one another
may lose some of these communicative
capabilities.

A substantial body of research on computer-
mediated communication has been conducted in
the past several decades. Some studies have
indicated that the distribution of team members
over remote networks tends to impair team in-
teraction in comparison with face-to-face inter-
action. McLeod (1992) found that computer-
mediated interaction led to an increase in the
time required to make a decision and a decrease

in team member satisfaction. Straus (1997) and
Warkentin, Sayeed, and Hightower (1997) re-
ported that virtual teams developed lower cohe-
siveness than face-to-face teams. However,
other studies have produced conflicting results
that are somewhat more difficult to interpret.
For example, whereas Dubrovsky, Kiesler, and
Sethna (1991) found that status distinctions
among team members were reduced in comput-
er-mediated groups, Weisband, Schneider, and
Connolly (1995) found little evidence of status
equalization. Although some researchers have
reported a greater incidence of counternorma-
tive or uninhibited behavior in computer-medi-
ated groups (Siegel, Dubrovsky, Kiesler, &
McGuire, 1986), others have failed to find these
differences (Walther & Burgoon, 1992). A rea-
sonable and cautious interpretation of the evi-
dence at this point is that, indeed, distance mat-
ters—that working remotely in a mediated team
environment is different from working face-
to-face—but that the manner in which media-
tion affects team interaction warrants closer
examination.

There are several overarching points that are
relevant to the following discussion. First, when
we use the term *computer-mediated communi-
cations*, we must remain cognizant of the fact
that there are a number of different types of
mediated environments. Clark and Brennan
(1991) described several characteristics of face-
to-face and distributed settings that determine
the nature of communication:

> *Copresence:* Group members occupy the same physi-
> cal location.
>
> *Visibility:* Group members can see one another.
>
> *Audibility:* Group members can hear one another.
>
> *Cotemporality:* Communication is received at the ap-
> proximate time it is sent.
>
> *Simultaneity:* Group members can send and receive
> messages simultaneously.
>
> *Sequentiality:* Group members' speaking turns stay in
> sequence.

As shown in Table 1, computer-mediated en-
vironments differ according to the communica-
tion capabilities that are enabled. In face-to-face
interaction, group members share the same
physical location, can see and hear one another,
receive messages in real-time as they are pro-
duced, and send and receive information simul-
taneously and in sequence. Teams that are dis-
tributed over various types of computer-medi-

Table 1
Characteristics of Face-to-Face and Mediated Environments

Type of environment	Media characteristics					
	Copresence	Visibility	Audibility	Cotemporality	Simultaneity	Sequentiality
Face-to-face	X	X	X	X	X	X
Real-time audio/video (videoconference)		X	X	X	X	X
Audio-only (telephones, conference calls)			X	X	X	X
Real-time electronic dialogue, text-only (computer chat)				X	X	X
E-mail						

Note. From "Grounding in Communication," by H. H. Clark & S. E. Brennan, in L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on Socially Shared Cognition* (p. 142). Washington, DC: American Psychological Association. Copyright 1991 by the American Psychological Association.

ated environments lose certain capabilities. In a *videoconference* setting, distributed groups may interact over networked computer systems and exchange live video as well as audio and text. On the other hand, what we have termed *computer chat* refers to the computer-mediated electronic dialogue between two or more group members, in which the users exchange messages via text in real-time. Group communication over this type of distributed environment is cotemporal, simultaneous, and sequential, but group members lack the capability to see one another and to hear the timing or intonation of their speech.

The important point that this classification illustrates is that all of the settings in Table 1 (other than the face-to-face setting) may be defined as a computer-mediated environment. They are all alike in that group members work on a common task but do not share the same spatial location. However, they differ quite considerably regarding the communication capabilities that are enabled. Therefore, when we discuss virtual teams, we must be aware that virtual teams may operate in different types of communication environments and that the type of communication environment implemented will have a significant impact on team interaction.

A second broad point of consideration is that just as there are different types of technologically mediated environments, there are different types of teams. Teams may be ad hoc (a temporary team assembled solely for a specific task) or intact (an existing team in which team membership is stable). Teams may work to-gether on a task over time, or interaction may be short and time limited. Teams may meet initially prior to interaction, or team members may be completely anonymous. Team members may expect future interaction with one another after an initial task is performed, or the task may be a one-shot transaction. Teams can be composed of many members or few. All of these factors play a role in how teams develop and interact in a mediated environment.

Finally, a third point is that the distribution of team members over computer-mediated systems can disrupt team interaction under some conditions and facilitate interaction under other conditions. The focus of most research on computer-mediated team performance has been on the disadvantages incurred when team members must perform apart from one another. Clearly, coordination of team activities can become more difficult when team members are not in the same physical location. However, team membership can be a double-edged sword. For example, research indicates that under certain conditions, being in a team can lead to negative consequences such as increased pressure for conformity and impaired decision making (Mullen, Anthony, Salas, & Driskell, 1994). Thus, it follows that there are some circumstances in which separating team members apart from one another may serve to overcome the negative consequences of team membership. Therefore, the question is not simply "How is performance impaired in virtual teams?" Instead, we expect that performing in a virtual team environment will affect teams in ways that may be advantageous as well as disadvanta-

geous. As a practical strategy, we may wish to mitigate the costs of computer-mediated communication in circumstances in which it interferes with effective team functioning; at the same time, we want to realize the benefits in circumstances in which computer-mediated communications may facilitate team interaction.

A Research Model

Figure 1 presents a model that illustrates the effects of computer-mediated communications on team performance. This model adopts a general input–process–output framework. The input factor, shown in column 1, is the computer-mediated environment. Note that, as we discussed above, the term *computer-mediated communications* is a general term and that specific types of computer-mediated environments offer different communicative capabilities. In fact, the type of communications environment over which team members interact is one of the primary moderators that we intend to examine in the following sections.

The second column in Figure 1 describes several team processes of interest. Research has examined the effect of computer-mediated environments on cohesiveness (Straus, 1997;
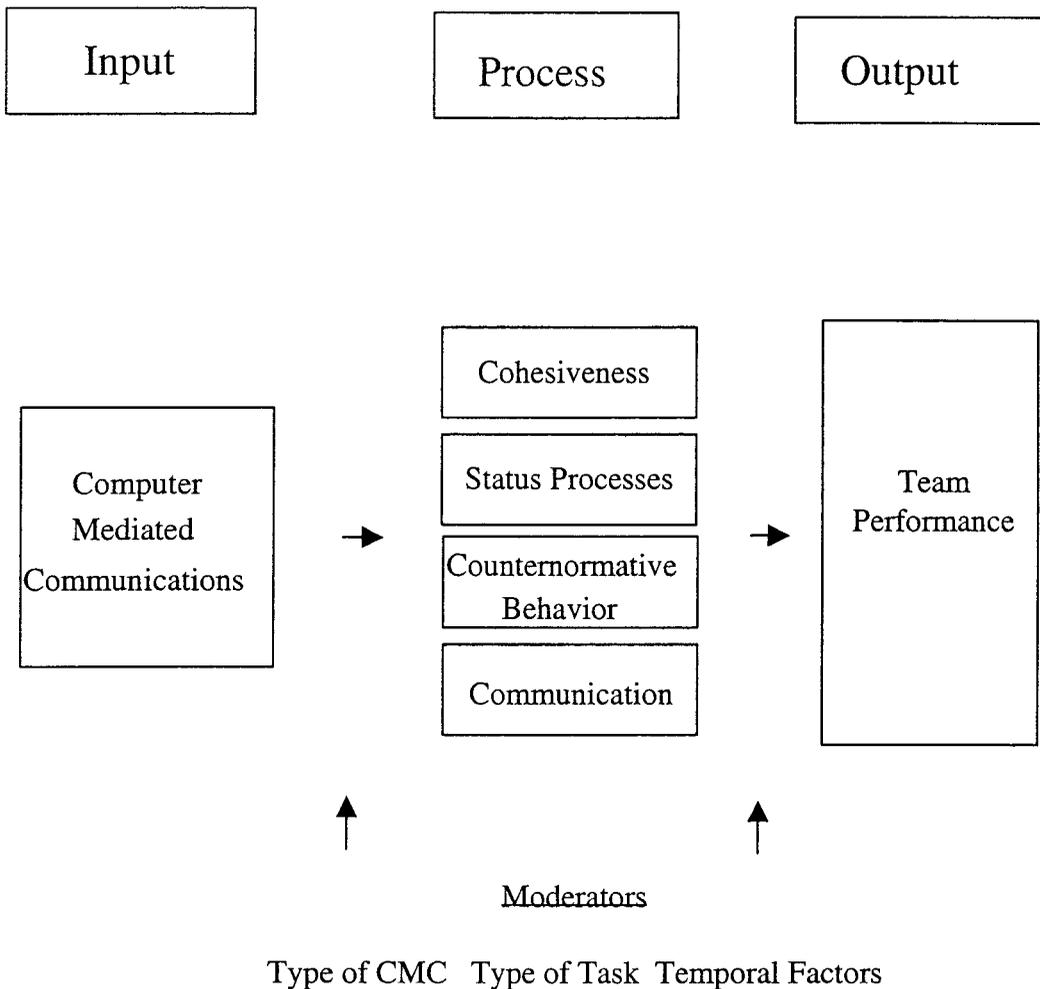

Figure 1. Input–process–output model of the effects of mediation on team interaction. CMC = computer-mediated communications.

Warkentin et al., 1997), status and authority relations (Dubrovsky et al., 1991; Hiltz, Turoff, & Johnson, 1989; Silver, Cohen, & Crutchfield, 1994), counternormative behavior (Dubrovsky et al., 1991; Kiesler, Zubrow, Moses, & Geller, 1985; Siegel et al., 1986, Sproull & Kiesler, 1986), and communication (Sellen, 1995; Thompson & Coovert, 2003). Although this review must by necessity be selective, we chose these specific team processes to examine because they have been examined in prior reviews of team performance in general and in reviews of team performance in computer-mediated environments (cf. Hollingshead & McGrath, 1995; Straus, 1997) and because evidence suggests these team processes are affected by technological mediation.

In Baron and Kenny's (1986) terms, we view process variables as mediators. That is, team process variables are patterns of group interaction through which input factors influence or affect team outcomes (see Hackman & Morris, 1975). In reality, this input–process–output relationship is often not as linear or static as this model implies. If we consider team performance over time, team outcomes such as the performance of the group can in turn impact team processes such as cohesiveness. Moreover, given the specific interests of the researcher, variables such as cohesiveness can be considered as input variables and outcome variables as well.

The third column describes performance outcomes. Note that we restrict our focus to the effects of technological mediation on performance in *task* groups. Furthermore, although performance can be defined by more specific outcome measures such as accuracy, speed, and variability of performance, it is appropriate for our purposes to simply address team performance, broadly defined.

Finally, moderators are factors that affect the strength of the relation between two variables (Baron & Kenny, 1986) or that can account for observed variation in a relationship. Typically, each specific research literature, such as the research on group status or on communication, has its own idiosyncratic cluster of moderators that are dictated by research concerns and findings within that domain. However, there are some moderators that emerge at least to some extent across most domains. We examine three such variables that seem most relevant to virtual

teams: (a) type of computer-mediated environment, (b) type of task, and (c) temporal context.

We have previously described differences in types of computer-mediated environments (see Table 1). Types of computer-mediated environments (e.g., audio–video vs. audio only vs. text only) differ considerably in the richness of communications afforded (Daft & Lengel, 1986). Thus, we would expect the effect of technological mediation on team processes to vary depending on the type of computer-mediated communications environment.

