CROSS-UNDERSTANDING: IMPLICATIONS FOR GROUP COGNITION AND PERFORMANCE

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In this paper we articulate the cross-understanding construct, a group-level compositional construct having as its components each group member's understanding of each other member's mental model. We describe how the cross-understanding construct explains particular inconsistencies in the groups literature, how it provides explanations for specific group outcomes and processes beyond the explanations currently in the literature, and how different levels and different distributions of cross-understanding affect group performance and learning.

The effects of social cognition on group processes and outcomes have received considerable attention in the past two decades (see reviews by Harrison & Klein, 2007; Hinsz, Tindale, & Vollrath, 1997; Kerr & Tindale, 2004). Two areas of inquiry have been especially active. One concerns the effects on group processes and outcomes when group members' knowledge, beliefs, and perspectives are diverse—that is, heterogeneous—versus held in common—that is, homogeneous (Klimoski & Mohammed, 1994; Mohammed & Dumville, 2001; van Knippenberg & Schippers, 2007; Williams & O'Reilly, 1998). The other area of inquiry, a subset of the former, concerns the conditions under which members surface, discuss, and use their uniquely held knowledge versus knowledge that is widely shared among members (Larson, Christensen, Abbott, & Franz, 1996; Stasser & Stewart, 1992; Stasser, Stewart, & Wittenbaum, 1995; Stasser & Titus, 1985). These and related works have contributed to researchers' understanding of how group cognition influences group processes and outcomes.

It seems, however, that some important inconsistencies have yet to be resolved; the literature does not currently enable readers to draw straightforward conclusions about the effects on group outcomes of variation in group members' knowledge, beliefs, and perspectives (van Knippenberg & Schippers, 2007). For example, the *information/decision-making perspective* suggests that high levels of diversity in these matters can have positive effects on group performance (Jehn, Northcraft, & Neale, 1999; Polzer, Milton, & Swann, 2002; Williams & O'Reilly, 1998), whereas the *social categorization perspective* suggests that low levels of diversity are beneficial (see the reviews by Cohen & Bailey, 1997; Mohammed & Dumville, 2001; Williams & O'Reilly, 1998), as does the literature on shared mental models (Cannon-Bowers, Salas, & Converse, 1993).

Despite their volume, the literature on group diversity and the literature on group information processing and cognition lack attention to a seemingly relevant and useful concept—the extent to which a group's members possess insights into the features of other members' mental representations of the group's task and task situation. It appears that the concept may help resolve some inconsistencies in the literature and may also contribute to development of theory concerning the determinants of group outcomes. As will be made apparent, this cross-member understanding is different from other important group properties—the extent to which the mental models of group members are similar (as in shared mental models; Cannon-Bowers et al., 1993; Mohammed & Dumville, 2001) and the extent to which group members perceive expertise in other members (as in transactive memory systems; Moreland, 1999; Wegner, 1986).

We refer to the extent to which the group's members possess an accurate understanding of the mental models of other members as *cross-understanding* (cf. Huber, 2004: 69). We argue that the cross-understanding construct explains certain inconsistencies in the literature and, further, that it provides explanations for specific group outcomes and processes beyond the explanations currently in the literature. For example:

1. By showing how the social categorization bias is conditional on the level of cross-understanding, we spell out how the cross-understanding construct explains instances where diversity would be expected to have a negative effect on group information processing and, hence, on performance, but does not.
2. By showing how cross-understanding interferes with the occurrence of conflict, we point out how the cross-understanding construct explains instances where diversity would be expected to have a negative effect on group decision making and, hence, on performance, but does not.
3. By explaining how different forms of cross-understanding are manifested in groups, we show that cross-understanding can mitigate the negative effects of strong subgroups and that it can be a source of power in the group.
4. By showing how cross-understanding enables group members to adapt to the views and behaviors of group members, we illustrate how the cross-understanding construct explains instances where diversity would be expected to have a negative effect on group coordination and, hence, on performance, but does not.

Our work applies to groups engaged in tasks that require the use of diverse knowledge, beliefs, or perspectives and some degree of member interdependence and cooperation for their completion. Examples of such groups are cross-functional teams, task forces, product development teams, top management teams, and project teams, all of which benefit from considering and integrating the unique knowledge, experience, or points of view of their members.

In the next sections we define and elaborate on the cross-understanding construct and explain how cross-understanding is related to but different from two other important constructs in the literature. We then describe the mechanisms that account for the effects of cross-understanding and theorize about how, through these mechanisms, cross-understanding influences specific group processes and outcomes and provides explanations for these outcomes and processes beyond those currently available. Finally, we show how cross-understanding explains certain inconsistencies in the literature.

CROSS-UNDERSTANDING AND MENTAL MODELS

Cross-understanding refers to the extent to which group members have an accurate understanding of one another's mental models. Such understanding can evolve through intermember communications or interactive experiences; from observations of members' communications or behaviors; from access to members' biographical information; or from third-party descriptions of, for example, members' factual knowledge, cause-effect beliefs, sensitivity to the relevance of particular issues, or preferences. Cross-understanding is a group-level, compositional construct (cf. Chan, 1998; Miller, 1978), defined for groups composed of two or more members. It is compositional in that it depends on the extent and accuracy of each member's understanding of each other member's mental model. Thus, each member's understanding of each other member's mental model is a construct at the component level, whereas cross-understanding, which depends on component-level values, is a construct at the group level. The nature of the relationship between the component-level construct (a member's understanding of another member's mental model) and the group-level construct (cross-understanding) could conceivably take several forms (Harrison & Klein, 2007). We discuss three forms of particular theoretical interest later in the paper.

Mental model refers to a person's mental representation of a system and how it works (Johnson-Laird, 1983; Rouse & Morris, 1986). This definition takes into account (1) the variables included in the system, (2) the properties and states of those variables, and (3) the causal or other relationships among those variables. We focus on group members' mental models of the group's task and task situation, broadly defined. To give meaning to mental models in the context of our paper, immediately below we provide examples of information that might be contained in the mental models of members of groups to which our work applies.

Among the mental model features relevant to a group's task and task situation is mental model content relating to the *factual knowledge* a member possesses about the properties or states of the system's variables—for example, facts about the strength of building materials or the qualifications of a candidate for group membership. Also relevant are a member's *beliefs* about relationships among the system's variables, including cause-effect relationships (Chattopadhyay, Glick, Miller, & Huber, 1999; Sproull, 1981)—for example, whether a failing product can be rejuvenated with an increase in advertising or whether an improvement in its design is required. A third feature concerns the scope of the variables a member assumes to be within the system—for example, whether or not a particular issue is relevant to the group's task or task situation (Graham, 1986) or whether or not it should be part of the group's problem representation (Moreland & Levine, 1992). A person's *sensitivity* to the relevance of particular issues can be a consequence of the person's preferences, or the sensitivity can be either role induced (i.e., it follows from a felt or assigned special responsibility) or experience induced (as might be the case where a group member's previous experiences cause him or her to be sensitive to the need for the group to consider political implications of a decision, even though he or she abhors the idea that politics can influence technical decisions).

Finally, the content of a member's mental model may also reflect the desired system properties or states that the individual prefers, expects, or demands (also known as utilities, values, or evaluative beliefs; for examples of this extension of the mental model concept, see Carlson & Bond, 2006; Mohammed, Klimoski, & Rentsch, 2000; Ward & Reingen, 1990). *Preferences* may be politically motivated or otherwise self-serving (House, 1991) or may be based on deep-rooted values (Tetlock, 2000), and besides influencing a person's choice-making propensity, they can influence the perceived validity of knowledge, reasonableness of cause-effect beliefs, or relevance of issues (Lord, Ross, & Lepper, 1979). We elaborate these features of mental models not to establish a typology but, rather, to give some substance to what we have in mind when we refer to mental models of the group's task or task situation.

Among the processes through which a person's mental model can develop are personal or vicarious experiences, adoption of mental model features thought to be held by valued others, formal or informal teaching or persuasion, and, drawing on the results of these learning processes, reflection and imagination. Because the specific contents of these antecedent processes vary across persons, the content of mental models tends to differ across group members (Rouse & Morris, 1986).