Perhaps no factor has a greater effect on team interaction than the type of task that the team is engaged in. There have been a number of attempts to classify group tasks along a variety of dimensions, such as the cognitive versus physical requirements of the task or the requirement for cooperation or interdependence (cf. McGrath, 1984; Shaw, 1973; Steiner, 1972). One of the most recent and comprehensive classification systems relevant to teams has been offered by Devine (2002), who identified 14 team types on the basis of the type of work that they are engaged in, and further classified them along seven contextual dimensions. Driskell, Hogan, and Salas (1987) also classified group tasks on the basis of the primary activities or behaviors required of team members, resulting in six task categories: (a) mechanical/technical tasks, requiring the construction or operation of things; (b) intellectual/analytic tasks, requiring generation of ideas, reasoning, or problem solving; (c) imaginative/aesthetic tasks, requiring creativity or artistic endeavor; (d) social tasks, requiring training, supporting, or assisting others; (e) manipulative/persuasive tasks, requiring motivation or persuasion of others; and (f) logical/precision tasks, requiring performance of routine, detailed, or standardized tasks. We adopt this typology, focusing on the behaviors required for task completion, to examine the effects of type of task. We would expect the effect of technological mediation on team processes to vary depending on the type of task.

A third factor that we would expect to have a significant effect on the relationship between technological mediation and team interaction is the temporal context of the team. McGrath (1997) has noted that research is often conducted with ad hoc laboratory groups with no past or anticipated future, in contrast to dynamic groups that are intact and perform over a longer

period of time (see also Hollingshead & McGrath, 1995; McGrath, 1990). Teams that perform over time gain experience with the task and the communications technology, which may reduce performance decrements (Hollingshead, McGrath, & O'Conner, 1993). Although there are a number of temporal distinctions that can be drawn related to the synchronicity, pacing, and sequencing of performance, we focus on the simple distinction between ad hoc teams that interact for a single session and dynamic teams that interact over time. We would expect the effect of technological mediation on team processes to vary depending on the temporal context of the team.

These moderators may have an impact on the relationships depicted in Figure 1 at two separate points. A moderator such as the type of task may impact the extent to which a variable such as cohesiveness affects team performance (reflected in the rightmost arrow from the "Moderator" box shown in Figure 1). However, the relationship between cohesiveness and performance is not unique to the topic of virtual teams, and the extent to which this general relationship is moderated by the type of task is captured within that more general research literature. Our more specific interest is in examining factors that moderate the extent to which the computer-mediated communications environment affects team processes (the leftmost arrow from the "Moderator" box in Figure 1). Thus, our focus, for example, is on whether the effects of technological mediation on cohesiveness may vary according to the type of task the team is engaged in.

In summary, this model is intended to organize or structure examination of the effects of technological mediation on team interaction. We propose that technological mediation may impact team performance because of changes in cohesiveness, status, counternormative behavior, and communication and that these changes may be moderated by factors such as the type of communications environment, the type of task, and the temporal context of the team. In the following sections, we use the framework of this model to examine each of the team processes identified. In each case, we briefly describe the team process, discuss how that process may be affected within a virtual team environment, discuss possible performance effects, and examine potential moderators.

Cohesiveness

Cohesiveness is considered to be one of the most fundamental aspects of groups. Golembiewski (1962) described it as "the essential small group characteristic" (p. 149). Moreover, research has shown that cohesive groups tend to interact more (Back, 1951), agree more readily (Lott & Lott, 1961), report greater satisfaction with the group (Curtis & Miller, 1986), and at least under some circumstances, outperform less cohesive groups (Mullen & Copper, 1994). However, there is some concern that virtual teams may experience greater difficulty in developing strong relational bonds that underlie group identity, cohesiveness, and trust (Jarvenpaa & Leidner, 1999; Rocco, 1998; Warkentin et al., 1997).

Within the research literature, cohesiveness has been viewed as group pride, loyalty, shared understanding, bonding, interpersonal attraction, trust, task commitment, and mutual aid, leading some researchers to question the clarity and uniformity of existing conceptualizations (Levine & Moreland, 1990). However, it is important to note that even the earliest conceptualizations of cohesiveness treated it as a multidimensional construct. Festinger (1950) provided the seminal definition of cohesiveness as the forces that act on team members to remain in the team, including interpersonal attraction to other team members, group prestige, and attraction to the activities in which the group engages. Most subsequent research on group cohesiveness has elaborated one or more of these three major dimensions of cohesiveness.

Mullen and Copper (1994), in a meta-analysis of the effects of group cohesiveness on performance, examined separately the three components of cohesiveness first identified by Festinger. *Interpersonal attraction* reflects affective relations or attraction to other team members. *Group pride* reflects group prestige, loyalty, and normative bonds. *Task commitment* reflects commitment to the task or goals of the team. Mullen and Copper found that group cohesiveness had a positive effect on performance and further found that this relationship was primarily a function of the task commitment component of cohesiveness.

Furthermore, some research has shown that the components of cohesiveness may have differential effects depending on the type of task.

For example, on an additive task, group members pool individual products to produce a team outcome but are not required to coordinate actions among themselves. Zaccaro and Lowe (1986) found that higher task-based cohesiveness led to greater performance on an additive task (folding paper tents), whereas interpersonal cohesiveness had no effect. However, on a "survival exercise" disjunctive task that required team members to communicate and coordinate individual efforts, Zaccaro and McCoy (1988) found that team performance was affected by both task cohesiveness and interpersonal cohesiveness. Craig and Kelly (1999) also found that both task cohesiveness and interpersonal cohesiveness enhanced performance on an interactive group creativity task.

Cohesiveness in Virtual Teams

Generally speaking, researchers have suggested that the process of team development may be more complex in a virtual environment. In contrast to face-to-face interaction in which individuating information on team members is abundant, some have argued that members of virtual teams are more anonymous and deindividuated. Thus, interaction that is mediated by technology may lead to less intimacy and difficulty in establishing relationships among team members. Furthermore, some research has shown that weaker relational ties in virtual teams can lead to lower cohesion (Straus, 1997; Warkentin et al., 1997).

However, we have noted that cohesiveness is composed of three primary components—interpersonal attraction, group pride, and task commitment—and we propose that technological mediation may have a differential effect on these three components of cohesiveness. First, it is likely that a weakening of social cues or a reduction in personalizing information among virtual team members may lead to weaker affective bonds and a decrease in intimacy (Straus, 1997; Weisband & Atwater, 1999). Thus, we would expect technological mediation to have a negative impact on cohesiveness, when defined as interpersonal attraction.

Second, technological mediation may affect the group pride component of cohesiveness. To the extent that normative bonds may be weakened in computer-mediated teams, the distribution of team members over a computer-medi-

ated network may lead to lower commitment to the team. However, the impact of mediation on group pride may be minimized if group members possess a strong preexisting sense of pride and loyalty to the group or organization to which they belong. In other words, ad hoc teams that have never met prior to the virtual team interaction may have difficulty in developing a strong team commitment, whereas intact teams may have developed strong normative bonds prior to interaction in a virtual team setting. Thus, we would expect technological mediation to have a negative impact on cohesiveness, when defined as group pride, in some situations but not in others.

Third, technological mediation may also impact the task commitment component of cohesion. Task commitment is an instrumental bond, rather than an interpersonal or normative bond, reflecting attractiveness of and satisfaction with the task or the group's activities (Mullen & Copper, 1994). Some studies suggest team members mediated by technology experience less satisfaction with the task, although this may be a function of the requirements of the task or the newness of the task experience (Straus, 1996; Straus & McGrath, 1994). In general, we would expect technological mediation to have a negative impact on cohesiveness, when defined as task commitment.

Performance Effects

The empirical evidence for the effect of cohesiveness on performance is mixed. Studies report that cohesiveness may have a positive effect on performance (Tziner & Vardi, 1982), no effect on performance (Terborg, Castore, & DeNinno, 1976), or either positive or negative effects depending on the performance standards of the group (Schachter, Ellertson, McBride, & Gregory, 1951). However, meta-analyses of the cohesiveness–performance literature report overall positive mean effects of cohesiveness on performance (Evans & Dion, 1991; Mullen & Copper, 1994; Oliver, Harman, Hoover, Hayes, & Pandhi, 1999). Furthermore, the Mullen and Copper (1994) meta-analysis reported that the strongest effect of cohesiveness on performance occurred when cohesiveness was operationalized as task commitment and that the interpersonal attraction and group pride components of cohesiveness had weaker effects on perfor-

mance. This evidence suggests that cohesiveness enhances performance and that it does so primarily because cohesive team members are more committed to successful task performance. This suggests that team task performance would be most degraded through the negative effect of technological mediation on task commitment and that there is less of a potential effect on performance of reduced socioemotional bonds or normative bonds. In other words, technological mediation is more likely to impact team performance through its effect on task commitment rather than through its effect on socioemotional bonds or normative bonds.

In brief, we would expect technological mediation to affect the different components of cohesiveness, with the potential to reduce interpersonal attraction, group pride, and task commitment. In the following, we consider factors that may moderate the effect of technological mediation on cohesiveness.

Moderators

Type of task. In keeping with our focus on the three primary components of cohesiveness, we propose that the effect of technological mediation on cohesiveness will differ according to the type of task that the team is performing and the components of cohesiveness that are most relevant to that task. To the extent that technological mediation impairs *interpersonal attraction*, this should have a greater impact on cohesiveness for tasks in which interpersonal relations are most salient. Thus, we would expect the impact of technological mediation on the interpersonal attraction component of cohesiveness to be greater for social tasks or manipulative/persuasion tasks that emphasize affective relations. To the extent that technological mediation impairs *group pride*, this would have a greater impact on tasks that require strong shared beliefs and normative consensus. We would expect the impact of technological mediation on the group pride component of cohesiveness to be greater for teams organized for ideological or special-interest purposes. Finally, to the extent that technological mediation impairs *task commitment*, this would have a greater impact on tasks that are primarily performance or productivity oriented and that emphasize instrumental relations. Thus, we would

expect the impact of technological mediation on the task commitment component of cohesiveness to be greater for mechanical/technical or intellectual/analytic tasks. Unfortunately, there is little empirical evidence to support these predictions.

Type of computer-mediated environment. Two major approaches to understanding the effects of different types of communications media, theories of social presence (Short, Williams, & Christie, 1976) and media richness (Daft & Lengel, 1984), hold that the capacity to transmit communicative information (visual, verbal, and contextual cues) is progressively restricted as one moves from face-to-face to audio–video to audio-only to textual modes of communication. The type of information that is restricted includes verbal and nonverbal expressive cues, body language, gaze, gesture, appearance, and voice tone. This loss of contextual information across various communication modes may differentially impact the three primary components of cohesiveness.

It is likely that the loss of expressive contextual information, especially in audio-only and text communication modes, will lead to weaker interpersonal bonds. Straus (1997) found that computer-mediated teams (engaged in computer conferencing via text messaging) reported less cohesiveness, measured as interpersonal attraction, than did face-to-face teams. Weisband and Atwater (1999) reported that teams communicating via a text-messaging network liked other team members less than did face-to-face teams. Examining trust across different types of media, Bos, Olson, Gergle, Olson, and Wright (2002) found that teams using text had the greatest difficulty establishing trust, and that teams using video conferencing and audio conferencing took longer to establish trust than face-to-face teams. Thus, although it is reasonable to expect that strong interpersonal bonds can develop in less rich modes of communication such as chat or e-mail, it is likely that these bonds will develop more slowly and with greater difficulty.