DISTINCTIVENESS OF THE CROSS-UNDERSTANDING CONSTRUCT

Cross-understanding and the component-level construct (a member's understanding of another member's mental model) on which the group-level cross-understanding construct depends bear similarities to other constructs in the literature, including *transactive memory systems* (TMSs) and *perspective taking*. The differences between cross-understanding and these other constructs are such, however, that to call them by the same name or to subsume cross-understanding under the other constructs would create confusion in theory construction and in the comparison and interpretation of empirical findings.

Cross-understanding and the TMS construct are similar in that they are both composed in some way of members' understandings. A TMS is defined as the shared division of cognitive labor with respect to encoding, storing, and retrieving knowledge from different but complementary areas of expertise (Hollingshead, 2001; Wegner, 1986). According to TMS theory, groups develop an implicit structure for dividing responsibility for information based on members' common understanding of one another's expertise. When a TMS is operating in a group, members rely on one another to be responsible for learning, communicating, and remembering information about distinct aspects of the group's task (Lewis, 2003). Mutual reliance frees each individual member to deepen his or her expertise while ensuring that task-relevant knowledge remains available to the group. As a result of the delegation of knowledge responsibilities to different members, the knowledge associated with a TMS becomes more *differentiated* over time (Brandon & Hollingshead, 2004; Hollingshead, 1998; Wegner, 1986, 1995). Differentiated

knowledge is a hallmark of a functioning TMS such that many of the beneficial effects of a TMS stem from dividing the cognitive labor of the task and coordinating members' specialized knowledge (Brandon & Hollingshead, 2004; Reagans, Argote, & Brooks, 2005; Sharma & Yetton, 2007; Wegner, 1986, 1995; Wegner, Giuliano, & Hertel, 1985; Wilson, Goodman, & Cronin, 2007). In contrast to a TMS, the knowledge associated with cross-understanding does not necessarily become progressively more differentiated.

While a very few researchers have defined TMS in simple, general terms—as a shared understanding of who knows what—this simple definition does not acknowledge the essence of a TMS as a distributed memory system and the usefulness of differentiated knowledge for group performance. TMS theory and empirical research are clear on the point that both concepts—shared knowledge (of who knows what) and differentiated (specialized) knowledge—are integral to the definition of a TMS. In TMS articles published in major journals during the period 2003 to 2008, twenty-three of twenty-eight use a more elaborate, specific definition describing TMS as a division of cognitive labor and/or including specialized or differentiated knowledge. Only five of the twenty-eight articles describe TMS in simple terms; in every one of these five articles, the references cited for the TMS definition are to articles in which TMS is defined in terms of a division of cognitive labor. Thus, the volume and breadth of the research in which TMS is defined in terms of a shared division of cognitive labor and/or with specialized, differentiated knowledge leave no doubt about the acceptance in the field of the more elaborate, specific definition of TMS.

Cross-understanding differs fundamentally from TMS in that cross-understanding does not depend on, nor does it necessarily lead to, a division of cognitive labor. While a TMS leads to knowledge that is progressively more differentiated, cross-understanding does not. Moreover, cross-understanding is agnostic with respect to whether members' mental models are different or similar; rather, the concept focuses fundamentally on the extent to which members understand other members' mental models.

Another important difference between cross-understanding and TMS is that cross-understanding differs from TMS in scope. TMS reflects information about who knows what, or possibly even who is good at what, whereas cross-understanding reflects additional information about who believes what, who is sensitive to what issues, and who prefers what. Importantly, while knowledge is characterized by apparent certainty in both TMS and cross-understanding, the three additional features of cross-understanding not included in the definition of TMS are characterized by uncertainty. That is, beliefs may be incorrect or may be based on out-of-date or otherwise incorrect information and can be strongly biased by personal values (Tetlock, 2000), sensitivity to an issue may be a function of ignorance as well as of knowledge (e.g., ungrounded fears or unnecessary concerns), and personal preferences (such as for men as managers or for blue-gray as a wall color) are often unrelated to knowledge. Thus, beliefs, sensitivities, and preferences are not reliable indicators of who knows what, nor are they predictors of who is good at what, and they do not fit within the TMS construct even when the construct is construed more broadly than is commonly the case.