The richness of the mode of communication may also moderate the effect of technological mediation on task commitment. Doherty-Sneddon et al. (1997) found that task efficiency and understanding were lessened in videoconferencing and audio-only communications versus face-to-face communications.

Straus and McGrath (1994) similarly found that productivity, or the time it took to complete a given task, was less for computer-mediated communications (computer conferencing via text messaging) than with face-to-face communications. Straus and McGrath also reported that computer-mediated team members had a harder time understanding one another than did face-to-face teams, and Straus (1996) found that computer-mediated team members were less satisfied with the task process than face-to-face members. Thus, we would expect that richer modes of communication may allow more satisfactory task participation and accomplishment (especially for more demanding tasks), which would be reflected in greater task commitment.

Finally, the richness of the mode of communication may moderate the effect of technological mediation on group pride. No studies that we are aware of have tested this relationship directly. However, group pride is related to normative consensus, shared beliefs, and satisfaction with the team, and some research has shown that less rich modes of communication can result in longer time to reach consensus and agreement (Connolly, Jessup, & Valacich, 1990; Hiltz, Johnson, & Turoff, 1986) and lower identification with the group (Cappel & Windsor, 2000). Sellen (1995) examined face-to-face teams, teams who interacted via audio–video communications, and teams who interacted via audio-only communications. She found that compared with face-to-face groups, technology-mediated teams (with or without video) exhibited clear symptoms of depersonalization and psychological distance. Moreover, she found that overall, the use of audio versus video mattered less than whether group members were mediated or interacted face-to-face. Sellen concluded that some forms of interaction may be fundamentally altered when team members do not share the same space. Thus, for the development and maintenance of strong normative bonds, the important distinction may be between mediated and face-to-face teams, with the type of mediated communication environment less relevant.

Temporal context. Some research has suggested that team processes develop more slowly in virtual teams and that the weaker relational ties observed in virtual teams may be the simple result of these teams needing longer to develop

(Griffith & Neale, 1999). Walther and Burgoon (1992) found that members of computer-mediated groups initially rated each other unfavorably. Yet over the course of several weeks, group members' ratings of composure/relaxation, informality, receptivity, trust, and social orientation became more positive. Thus, deficits in the development of team processes in virtual teams may be temporary, and some research suggests that virtual teams can function as effectively as face-to-face teams provided they have sufficient time to develop.

Furthermore, most of the research that has suggested a weakening of cohesiveness in virtual teams examined teams that had never met, had no history, and were not likely to meet again after the interaction ceased. Research suggests that these ad hoc teams may experience difficulty in development of team processes such as trust (Jarvenpaa & Leidner, 1999). However, some research has suggested that trust can develop in virtual teams but that it develops in a different manner from the gradual development of trust in face-to-face groups. Meyerson, Weick, and Kramer (1996) argued that such groups may develop "swift trust," based on existing bonds of organizational membership rather than on interpersonal feedback from the task.

Status and Authority Relations

Several decades of research conducted with mock juries, military teams, and problem-solving groups have revealed how status differences among group members structure the nature of group interaction. In a typical work group, those with higher status assume a leadership position and command more of the group's resources—they talk more, they direct group activities, and they are more likely to exert their opinion during decision making. In brief, individuals who are perceived as having high status within the group command more of the group's resources—they dominate conversation, their ideas are accepted more often, and they are seen as more competent and leaderlike (see Driskell & Mullen, 1990; Driskell, Olmstead, & Salas, 1993).

The theory of status characteristics and expectation states provides one of the most comprehensive and well documented explanations of how status differentials emerge and are main-

tained in small groups (see Berger, 1992; Wagner & Berger, 1993; Webster & Driskell, 1983). According to this theory, status and influence in task groups are determined by the performance expectations formed for group members relative to one another. The higher the performance expectations formed for a group member are, the more likely that person is to be given opportunities to perform in the group, initiate interaction, receive positive evaluations and agreement from others, and exert influence.

To illustrate this process, consider a decision-making group that has initially gathered to perform a task. The group members are task oriented, they want to achieve a successful outcome of the task, and they search for information regarding each others' capabilities to help them achieve this goal. It is in each individual's self-interest, in order to accomplish the task, to defer to others on the basis of the others' expected task contributions. In other words, it is in Person A's best interest to defer to Person B (i.e., to allow B to command more time speaking, to accept B's influence attempts, etc.) if Person B seems to possess superior task capability. Therefore, deference is exchanged by some members of the group for the perceived superior task contributions of others.

There are several types of characteristics of individuals that are typically salient in face-to-face groups and that provide a basis for the formation of performance expectations. We will discuss two types, status characteristics and status cues. *Status characteristics* are external characteristics that differentiate individuals, such as race, gender, occupation, and even physical attractiveness (Webster & Driskell, 1983). In most cases, the status hierarchy that emerges within the small group reflects these cultural stereotypes: Males, Whites, and those of higher occupational status enact a more proactive role and command more of the group's resources, whereas females, ethnic minorities, and those of lower occupational status are less active and generally more compliant during group deliberations. There are two types of status characteristics: (a) diffuse status characteristics such as race, gender, and age, which evoke broad, general expectations for performance, and (b) specific status characteristics, which include specific skills or abilities and have more specific, delimited expectations for performance. In brief, status characteristics are

visible characteristics of individuals that structure such group behaviors as who speaks to whom, who speaks more often, and whose ideas are more likely to be solicited and accepted.

Status cues are expressive behaviors that people exhibit, such as body position, intonation, gaze, gestures, and other expressive cues. In general, individuals who speak rapidly, with few verbal disfluencies or hesitations, who select the head of the table, who speak more often, and who maintain eye contact, especially while speaking, are perceived as more competent and occupy a higher position in the group status hierarchy (see Berger, Webster, Ridgeway, & Rosenholtz, 1986; Erickson, Lind, Johnson, & O'Barr, 1978; Mullen, Salas, & Driskell, 1989; Ridgeway, 1987). These types of expressive status cues may have as strong an informational impact as one's "formal" status. For example, when expressive cues and formal status provide contradictory information (e.g., when someone is a task group leader by virtue of his or her organizational position but sounds hesitant and looks confused), we attend to the information provided by both types of characteristics. In this example, the group leader may be afforded less influence in the group than when his or her expressive behavior suggests competence.

Status in Virtual Teams

A number of studies have examined the effects of computer-mediated environments on status and authority relations in teams. Dubrovsky et al. (1991) examined the effects of status on groups who communicated either face-to-face or through e-mail. Their results indicated that in groups communicating via e-mail, the high-status team member's relative dominance in participation over the low-status team member was reduced compared with face-to-face groups, resulting in greater equality of interaction. Note that status distinctions were diminished but not eliminated; high-status team members participated more than low-status team members in both the face-to-face and e-mail groups. Sproull and Kiesler (1986) reported that the use of e-mail breaks down status barriers, resulting in a less hierarchical pattern of communication that is less likely to reflect differences in rank or status among group members. Sproull and Kiesler (1991) concluded, "The high status group member participated

less when the group communicated electronically . . . the low status members spoke more" (p. 62). However, other studies have shown no effect of technological mediation on reducing status differentials. For example, Linville, Liebhaber, Obermayer, and Fallesen (1991) examined the effect of computer-mediated interaction on a simulated military task and found little evidence that status or leadership was impaired. Weisband et al. (1995) and Silver et al. (1994) found status differences to persist in both face-to-face and computer-mediated groups. Saunders, Robey, and Vaverek (1994) reported that status differentials were maintained among hospital personnel (physicians and nurses) when communicating via computer conferencing.

Although the available research suggests that technological mediation may affect the status structure of the group, there is a good bit that is not known at this point. For example, the status characteristics theory describes a process whereby certain evaluated characteristics that differentiate group members lead to the formation of performance expectations, which then determine behavioral inequalities in the group, such as the rate of speaking. Figure 2 illustrates this *status → expectations → behavior* process. One question that is unclear from the existing literature is, at what point in this process does technological mediation affect status? We propose that there are three primary mechanisms through which mediation may impact status processes, differing in the stage at which this impact occurs. First, it is clear that some computer-mediated communications systems may

block the transmission of status information (status characteristics and status cues) that differentiates group members. Thus, in some cases, because information that differentiates other group members is not available or accessible, initial status differentials are not established as they would be in normal face-to-face interaction. Thus, computer-mediated systems may block the transmission of differentiating information on group members that initiates the operation of status processes.

A second possibility is that the effects of status cues are dampened in computer-mediated environments. Status cues such as strong eye contact while speaking, fluid gestures, and a well-moderated voice tone have been shown to structure interaction in face-to-face settings (Driskell et al., 1993). However, these expressive behaviors may not have the same impact when expressed by a remote group member over a computer-mediated network. Indeed, some have argued that gestures and expressions may lose their interactional significance when abstracted from the environment in which they are produced and mediated via a video image (Doherty-Sneddon et al., 1997; Heath & Luff, 1992). Thus, it is possible that status cues may be dampened in a computer-mediated environment and performance expectations that are formed on the basis of these weakened cues may be attenuated.

A third possibility is that the manner in which expectations are translated into behavior may differ in a computer-mediated environment. The status structure in a group is a normatively
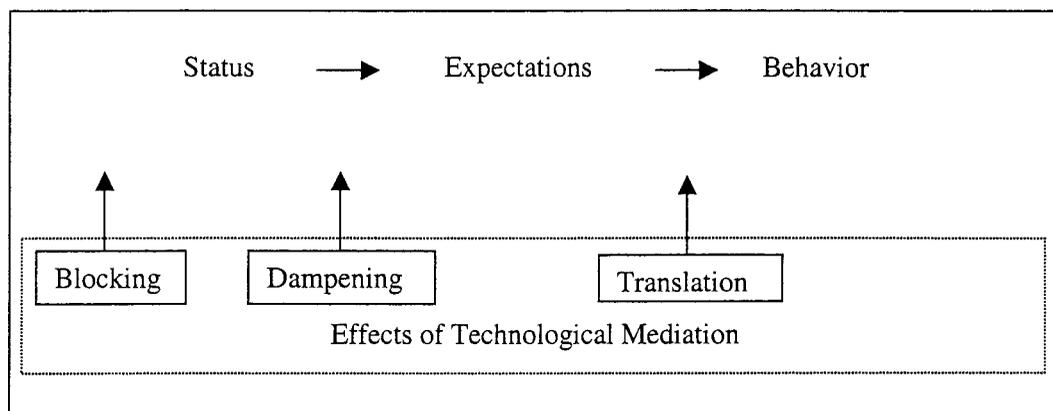

Figure 2. Stages at which technological mediation may impact status processes.

supported process (Ridgeway & Diekema, 1989). As we noted earlier, group members may defer to Member A because Member A shows competence or other evidence of helping the group reach its cooperative goal. Behaviors inconsistent with this status structure, as when Member B repeatedly overrules the higher status Member A, are deemed to be a violation of group norms and typically result in negative reactions toward the norm violator. In a normal group setting, negative reactions to a norm violation may range from a disapproving glance to a face-to-face confrontation. Given that virtual team members are more remote and less immediately accessible than members of face-to-face groups, it is possible that the pressure to conform to these norms of status allocation may be weaker. In this case, even if status differentials are salient and performance expectations are formed on this basis, there may be less pressure to behave in a manner consistent with these expectations. It is likely that previous results showing a status equalization effect in computer-mediated groups may be a combination of (a) blocking of status information, (b) dampening of status cues, and (c) weakening of the normatively supported process by which expectations are translated into behavior.

There may be some aspects of computer-mediated communications that bolster or strengthen status effects. For example, in normal group settings, one's position in the group status structure is established on the basis of multiple indicators of status: A person may have the relative disadvantage of being a lower level employee in a group of managers but may also provide evidence of specialized skills and training, professional demeanor, and competency. Research indicates that people combine multiple items of differentiating information to form composite performance expectations for others (Webster & Driskell, 1983). To the extent that computer-mediated environments restrict the transmission of differentiating information (especially expressive and other contextual cues), interaction may be more likely to be patterned simply on a single salient distinction, such as the primary employee–manager distinction in this example. In fact, the social identity model of deindividuation effects suggests that when individuating information is scarce, relevant group membership cues may become more influential (Postmes, Spears, & Lea, 2002). Thus,

it is possible that major status characteristics that are salient, such as occupational position, may have a relatively greater impact in computer-mediated environments in which other differentiating information is suppressed.

Performance Effects

It is important to note that status processes in groups may have desirable *and* undesirable consequences. Furthermore, any potential attenuation of status differences in computer-mediated groups can likewise have desirable as well as undesirable effects. Ideally, status processes provide structure to the team so that it can use its resources more effectively to accomplish a task. Status processes operate in groups to produce a hierarchical patterning of interaction, such that those with higher status (i.e., those who are perceived to be more competent) tend to dominate group discussion. To the extent that status differentials within the group are based on cultural stereotypes (such as race or gender) this may result in loss of resources to the group and undesirable barriers to equal participation for females and ethnic minorities. In this case, a flattening of the status hierarchy may lead to more open and equal participation and greater resources for the group to draw upon. On the other hand, status generalization may have positive effects when it operates in general accordance with the distribution of ability in the group. To the extent that status differences reflect actual differences in ability, expertise, and competence, it is desirable for higher status group members to be more active and influential. In this case, the dampening of status effects can lead to lower participation by those with greater competence.

There are ways in which status can affect performance other than by determining the extent that team members participate or contribute to the task. Under conditions in which status distinctions are blurred, when there is uncertainty about status, or when team members hold conflicting expectations, status incongruence may arise. One type of status incongruence may occur when Team Member A possesses high status (perhaps having more experience or having specific content knowledge) and is ignored or afforded fewer opportunities to contribute to the task. Status incongruence can lead to dissatisfaction and lower productivity (Nixon, 1979).

Furthermore, for technology-mediated teams, it may be more difficult to correct normative violations of the status structure. In normal interaction, when there is a discrepancy between a team member's status, behavior, or rewards (e.g., if the low-ability team member dominates conversation), team members tend to act to correct these discrepancies. In situations in which status distinctions are unclear, these normative violations are less likely to be perceived or addressed.

Moderators

Type of task. In general, a hierarchical status structure is potentially more advantageous, and more likely to be established, for tasks that are ambiguous, uncertain, and complex versus tasks that are highly structured and routine (Nixon, 1979). Thus, in general, technological mediation should impact status processes less for more routine logical/precision tasks than for intellectual/analytic tasks.

Examining the moderating effects of type of task more precisely requires that we also consider the temporal context of the team and the consequences of changes in the status structure. One point that we have touched on previously is that status processes in teams are not passive but are normatively supported by team members, both high status and low status. Given that the status structure is a means to organize interaction within the team to achieve effective task performance, changes to this structure are likely to be resisted, especially if the status structure supports the effective accomplishment of the task. In other words, real groups that have a history of interaction are likely to resist changes to an established status structure.

Straus and McGrath (1994) noted that *idea generation* tasks require very little coordination or consensus to accomplish. And, in fact, status-differentiated groups tend to do more poorly on idea generation tasks than status-undifferentiated groups (Silver et al., 1994). Thus, if technological mediation suppresses status effects on idea generation tasks, there will probably be little effort by team members to restore a structure that does not support successful task performance in the first place. However, *judgment* tasks are tasks for which team members must seek consensus on a preferred alternative. Structuring interaction so that those who have better ideas contribute more to team deliberations should result in better performance. Technological mediation may suppress status effects on judgment tasks, but it may be temporary, as team members seek to restore an effective status structure. Status differentiation may be somewhat less beneficial for *intellective* tasks that have a correct answer, given that as long as one person has the answer, consensus is not required. However, to the extent that status processes operate to place those who are more likely to have a correct answer in an advantaged position in the group, an appropriate status structure should support effective performance. Again, for this type of task, technological mediation may initially suppress status effects, but this effect may be temporary, as team members attempt to restore an effective status structure.

Type of computer-mediated environment. Some computer-mediated communications systems restrict the transmittal of visible as well as expressive indicators of group members' status. For example, group members who are separated over a computer network with no visual capabilities lose access to visual cues of others' status that are present in face-to-face interaction, such as eye contact, style of dress, selecting the head of the table, or perhaps even the race, age, and gender of other group members. The relative anonymity of other group members (compared with face-to-face groups) may result in less hierarchically structured and more equal participation across group members.

Computer-mediated environments in which group members communicate primarily via text, with no visual *or* verbal communication, may also limit the transmittal of expressive status cues such as rate of speech, verbal fluency, and loudness and tone of speech. Furthermore, many computer-mediated systems impose standardized forms of communication that further limit the expression of status. In fact, more formalized means of communication may allow team members to speak uninterrupted, which may in itself lead to changes in patterns of team member interaction. By masking cues to status or by imposing more standardized forms of communications, we would expect interaction in these types of mediated environments to be less hierarchical and more equal.

Temporal context. Teams may be composed of members who are initially differentiated by status distinctions (i.e., teams of mixed

organizational status, gender, or ability) or they may be composed of status equals, undifferentiated with regard to observable status differences. In status-unequal teams, a status structure develops very quickly at the onset of interaction, on the basis of the observable status characteristics that differentiate team members. In status-equal teams, this structure develops more slowly on the basis of the contributions that team members make during team interaction. There are several implications of this distinction. First, in teams that interact over a period of time, the strong initial impact of status characteristics declines as interaction becomes patterned more on the quality of the contributions that team members make. Thus, the effect of technological mediation on blocking observable indicators of status may become less relevant to team interaction over time. Second, the impact of status characteristics in structuring interaction is relatively more salient when the task situation is ambiguous and team members do not have much information regarding the performance abilities of each other. This is more likely to be the case for ad hoc, newly formed teams than for teams that are experienced and have interacted over time.

Counternormative Behavior

Reviews of computer-mediated interaction invariably address differences in counternormative or uninhibited behavior in face-to-face and computer-mediated groups. In fact, this is perhaps one of the most widely cited yet unimpressively supported phenomena in this literature. This ambiguity leads to conflicting conclusions drawn by reviewers that uninhibited communication is either "a common, if not universal, feature of computer-based conferences" (Selfe & Meyer, 1991, p. 170) or "a comparatively rare occurrence in [computer-mediated communications]" (Lea, O'Shea, Fung, & Spears, 1992, p. 108).

It is important to note that the term *counternormative* refers to behavior that deviates from the norm, and it can refer to behavior that is more positive than normal or behavior that is more negative than normal (Blanton & Christie, 2003). Within the computer-mediated communications literature, counternormative or uninhibited behavior is often discussed in terms of hostile or negative communication (i.e., flam-

ing), but this association may not be consistent and can be misleading. In fact, authors of one study that is often cited as providing supporting evidence for negative communications in computer-mediated communications (Kiesler et al., 1985) included in their measure of uninhibited behavior both impolite statements and swearing as well as exclamations (e.g., "Hooray!") and expressions of high positive regard. Thus, caution is advised in that some may treat counternormative or uninhibited behavior as both desirable and undesirable behaviors that deviate from the norm, whereas others may discuss counternormative or uninhibited behaviors as referring specifically to negative behavior.

Counternormative Behavior in Virtual Teams

Certainly the primary concern prevalent in the literature is with counternormative behavior as negative behavior, such as verbal aggression, expressions of hostility, or negative socioemotional content. Dubrovsky et al. (1991) argued that the lack of contextual means of communicating in computer-mediated environments forces interactants to be more forceful and less inhibited. Further, Kiesler et al. (1985) noted that computer-mediated systems transmit social information poorly and that computer-mediated interaction is likely to be characterized by less attention to others, less social feedback, and depersonalized communication. Sproull and Kiesler (1991) concluded, "People interacting on a computer are isolated from social cues. . . . This feeling of privacy makes them feel less inhibited with others" (p. 48). However, the existing research on the effects of computer-mediated communications on counternormative behavior is much more equivocal. Although early research studies revealed more negative socioemotional content in computer-mediated groups than in face-to-face groups, more recent reports have called this relationship into question.

Siegel et al. (1986) argued that the deindividuation stemming from the relative absence of social cues and social feedback in computer-mediated groups would lead to greater uninhibited behavior. They compared three-person groups who either met face-to-face or were physically separated and communicated via a computer-mediated text messaging program. In

the computer-mediated groups, they observed significantly greater instances of uninhibited behavior (swearing, insults, and name calling) than in the face-to-face groups. Dubrovsky et al. (1991) found greater swearing, name calling, and threats in groups communicating via e-mail than in face-to-face groups. Sproull and Kiesler (1986) reported more flaming in groups communicating via e-mail, on the basis of research subjects' self-reports of how much flaming they observed in e-mail messages versus how much they observed in everyday conversations.

However, other studies have found that there is little difference in uninhibited negative behavior between computer-mediated and face-to-face groups. Hiltz, Johnson, and Turoff (1986) compared communication in computer-mediated and face-to-face groups using the Bales Interaction Process Analysis categories. Although they found evidence of fewer socioemotional statements in computer-mediated groups, they also found other results that were more equivocal. Computer-mediated groups made more statements relating to showing tension than face-to-face groups on one experimental task; however, for the other task, this difference was reversed. There was no difference in statements showing antagonism between the two groups. Hiltz, Turoff, and Johnson (1989) found little evidence of uninhibited behavior (e.g., insults, profanity) in either computer-mediated or face-to-face groups composed of corporate managers. Walther and Burgoon (1992) reported no difference in communications showing tension or composure between face-to-face and computer-mediated groups. Walther, Anderson, and Park (1994), in a meta-analysis of negative communication in computer-mediated interaction, concluded that the overall proportion of communications considered negative was quite small and that the difference between negative communication in computer-mediated and face-to-face groups was minute ($d = .017$).

The most reasonable conclusion that can be drawn from this research is that negative counternormative behavior is not inevitable in computer-mediated groups but may occur under some situations. There are several explanations that can account for the potential for greater counternormative behavior in computer-mediated groups, including the effect of the impoverished computer-mediated communications environment, anonymity and deindividuation,

lack of accountability, frustration, and confusion. We consider each of these potential explanations in the following.

One explanation for uninhibited behavior in computer-mediated communication is directly related to the impoverishment of the medium itself. Normal communication involves both verbal and nonverbal channels, and researchers have drawn a distinction between verbal (content) and nonverbal (expressive) communication (Ambady & Rosenthal, 1992; DePaulo, Rosenthal, Eisenstat, Rogers, & Finkelstein, 1976). Moreover, when the content of a message and the expressive behavior accompanying the message are discrepant—for instance, when a person states "That's horrible!" but with a warm voice tone, a smile, and open, relaxed gestures—we are likely to interpret the message as a friendly jibe rather than an insult or a threat. Computer-mediated systems that do not convey expressive behavior may result in more misinterpretations and mistakes in interpreting message intent. Computer-mediated systems that do not provide an audio channel block paralinguistic information, those that do not provide a video channel block the transmission of visual expressive behavior, and even those that provide "head and shoulders" video may distort expressive behavior when it is abstracted from the context in which it is produced and presented via a restricted video image (Heath & Luff, 1992). Furthermore, we may find greater evidence of overt disagreements or more strident statements in computer-mediated groups simply because more subtle forms of disagreement (such as shaking one's head) are rendered less useful by the communications medium. In this case, one form of disagreement may serve as a substitute in computer-mediated communications for another form of disagreement that is suppressed.

A number of researchers have argued that the relative anonymity and loss of social cues in computer-mediated interaction lead to greater depersonalization or deindividuation. The traditional perspective holds that anonymity (such as induced by wearing a mask or being in a large crowd) leads to a loss of self-awareness, and in this state of lowered self-attentiveness, people fail to regulate their behavior with the prevailing standards of performance (Carver & Scheier, 1981; Mullen & Baumeister, 1987). Thus, those "lost in a crowd" are more likely to

become deindividuated and commit atrocities (Mullen, 1987), and those depersonalized in a virtual team environment are less likely to be concerned with prevailing team standards and more likely to exhibit counternormative behavior. The social identity model of deindividuation (SIDE) provides an alternative and competing explanation (Postmes & Spears, 1998; Spears & Lea, 1992). According to the SIDE perspective, deindividuation leads to greater, not less, conformity under certain conditions. More specifically, if group standards are salient (i.e., group membership is emphasized), then deindividuation will lead to greater adherence to group norms. Further, if the reference group supports the expression of uninhibited behavior (as SIDE proponents imply that many online groups do), then this increased responsivity to group norms will lead to greater uninhibited behavior.

A related argument is that deindividuated virtual team members, isolated from the physical presence of other team members, may be less accountable for their actions. Normative bonds are consensual—we adhere to norms because it is the right thing to do. But we also conform to norms because of the coercive power of others. For example, I may choose not to insult someone sitting across the table from me because he or she may take umbrage and respond. Virtual team members are under less coercive control, stemming from the lack of immediate presence of other team members, and are less accountable for their actions. Furthermore, in ad hoc one-shot or single-meeting virtual teams, not only do we not have someone who can figuratively reach over and thump us on the ears, but there is no potential for future interaction in which transgressions can be righted. Thus, the loss of the coercive power of other physically present team members may lead to greater uninhibited behavior in virtual teams.

It is reasonable to expect that there is greater "mechanical friction" (i.e., frustration with new or awkward procedures and systems) involved in using computer-mediated systems, which may lead to greater annoyance and emotionality (Poole, Holmes, Watson, & DeSanctis, 1993). It is further likely that these procedural difficulties and resulting frustrations would subside over time. However, because of the short-term, temporary nature of many research studies, there is little evidence available regarding whether or how this type of adaptation occurs.

Finally, there may be greater counternormative behavior in computer-mediated teams because interaction is more confusing than in face-to-face communication (Thompson & Coovert, 2003). Thompson and Coovert claim that virtual teams have greater difficulty establishing mutual or shared knowledge because they lack the direct knowledge gained from firsthand, immediate experience with other team members. They found that in comparison with teams that worked face-to-face, teams that interacted via text-based computer conferencing reported greater confusion and less understanding of team discussions. These results suggest that technological mediation may lead to greater counternormative behavior, especially unintentional norm violations, because virtual team members may find it more difficult to understand just what the rules are.

Performance Effects

There is little direct research on the effects of counternormative behavior on performance in computer-mediated groups. However, assuming that team norms support performance, adherence to team norms should generally result in greater productivity (Postmes, Spears, & Cihangir, 2001). Moreover, negative or hostile communications may lead to greater task-irrelevant communications and may disrupt team interaction and interpersonal relations among team members.

Moderators

Type of task. Many of the studies that have examined counternormative behavior in computer-mediated groups have used judgment or choice dilemma tasks, including studies that have reported greater counternormative behavior in computer-mediated groups versus face-to-face groups (Dubrovsky et al., 1991; Siegel et al., 1986) as well as those reporting no difference (Hiltz et al., 1989). It is likely that the relative anonymity, lack of accountability, frustration, and confusion that may stem from interaction in computer-mediated environments would have similar effects on a broad range of tasks. However, the tendency for these conditions to result in negative socioemotional out-

bursts may be greater for tasks in which socio-emotional relations are more salient, such as social or persuasive tasks, than in more routinized mechanical/technical or logical/precision tasks.

One further characteristic of the task is relevant to the effect of deindividuation on counternormative behavior. The SIDE model argues that deindividuation leads to greater identification with the group and stronger normative commitment when social identity is salient (Postmes, Spears, & Lea, 1998). That is, for tasks in which group members perceive strong membership to the group, deindividuation may reinforce conformity to group norms (i.e., team members are less self-aware and more group-aware). When group members do not identify strongly with the group, deindividuation may weaken social influence and increase counternormative behaviors.

Type of computer-mediated environment. Research on counternormative behavior has almost exclusively compared face-to-face groups with groups communicating via e-mail or text-based computer conferencing systems (cf. Dubrovsky et al., 1991; Hiltz et al., 1989; Kiesler et al., 1985; Siegel et al., 1986; Sproull & Kiesler, 1986; Walther & Burgoon, 1992). We would expect deindividuation or loss of self-awareness to be more prevalent the more that the communications medium restricts the transmission of individual cues. Thus, we would expect deindividuation to be greatest for text-based communications systems, relatively less likely to occur for audio-based systems, and even less likely to occur for audio–video communications. Frustration with the communications medium and confusion with team deliberations are also likely to be greater for more restrictive communications environments. On the other hand, the loss of accountability stems primarily from the physical separation of team members, and this is likely to be salient in any communications environment in which team members are separated from one another.

Temporal context. Sproull and Kiesler (1986) and Hiltz et al. (1989) examined counternormative behavior in intact work teams. Sproull and Kiesler reported greater counternormative behavior in e-mail communications, and Hiltz et al. reported no differences between teams communicating via text conferencing and those interacting face-to-face. The vast majority of other studies of counternormative behavior examined newly formed groups whose time together lasted approximately 90 min or less. Walther (1997) has argued that short-term computer-mediated groups are more task oriented, impersonal, and hostile than long-term groups. He states that groups that anticipate future interaction increase social information seeking, show more positive affect, and enact more relationally positive communication than ad hoc one-shot groups. Indeed, Walther et al. (1994) reported that differences in the extent of negative communications between face-to-face and computer-mediated groups were reduced when interaction was longer term versus time restricted.

Communication

Communication is a multimodal process that includes both verbal and nonverbal components. As people speak, they also gesture to elaborate speech, they change body position and posture, and they vary facial expression and gaze. In fact, one primary characteristic of communication is that the literal meaning of speech underspecifies the speaker's intended meaning. To infer the speaker's intended meaning requires that the listener supplement speech content with contextual information that is not represented in speech. This contextual information may include a speaker's gaze or eye contact, facial expressions, gestures, posture and body movements, as well as paralinguistic cues such as intonation and loudness of speech. For example, expressive behaviors such as gestures can serve multiple functions: they may supplement and elaborate speech content, accent or punctuate speech, substitute for speech, clarify ambiguity, regulate the timing and sequence of communication, and convey emotion (Driskell & Radtke, in press). All of these functions can serve to more fully convey information to the listener. The promise of computer-mediated communications systems is to produce an environment that captures the richness of face-to-face communication.

Communication in Virtual Teams

Communications systems that do not support the transmission of contextual information are viewed as impoverished and less informative

(Fussell & Benimoff, 1995). One perspective on communication in computer-mediated groups contends that transfer of information is restricted in a computer-mediated environment owing to a reduction in the amount and type of cues available to interactants. More specifically, the types of information reduced in a computer-mediated environment are largely cues of context—verbal and nonverbal behaviors that play a large part in defining the message that is communicated. In brief, the available body of research suggests that (a) communication involves the transfer of information through multiple channels, (b) computer-mediated interaction may filter out certain communicative cues (primarily visual and contextual) found in face-to-face interaction, and (c) this restriction in contextual cues may lead to significant changes in group communication (see Culnan & Markus, 1987).

One fundamental problem present in computer-mediated communications is the failure to establish and maintain mutual knowledge (Cramton, 2001; Thompson & Coovert, 2003) or common ground (Clark & Brennan, 1991). Mutual knowledge refers to knowledge that team members share and know they share (Krauss & Fussell, 1990). Accordingly, a lack of mutual knowledge would be represented by team members who hold differing information and do not realize they do so. Whittaker and O'Conaill (1997) noted that group members must establish common ground in regard to the content of communication (mutual knowledge regarding the content of conversation) and also the process of communication (mutual knowledge regarding who will speak, who will listen, and how transitions are made).

Mutual knowledge is established through several mechanisms, including direct knowledge gained from shared experiences and first-hand observations of other team members and through the dynamics of the interaction process itself (Krauss & Fussell, 1990). Virtual team members are less likely to gain direct knowledge of other team members when they are located remotely from one another. Furthermore, establishing mutual knowledge through interaction is made more difficult in a computer-mediated environment because information exchange is less complete, is slower, and requires more effort. Cramton (2001) has noted that one reason communication is more difficult in com-

puter-mediated environments is the greater effort required to convey nuances of speech without the use of expressive and paralinguistic cues.

For example, one of the most common ways of establishing whether a statement is understood is through *acknowledgment*. Acknowledgments are attempts to provide positive evidence of understanding. Acknowledgments are often verbal but in many cases constitute what are termed *back-channel responses*, including signals or gestures such as head nods, shrugs, or smiles. Another basic form of acknowledgment is sustained attention. In normal communication, individuals typically monitor moment-to-moment what other interactants are doing. We detect cues of sustained attention from others, often through eye gaze, that indicate their understanding. On the other hand, when someone looks puzzled, breaks eye contact, or raises a brow, this provides critical information that understanding has not been established. In a computer-mediated environment, because this type of contextual communication is often lacking, it may be more difficult to ground communication and establish that a statement is understood; additionally, the costs of grounding communication will be greater, as team members must expend more effort to ensure that information is understood by others.

A related problem in attempting to achieve mutual knowledge in virtual teams is that restricted feedback may make it more difficult to transfer information and to identify and correct errors in the transfer of information as they occur. Cooperative behavior in a team setting is an iterative cycle of individual performance, feedback from others, adjustment, and action. Ashford and Tsui (1991) note that in many real-world task settings, formal feedback mechanisms regulate behavior only loosely. That is, the feedback that is received directly from external sources may in some cases be of less relevance than that which is abstracted actively from the environment by the individual. Drawing feedback from other team members requires an active process of seeking and evaluating feedback, monitoring performance, and initiating and revising corrective actions.

Models of self-regulation emphasize the importance of feedback that individuals generate for themselves, rather than information that is passively provided by others (Butler & Winne,

1995). *Self-regulation* refers to the active process whereby individuals set performance standards, seek and evaluate feedback, detect discrepancies in their performance, and take actions to reduce those discrepancies. Self-regulation is, in part, a social process. As team members monitor their ongoing task performance, they seek feedback from sources such as other team members. This feedback allows the learner to establish the validity of his or her own perceptions regarding current task performance, verify performance standards, and gather information regarding potential strategies to correct performance.

To the extent that team members are less immediate and accessible, accessing peer feedback is more difficult. Often, individuals may seek feedback from a team member's glance, nod, or frown—nuanced behaviors that are not easily transmitted in computer-mediated environments. Not only is this type of feedback more difficult to perceive in a computer-mediated environment, it may be less likely to be provided by a team member who is sitting remotely at a computer screen rather than in the direct presence of others. A second concern is that the nature or valence of feedback provided by members of virtual teams may differ from that of face-to-face groups. Ashford and Tsui (1991) have noted that there is a general tendency for people to give each other positive feedback spontaneously, while withholding negative feedback. However, research suggests that under certain circumstances, members of computer-mediated groups may offer more negative or extreme evaluations of others than members of face-to-face groups (Walther, 1997). Thus, there may be a tendency in computer-mediated environments for team members to be exposed to more negative feedback, disapproval, or censure. Finally, virtual team environments may affect how feedback is evaluated. Individuals do not simply absorb feedback but actively evaluate the extent to which feedback is an accurate reflection of their performance. Feedback that is seen as inaccurate is discounted; feedback that is seen as accurate is more likely to be accepted. Some research suggests that feedback is more likely to be accepted from sources that are psychologically closer to the source than from those more distant (Ilgen, Fisher, & Taylor, 1979). Thus, we may accept feedback less readily from others in a virtual team environment who are seen as more remote or removed from the immediate social setting.

Performance Effects

Cramton (2001) found several consequences of the failure to establish mutual knowledge in computer-mediated teams. Team members had difficulty in communicating and obtaining contextual information regarding the specific conditions and constraints under which remote teammates worked. Information was distributed unevenly among team members, and widely varying impressions were formed regarding the task. Team members had difficulty in communicating and in understanding what was most important in the information transmitted. Finally, team members reported problems in receiving timely feedback from other team members and in interpreting the meaning of other teammates' silence or lack of response. Interestingly, some team members interpreted others' failure to communicate as an unwillingness to work, reflecting the tendency to make negative personal attributions when situational information is absent. Thompson and Coovert (2003) found that a lack of mutual knowledge in computer-mediated teams led to greater confusion and inaccuracies in recording team decisions. Finally, some research has shown that the similarity of shared mental models among team members predicts the quality of team processes and performance (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000).

Moderators

Type of task. Cramton (2001) noted that the impact of computer-mediated communications on mutual knowledge is likely to be greater for tasks in which individual team members hold a great amount of unique information and in which contextual information between remote sites differs. Furthermore, this problem is exacerbated by high requirements for complexity, workload, and interdependence. Others have argued that technological mediation, especially the loss of visual cues, may have a greater impact on communication effectiveness for tasks that have a greater interpersonal requirement, such as social, manipulative/persuasive, or negotiation tasks (Sellen, 1995; Short, 1974; Williams, 1977).

Type of computer-mediated environment.
The advantages of audio over text-based communications are substantial, leading Whittaker and O'Conaill (1997) to conclude that speech is the critical medium for interpersonal communications. Thus, the negative impact of technological mediation on communication should be reduced when audio is available. However, the value of adding video to audio communications is less apparent. Rudman, Hertz, Marshall, and Dykstra-Erickson (1997) examined the role of the video channel in supporting computer-mediated communication. They proposed that one benefit of adding video to audio and data channels in a computer-mediated environment is that it allows teams to more effectively regulate the flow of interaction and to communicate emotions and attitudes. Rudman et al. found that team members using audio-only communications had difficulty knowing when others were paying attention and could not tell when they were understood because they could not see others' nonverbal reactions. Without visual feedback, team members delayed asking others for information out of fear of interrupting their work; further, they had problems knowing when others needed help, because they could not see others' level of frustration or confusion. In general, Rudman et al. observed that without visual input, team members had problems evaluating others' level of attention and concentration, determining how positive or negative others were feeling, determining whether others needed help, and knowing when to interrupt.

Nevertheless, the bulk of evidence on the value of adding video capabilities to computer-mediated systems is not supportive. In one of the earliest such studies, Chapanis, Ochsman, Parrish, and Weeks (1972) found that adding video to group communications did not enhance the efficiency of group problem solving or result in higher quality outcomes. Other studies have similarly shown little advantage of video over audio-only communication in enhancing team performance (Anderson et al., 1997; Boyle, Anderson, & Newlands, 1994; Doherty-Sneddon et al., 1997; Sellen, 1995; Williams, 1977). In a recent review of this literature, Whittaker and O'Conaill (1997) concluded, "Laboratory studies to demonstrate the benefits of adding a visual communication modality to voice have in general shown few objective improvements" (p. 24).

Why does video apparently do so little to enhance communication in computer-mediated systems? First, Doherty-Sneddon et al. (1997) note that a primary focus on task outcome may be misleading and that a more useful evaluation of communication requires consideration of both outcome and communicative process. By looking at outcome alone, their results showed little difference between face-to-face, audio, and audio–video communications. However, they also found that the structure of communication varied across these conditions and that the visual channel was useful to speakers, for example, in facilitating conversational flow.

However, one further factor underlies the apparent ineffectiveness of video in computer-mediated communications. Research suggests that people are able to make fairly accurate judgments of others' personality on the basis of minimal interactions (Ambady, Hallahan, & Rosenthal, 1995) and that people are able to recognize emotions as well as deception from demeanor (Frank & Ekman, 1997). However, studies also show that the assessment of other states, moods, or motivations from nonverbal behavior can be more difficult. For example, Jecker, Maccoby, Breitrose, and Rose (1964) found that assessing comprehension from nonverbal behavior was difficult and that teachers were able to accurately assess student comprehension about 30% of the time from video recordings. Furthermore, research that has attempted to improve the ability to decode nonverbal behavior suggests that training may increase decoding accuracy (Costanzo, 1992). However, most studies that contrast audio-only with audio–video communications simply make available a video channel (typically a facial image on a computer screen window) for team members to use. One reason that providing a video channel to computer-mediated systems has shown few benefits may be that individuals make poor use of the social cues that are available without specialized training to ensure accuracy in decoding nonverbal behavior.

Temporal context. It is likely that communication difficulties, and especially problems in establishing mutual knowledge, will be less for preexisting teams that have a history of interaction, team members who are more experienced using the communications media, and more mature teams that can function with less rich information exchanges (McGrath & Hollings-

head, 1994). Moreover, the value of video to enhancing communication in virtual teams may be greater as team members gain familiarity with one another. In ad hoc or newly formed groups, expressions and gestures are idiosyncratic. In other words, when we have not worked with someone before, that person's gestures, posture, and expressions may hold little meaning for us. It is only over time that these idiosyncratic gestures gain meaning (e.g., we learn that when Alice looks away, she is thinking, but when Bob looks away, he is bored). Therefore, the use of video in computer-mediated systems may be of less value for newly formed teams, because the social information provided may hold less meaning.

Discussion

Some see a future in which virtual team members interact seamlessly over advanced communications systems. Others are more cautious and argue that virtual teams differ in significant ways from teams that work face-to-face. For each of the topics we have discussed, we have examined research that has compared face-to-face teams and technology-mediated or virtual teams. The existing evidence leads us to conclude that overall, distance seems to matter—that being mediated by technology can have a significant impact on how teams perform. These performance effects may stem from changes in cohesiveness, status structure, counternormative behavior, and communication.

Technological mediation can have a negative effect on cohesiveness, affecting interpersonal bonds (interpersonal attraction), normative bonds (group pride), and instrumental bonds (task commitment) among team members. Team performance is likely to be affected especially to the extent that task commitment is lowered.

Technological mediation may affect the status structure of the team by blocking the transmission of status information, dampening the effects of status cues, or weakening the normative process that supports status-based behavior. To the extent that more competent persons occupy higher positions in the status hierarchy of the team, performance can be degraded if status differentials are reduced.

Although counternormative behavior is not necessarily a feature of computer-mediated teams, technological mediation can lead to a greater prevalence of behaviors, both desirable and undesirable, that deviate from the norm. Negative counternormative behavior may stem from a number of causes, including deindividuation, frustration, lack of accountability, and confusion, and can disrupt the smooth interpersonal relations required for effective team performance.

Technological mediation can make it more difficult to communicate information to others and to interpret the communications of others. The relative loss of contextual information in computer-mediated communications can result in greater difficulty in establishing mutual knowledge and can lead to greater confusion among team members and inaccuracies in performance.

However, the effects of technological mediation on these team processes are moderated by the type of computer-mediated environment, the type of task, and the temporal context of the team. We described the effects of these three moderators as overarching, and the evidence reviewed suggests they are indeed important. For example, there are few generalizations that can be made about virtual teams without considering the nature of the communications environment. Overall, less rich communications media serve to exacerbate the effects of technological mediation. Thus, to the extent that technological mediation impairs interaction, it impairs interaction more so for text-only communications than for text–audio and for audio–video communications. However, there also seems to be something about the physical presence or immediacy of another that differentiates face-to-face interaction from even high-quality audio–video. Sellen (1995) concluded,

> There appears to be something critically different about sharing the same physical space that needs to be examined more carefully. What aspects of interaction are fundamentally altered when people no longer share the same physical space? Why does the presence of a video channel fail to compensate? (p. 440)

At present, there is no satisfactory explication of this issue.

Similarly, few firm statements can be made regarding team interaction in virtual environments without consideration of the type of task that the team is performing. This variable is somewhat more difficult to examine, as there are any number of dimensions on which tasks

may be classified. We have attempted to focus on the behavioral requirements of the task; the distinction that seems to be most useful is that between tasks that have high interpersonal/social requirements (i.e., social and persuasive tasks) and tasks that have greater instrumental requirements (i.e., technical or logical tasks). The comparison is not a simple one, but technological mediation may be more disruptive for tasks that have high demands for either social or instrumental interdependence than for tasks that can be accomplished with less social or instrumental interaction.

Finally, McGrath (1990) has noted, "Groups develop and exist in a temporal context" (p. 23), an admonition that is all but ignored in most research on virtual teams. Overall, time and experience tend to brace teams against the deleterious effects of technological mediation. Thus, some of the negative effects of technological mediation observed in ad hoc, short-term teams may not be evident in intact or experienced teams. Further, some effects of technological mediation that are observed in the short term may be temporary and subside over time.

To draw firm conclusions from a model of team performance such as that presented in Figure 1, a research literature is needed that clearly and systematically varies important team and task characteristics. However, as Hollingshead and McGrath (1995) noted, this may be the ideal, but the reality is that the body of literature on computer-mediated teams virtually ignores the operation of key team and task variables. Accordingly, in many cases, our analyses are speculative rather than conclusive, and more research is needed to further elucidate the specific conditions under which technological mediation impacts team interaction. However, as is often the case, there is value in noting what we do not know at this point. Specifically, further research is needed to examine the effects of technological mediation on other processes, other outcomes, and other moderators.

Other Processes

We have discussed in some detail the effects of technological mediation on cohesiveness, status processes, counternormative behavior, and communication. There are a number of other team processes of interest such as leader-

ship, decision making, cooperation, and conformity that have not been fully examined in this literature. For example, one process that may be particularly relevant given the nature of the computer-mediated environment is social loafing. Social loafing refers to the tendency for individuals to become less motivated to exert full effort when working on a collective group task than when working independently (Latane, Williams, & Harkins, 1979). In the early part of this century, Ringelmann (1913) found that when research participants performed a rope-pulling task as a group, less force was exerted than would be expected by combining the forces of each individual. Furthermore, as the size of the group increased, the difference between expected and actual productivity became greater. Subsequent research has shown that social loafing is most likely to occur when the individual task performer is immersed in a larger group, when the task contributions of others cannot be easily identified, when the work group is composed of strangers or lacks cohesiveness, and when group members are less likely to perceive the direct contributions of their own efforts to the group outcome (Karau & Williams, 1993; Mullen & Baumeister, 1987). These conditions reflect those that occur in a virtual team environment. Members of virtual teams work together but individual outputs are often difficult to distinguish or monitor. Members of virtual teams work with others who are dispersed over a wide geographic area and with whom they have little direct contact, and they may be one "node" of a network that may contain a large group of members. Thus, a virtual team member, who may see five other group members represented on a computer screen (conferencing software typically places an image of each other member in a separate window on the screen), may become lost in the crowd and devote less effort to the task. Although a virtual team setting may be a prime environment for social loafing to occur, very little research has examined this topic.

Other Outcomes

We limited our interest to the effects of technological mediation on team performance, broadly defined. There are clearly more specific indicators of team performance that should be examined, including performance accuracy,

speed, and quality of solutions, among other measures. There are also important outcome variables other than performance, including team member satisfaction, the longevity or viability of the team, and organizational outcomes.

Other Moderators

There are a number of other potential moderators that warrant further scrutiny, including the size of the team. Steiner (1972) noted that team size may impact performance in several ways. As a group gets larger, the diversity of its members increases, thus increasing the variety of viewpoints and potentially increasing the number of problem solutions available to the team. However, larger teams do not always perform better than smaller ones. Increasing team size makes coordination requirements more difficult, and as groups increase in size and complexity, more group structure (role differentiation, etc.) is required to coordinate group activity. It is well established that whereas total group performance may increase as the size of the group increases, group member performance (i.e., performance per person) and satisfaction decrease as a function of group size (e.g., Mullen, 1991; Mullen & Baumeister, 1987).

Separating team members from one another, as in a virtual team environment, may serve to "reduce" the size of the group in a perceptual sense. In other words, we may be able to alleviate the negative consequences of being part of a larger team by having team members work together but remotely over a communications network. Thus, it is possible that technological mediation may increase team member satisfaction in large teams by making a large group feel smaller, yet it may decrease satisfaction in small teams by disrupting the closer interpersonal bonds forged by smaller groups. However, there has been little research conducted to examine potential social advantages of technological mediation.

In summary, some differences that have been observed between face-to-face and virtual teams are likely to be temporary. For example, the mechanical friction and user frustrations inherent in using a relatively crude audio–visual interface will dissipate as advances in hardware and software are achieved. Some differences that have been noted may be illusory: The observation that members of virtual teams verbally disagree more than members of face-to-face teams may simply reflect the fact that virtual team members are less able to disagree nonverbally. However, some differences are more fundamental. We believe that one such difference is the distinction between the immediacy of a physically present team member and the remoteness of a virtual team member. However, a social psychological analysis of the concept of presence is lacking.

One feature that characterizes much of the research on virtual teams is an emphasis on developing advanced technological environments for virtual team interaction. One disadvantage of this technology-focused approach is that key social and psychological variables may be overlooked or ignored, as Hollingshead and McGrath (1995) observed. If ever there was an essential need and role for social and psychological research, this is it. Although research on virtual teams may span the disciplines of human factors, communication, and human computer interaction, the knowledge of *group dynamics* is central to understanding performance in virtual teams.

References

Ambady, N., Hallahan, M., & Rosenthal, R. (1995). On judging and being judged accurately in zero-acquaintance situations. *Journal of Personality and Social Psychology, 69,* 518–529.

Ambady, N., & Rosenthal, R. (1992). Thin slices of expressive behavior as predictors of interpersonal consequences: A meta-analysis. *Psychological Bulletin, 111,* 256–274.

Anderson, A. H., O'Malley, C., Doherty-Sneddon, G., Langton, S., Newlands, A., Mullin, J., et al. (1997). The impact of VMC on collaborative problem solving: An analysis of task performance, communicative process, and user satisfaction. In K. E. Finn, A. J. Sellen, & S. B. Wilbur (Eds.), *Video-mediated communication* (pp. 133–155). Mahwah, NJ: Erlbaum.

Ashford, S. J., & Tsui, A. S. (1991). Self-regulation for managerial effectiveness: The role of active feedback seeking. *Academy of Management Journal, 34,* 251–280.

Back, K. W. (1951). Influence through social communication. *Journal of Abnormal and Social Psychology, 46,* 9–23.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statis-

tical considerations. *Journal of Personality and Social Psychology, 51,* 1173–1182.

Berger, J. (1992). Expectations, theory, and group processes. *Social Psychology Quarterly, 55,* 3–11.

Berger, J., Webster, M., Ridgeway, C., & Rosenholtz, S. J. (1986). Status cues, expectations, and behavior. In E. Lawler (Ed.), *Advances in group processes: Theory and research* (Vol. 3, pp. 1–22). Greenwich, CT: JAI Press.

Blanton, H., & Christie, C. (2003). Deviance regulation: A theory of action and identity. *Review of General Psychology, 7,* 115–149.

Bos, N., Olson, J. S., Gergle, D., Olson, G. M., & Wright, Z. (2002). Effects of four computer-mediated communications channels on trust development. In *Proceedings of CHI 2002* (pp. 135–140). New York: ACM Press.

Boyle, E., Anderson, A., & Newlands, A. (1994). The effects of visibility on dialogue and performance in a cooperative problem solving task. *Language and Speech, 37,* 1–20.

Burgelman, J. C. (2000). *Traveling with communication technologies in space, time and everyday life: An exploration of their impact.* Retrieved from http://www.firstmonday.dk/issues/issue5_3/burgelman/

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research, 65,* 245–281.

Cairncross, F. (1997). *The death of distance: The trendspotter's guide to new communications.* Boston: Harvard Business School Press.

Cappel, J. J., & Windsor, J. C. (2000). Ethical decision making: A comparison of computer-supported and face-to-face groups. *Journal of Business Ethics, 28,* 95–107.

Carver, C. S., & Scheier, M. F. (1981). *Attention and self-regulation: A control-theory approach to human behavior.* New York: Springer-Verlag.

Chapanis, A., Ochsman, R. B., Parrish, R. N., & Weeks, G. D. (1972). Studies in interactive communication: I. The effects of four communication modes on the behavior of teams during cooperative problem-solving. *Human Factors, 14,* 487–509.

Clark, H. H., & Brennan, S. E. (1991). Grounding in communication. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 127–149). Washington, DC: American Psychological Association.

Connolly, T., Jessup, L. M., & Valacich, J. S. (1990). Effects of anonymity and evaluative tone on idea generation in computer-mediated groups. *Management Science, 36,* 97–120.

Costanzo, M. (1992). Training students to decode verbal and nonverbal cues: Effects on confidence and performance. *Journal of Educational Psychology, 84,* 303–313.

Craig, T. Y., & Kelly, J. R. (1999). The effects of task and interpersonal cohesiveness on group creativity. *Group Dynamics: Theory, Research, and Practice, 3,* 243–256.

Cramton, C. D. (2001). The mutual knowledge problem and its consequences for dispersed collaboration. *Organizational Science, 12,* 346–371.

Culnan, M. J., & Markus, M. L. (1987). Information technologies. In F. M. Jablin, L. L. Putnam, K. H. Roberts, & L. W. Porter (Eds.), *Handbook of organizational communication: An interdisciplinary perspective* (pp. 420–443). Newbury Park, CA: Sage.

Curtis, R. C., & Miller, K. (1986). Believing another likes or dislikes you: Behaviors making the beliefs come true. *Journal of Personality and Social Psychology, 51,* 284–290.

Daft, R. L., & Lengel, R. H. (1984). Information richness: A new approach to managerial behavior and organization design. *Research in Organizational Behavior, 6,* 191–233.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness, and structural design. *Management Science, 32,* 554–571.

DePaulo, B. M., Rosenthal, R., Eisenstat, R. A., Rogers, P. L., & Finkelstein, S. (1976). Decoding discrepant nonverbal cues. *Journal of Personality and Social Psychology, 36,* 313–323.

Devine, D. J. (2002). A review and integration of classification systems relevant to teams in organizations. *Group Dynamics, 6,* 291–310.

Doherty-Sneddon, G., Anderson, A., O'Malley, C., Langton, S., Garrod, S., & Bruce, V. (1997). Face-to-face and video-mediated communication: A comparison of dialogue structure and task performance. *Journal of Experimental Psychology: Applied, 3,* 105–125.

Driskell, J. E., Hogan, R., & Salas, E. (1987). Personality and group performance. In C. Hendrick (Ed.), *Review of personality and social psychology* (Vol. 9, pp. 91–112). Newbury Park, CA: Sage.

Driskell, J. E., & Mullen, B. (1990). Status, expectations, and behavior: A meta-analytic review and test of the theory. *Personality and Social Psychology Bulletin, 16,* 541–553.

Driskell, J. E., Olmstead, B., & Salas, E. (1993). Task cues, dominance cues, and influence in task groups. *Journal of Applied Psychology, 78,* 51–60.

Driskell, J. E., & Radtke, P. H. (in press). The effect of gesture on speech production and comprehension. *Human Factors.*

Dubrovsky, V., Kiesler, S., & Sethna, B. (1991). The equalization phenomenon: Status effects in computer-mediated and face-to-face decision-making groups. *Human-Computer Interaction, 6,* 119–146.

Erickson, B., Lind, E. A., Johnson, B. C., & O'Barr, W. M. (1978). Speech style and impression forma-

tion in a court setting: The effects of "powerful" and "powerless" speech. *Journal of Experimental Social Psychology, 14,* 266–279.

Evans, C. R., & Dion, K. L. (1991). Group cohesion and performance: A meta-analysis. *Small Group Research, 22,* 175–186.

Festinger, L. (1950). Informal social communication. *Psychological Review, 57,* 271–282.

Frank, M. G., & Ekman, P. (1997). The ability to detect deceit generalizes across different types of high-stake lies. *Journal of Personality and Social Psychology, 72,* 1429–1439.

Fussell, S. R., & Benimoff, N. I. (1995). Social and cognitive processes in interpersonal communication: Implications for advanced telecommunications technologies. *Human Factors, 37,* 228–250.

Golembiewski, R. T. (1962). *The small group: An analysis of research concepts and operations.* Chicago: University of Chicago Press.

Griffith, T., & Neale, M. A. (1999). *Information processing and performance in traditional and virtual teams: The role of transactive memory* (Research Paper No. 1613). Stanford, CA: Stanford University Graduate School of Business.

Hackman, J. R., & Morris, C. G. (1975). Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. *Advances in Experimental Social Psychology, 8,* 45–99.

Heath, C., & Luff, P. (1992). Media space and communicative asymmetries: Preliminary observations of video-mediated interaction. *Human-Computer Interaction, 7,* 315–346.

Hiltz, S. R., Johnson, K., & Turoff, M. (1986). Experiments in group decision making: Communication process and outcome in face-to-face versus computerized conferences. *Human Communication Research, 13,* 225–252.

Hiltz, S. R., Turoff, M., & Johnson, K. (1989). Experiments in group decision making: 3. Disinhibition, deindividuation, and group process in pen and real name computer conferences. *Decision Support Systems, 5,* 217–232.

Hollingshead, A. B., & McGrath, J. E. (1995). Computer-assisted groups: A critical review of the empirical research. In R. A. Guzzo, E. Salas, I. L. Goldstein, et al. (Eds.), *Team effectiveness and decision making in organizations* (pp. 46–78). San Francisco: Jossey-Bass.

Hollingshead, A. B., McGrath, J. E., & O'Conner, K. M. (1993). Group task performance and communication technology: A longitudinal study of computer-mediated versus face-to-face work groups. *Small Group Research, 24,* 307–334.

Ilgen, D. R., Fisher, C. D., & Taylor, M. S. (1979). Consequences of individual feedback on behavior in organizations. *Journal of Applied Psychology, 64,* 349–371.

Jarvenpaa, S. L., & Leidner, D. E. (1999). Communication and trust in virtual teams. *Organizational Science, 10,* 791–815.

Jecker, J., Maccoby, N., Breitrose, H. S., & Rose, E. D. (1964). Teacher accuracy in assessing cognitive visual feedback from students. *Journal of Applied Psychology, 48,* 393–397.

Karau, S. J., & Williams, K. D. (1993). Social loafing: A meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology, 65,* 681–706.

Kiesler, S., Zubrow, D., Moses, A., & Geller, V. (1985). Affect in computer-mediated communication: An experiment on synchronous terminal-to-terminal discussion. *Human-Computer Interaction, 1,* 77–104.

Krauss, R., & Fussell, S. (1990). Mutual knowledge and communicative effectiveness. In J. Galegher, R. E. Kraut, & C. Egido (Eds.), *Intellectual teamwork: Social and technical bases of collaborative work* (pp. 111–146). Hillsdale, NJ: Erlbaum.

Latane, B., Williams, K., & Harkins, S. (1979). Many hands make light work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology, 37,* 822–832.

Lea, M., O'Shea, T., Fung, P., & Spears, R. (1992). "Flaming" in computer-mediated communication: Observations, explanations, and implications. In M. Lea (Ed.), *Contexts of computer-mediated communication* (pp. 89–112). Hertfordshire, England: Harvester Wheatsheaf.

Levine, J. M., & Moreland, R. L. (1990). Progress in small group research. *Annual Review of Psychology, 41,* 585–634.

Linville, J. M., Liebhaber, M. J., Obermayer, A. H., & Fallesen, J. J. (1991). *Computer-mediated group processes in distributed command and control systems: Supervised shared work* (Tech. Rep. 926). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Lott, A. J., & Lott, B. E. (1961). Group cohesiveness, communication level, and conformity. *Journal of Abnormal and Social Psychology, 62,* 408–412.

Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology, 85,* 273–283.

McGrath, J. E. (1984). *Groups: Interaction and performance.* Englewood Cliffs, NJ: Prentice-Hall.

McGrath, J. E. (1990). Time matters in groups. In J. Galegher, R. E. Kraut, & C. Egido (Eds.), *Intellectual teamwork: Social and technical bases of collaborative work* (pp. 23–61). Hillsdale, NJ: Erlbaum.

McGrath, J. E. (1997). Small group research, that once and future field: An interpretation of the past

with an eye to the future. *Group Dynamics, 1,* 7–27.

McGrath, J. E., & Hollingshead, A. B. (1994). *Groups interacting with technology: Ideas, issues, evidence, and an agenda.* Newbury Park, CA: Sage.

McLeod, P. L. (1992). An assessment of the experimental literature on electronic support of group work: Results of a meta-analysis. *Human-Computer Interaction, 7,* 257–280.

Meyerson, D., Weick, K. E., & Kramer, R. M. (1996). Swift trust and temporary groups. In R. M. Kramer & T. R. Tyler (Eds.), *Trust in organizations: Frontiers of theory and research* (pp. 166–195). Thousand Oaks, CA: Sage.

Mullen, B. (1987). Self-attention theory: The effects of group composition on the individual. In B. Mullen & G. R. Goethals (Eds.), *Theories of group behavior* (pp. 125–146). New York: Springer-Verlag.

Mullen, B. (1991). Group composition, salience, and cognitive representations: The phenomenology of being in a group. *Journal of Experimental Social Psychology, 27,* 297–323.

Mullen, B., Anthony, T., Salas, E., & Driskell, J. E. (1994). Group cohesiveness and quality of decision making: An integration of tests of the groupthink hypothesis. *Small Group Research, 25,* 189–204.

Mullen, B., & Baumeister, R. F. (1987). Group effects on self-attention and performance: Social loafing, social facilitation, and social impairment. In C. Hendrick (Ed.), *Review of personality and social psychology* (pp. 189–206). Beverly Hills, CA: Sage.

Mullen, B., & Copper, C. (1994). The relation between group cohesiveness and performance: An integration. *Psychological Bulletin, 115,* 210–227.

Mullen, B., Salas, E., & Driskell, J. E. (1989). Salience, motivation, and artifact as contributions to the relation between participation rate and leadership. *Journal of Experimental Social Psychology, 25,* 545–559.

Nixon, H. L. (1979). *The small group.* Englewood Cliffs, NJ: Prentice-Hall.

Oliver, L. W., Harman, J., Hoover, E., Hayes, S. M., & Pandhi, N. A. (1999). A quantitative integration of the military cohesion literature. *Military Psychology, 11,* 57–83.

Olson, G. M., & Olson, J. S. (2000). Distance matters. *Human-Computer Interaction, 15,* 139–179.

Poole, M. S., Holmes, M., Watson, R., & DeSanctis, G. (1993). Group decision support systems and group communication: A comparison of decision making in computer-supported and nonsupported groups. *Communication Research, 20,* 176–213.

Postmes, T., & Spears, R. (1998). Deindividuation and antinormative behavior: A meta-analysis. *Psychological Bulletin, 123,* 238–259.

Postmes, T., Spears, R., & Cihangir, S. (2001). Quality of decision making and group norms. *Journal of Personality and Social Psychology, 80,* 918–930.

Postmes, T., Spears, R., & Lea, M. (1998). Breaching or building social boundaries? SIDE-effects of computer-mediated communications. *Communication Research, 25,* 689–715.

Postmes, T., Spears, R., & Lea, M. (2002). Intergroup differentiation in computer-mediated communication: Effects of depersonalization. *Group Dynamics, 6,* 3–16.

Ridgeway, C. L. (1987). Nonverbal behavior, dominance, and the basis of status in task groups. *American Sociological Review, 52,* 683–694.

Ridgeway, C. L., & Diekema, D. (1989). Dominance and collective hierarchy formation in male and female task groups. *American Sociological Review, 54,* 79–93.

Ringelmann, M. (1913). Research on animate sources of power: The work of man. *Annales de l'Institut National Agronomique (2e serie, Tome XII),* 1–40.

Rocco, E. (1998). Trust breaks down in electronic contexts but can be repaired by some initial face-to-face contact. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 496–502). Los Angeles: ACM Press.

Rudman, C., Hertz, R., Marshall, C., & Dykstra-Erickson, E. (1997). Channel overload as a driver for adoption of desktop video for distributed group work. In K. E. Finn, A. J. Sellen, & S. B. Wilbur (Eds.), *Video-mediated communication* (pp. 199–223). Mahwah, NJ: Erlbaum.

Saunders, C., Robey, D., & Vaverek, K. (1994). The persistence of status differentials in computer conferencing. *Human Communication Research, 20,* 443–472.

Schachter, S., Ellertson, N., McBride, D., & Gregory, D. (1951). An experimental study of cohesiveness and productivity. *Human Relations, 4,* 229–238.

Selfe, C. L., & Meyer, P. R. (1991). Testing claims for online conferences. *Written Communication, 8,* 163–192.

Sellen, A. J. (1995). Remote conversations: The effects of mediating talk with technology. *Human Computer Interaction, 10,* 401–444.

Shaw, M. E. (1973). *Group dynamics: The psychology of small group behavior.* New York: McGraw-Hill.

Short, J. (1974). Effects of medium of communication on experimental negotiation. *Human Relations, 27,* 225–243.

Short, J., Williams, E., & Christie, B. (1976). *The social psychology of telecommunications.* New York: Wiley.

Siegel, J., Dubrovsky, V., Kiesler, S., & McGuire, T. (1986). Group process in computer-mediated communication. *Organizational Behavior & Human Decision Processes, 37,* 157–187.

Silver, S. D., Cohen, B. P., & Crutchfield, J. H. (1994). Status differentiation and information exchange in face-to-face and computer-mediated idea generation. *Social Psychology Quarterly, 57,* 108–123.

Spears, R., & Lea, M. (1992). Social influence and the influence of the "social" in computer-mediated communication. In M. Lea (Ed.), *Contexts of computer-mediated communication* (pp. 30–65). Hertfordshire, England: Harvester Wheatsheaf.

Sproull, L., & Kiesler, S. (1986). Reducing social context cues: Electronic mail in organizational communication. *Management Science, 32,* 1492–1512.

Sproull, L., & Kiesler, S. (1991). *Connections—New ways of working in the networked organization.* Cambridge, MA: MIT Press.

Steiner, I. D. (1972). *Group process and productivity.* New York: Academic Press.

Straus, S. G. (1996). Getting a clue: The effects of communication media and information distribution on participation and performance in computer-mediated and face-to-face groups. *Small Group Research, 27,* 115–142.

Straus, S. G. (1997). Technology, group process, and group outcomes: Testing the connections in computer-mediated and face-to-face groups. *Human-Computer Interaction, 12,* 227–266.

Straus, S. G., & McGrath, J. E. (1994). Does the medium matter? The interaction of task type and technology on group performance and member reactions. *Journal of Applied Psychology, 79,* 87–97.

Terborg, J. R., Castore, C., & DeNinno, J. A. (1976). A longitudinal investigation of the impact of group composition on group performance and cohesion. *Journal of Personality and Social Psychology, 34,* 782–790.

Thompson, L. F., & Coovert, M. D. (2003). Teamwork online: The effects of computer conferencing on perceived confusion, satisfaction, and postdiscussion accuracy. *Group Dynamics, 7,* 135–151.

Tziner, A., & Vardi, Y. (1982). Effects of command style and group cohesiveness on the performance of self-selected tank crews. *Journal of Applied Psychology, 67,* 769–775.

Wagner, D. G., & Berger, J. (1993). Status characteristics theory: The growth of a program. In J. Berger & M. Zelditch (Eds.), *Theoretical research programs: Studies in the growth of theory* (pp. 23–63). Stanford, CA: Stanford University Press.

Walther, J. B. (1997). Group and interpersonal effects in international computer-mediated collaboration. *Human Communication Research, 23,* 342–369.

Walther, J. B., Anderson, J. F., & Park, D. W. (1994). Interpersonal effects in computer-mediated interaction: A meta-analysis of social and antisocial communication. *Communication Research, 21,* 460–487.

Walther, J. B., & Burgoon, J. K. (1992). Relational communication in computer-mediated communication. *Human Communications Research, 19,* 50–83.

Warkentin, M. E., Sayeed, L., & Hightower, R. (1997). Virtual teams versus face-to-face teams: An exploratory study of a web-based conference system. *Decision Science, 28,* 975–996.

Webster, M., & Driskell, J. E. (1983). Processes of status generalization. In H. Blumberg, A. P. Hare, V. Kent, & M. Davies (Eds.), *Small groups and social interaction* (pp. 57–67). New York: Wiley.

Weisband, S., & Atwater, L. (1999). Evaluating self and others in electronic and face-to-face groups. *Journal of Applied Psychology, 84,* 632–639.

Weisband, S. P., Schneider, S. K., & Connolly, T. (1995). Computer-mediated communication and social information: Status salience and status differences. *Academy of Management Journal, 38,* 1124–1151.

Whittaker, S., & O'Conaill, B. (1997). The role of vision in face-to-face and mediated communication. In K. E. Finn, A. J. Sellen, & S. B. Wilbur (Eds.), *Video-mediated communication* (pp. 23–49). Mahwah, NJ: Erlbaum.

Williams, E. (1977). Experimental comparisons of face-to-face and video mediated communication. *Psychological Bulletin, 84,* 963–976.

Zaccaro, S., & Lowe, C. (1986). Cohesiveness and performance on an additive task: Evidence for multidimensionality. *Journal of Social Psychology, 128,* 547–558.

Zaccaro, S., & McCoy, M. C. (1988). The effects of task and interpersonal cohesiveness on performance of a disjunctive group task. *Journal of Applied Social Psychology, 18,* 837–851.