The greater scope of cross-understanding contributes to decisions likely to be better informed than those produced by TMS. Specifically, by understanding what others know, believe, are sensitive to, and prefer, members are much more able to anticipate other members' behaviors and thereby choose their own actions more effectively than if they understand only what others know. For example, understanding that John knows about alternative energy sources provides information that is less predictive of a bias in John's investment recommendations than is the awareness that John believes solar power will never successfully compete with wind power. Similarly, understanding that Susan knows a great deal about U.S. politics is less comprehensive and potentially less useful for planning communications and interactions than is the awareness that Susan identifies with Libertarian ideals.

While cross-understanding is broader in scope than TMS, perspective taking is broader still. Perspective taking is defined as a stable trait or disposition, the "tendency to spontaneously adopt the psychological point of view of others" (Davis, 1983: 113–114), or as an activity or process: "perspective taking entails the active consideration of another's point of view, imagining what the person's life and situation are

like, walking a mile in the person's shoes" (Galinsky & Ku, 2004: 596). Matters such as insight into another person's life and situation or how other group members came to acquire their knowledge or preferences are beyond the scope of matters addressed by cross-understanding.

Cross-understanding is concerned with group members' accurate understanding of other members' mental models. Accurately understanding another's mental model is different from adopting or considering another's point of view (as in perspective taking). Emphasizing this point, Davis states that "accuracy in predicting others' thoughts or emotions is not prima facie evidence of successful role taking, nor is inaccuracy necessarily evidence of role taking failure" (1994: 85). Thus, the accurate understanding of another's mental model that is fundamental to cross-understanding distinguishes cross-understanding from perspective taking, which involves, in contrast, placing oneself (either cognitively or emotionally) in the role or situation of another.

There is some evidence that perspective taking can lead to more accurate perceptions of others (e.g., Bernstein & Davis, 1982). Thus, it is possible that the tendency to adopt or actively consider another's point of view could lead to a more accurate understanding of another's mental model. However, perceptions of another's mental model are nevertheless prone to perceiver error and bias. For reasons ranging from the perceiver's stereotyping of the other member to the perceiver's random cognitive errors, inferences may be inaccurate, even when a person has a high degree of perspective-taking ability.

Another difference between perspective taking and cross-understanding is in the mechanisms that contribute to their effects. Perspective taking is thought to arouse empathy and to create positive attributions about another's behaviors and outcomes (Davis, Conklin, Smith, & Luce, 1996). Through empathy and positive attributions, perspective taking facilitates social integration by reducing stereotyping (e.g., Galinsky & Moskowitz, 2000) and increasing helping behaviors (e.g., Parker & Axtell, 2001). In contrast, the effects of cross-understanding on group processes and outcomes are unlikely to vary based on members' empathy for one another or on members' positive attributions of other members; the effects of cross-understanding depend fundamentally on members' accu-

rate understanding of one another's factual knowledge, cause-effect beliefs, sensitivities, and preferences.

MECHANISMS EXPLAINING THE EFFECTS OF CROSS-UNDERSTANDING

Cross-understanding affects group processes and outcomes by influencing the content and efficacy of members' communications, by elaborating or modifying members' mental models, and by affecting members' individual and collaborative behaviors. Immediately below we describe how each of these mechanisms is affected by cross-understanding. We subsequently describe how, through its effects on these mechanisms, cross-understanding provides explanations for specific group processes and outcomes beyond explanations currently in the literature.

Effects on Communication and Comprehension

Cross-understanding increases the effectiveness of communication by enabling members to choose concepts and words that are maximally understandable and minimally off-putting to other group members. An understanding of other members' mental models allows members to begin their conversations with other members on *common ground* (Clark, 1985, 1998), permitting them to tailor communication to refer to concepts, terms, and perspectives that members have in common. In so doing, members increase the likelihood that their arguments are understood and accepted and that the relevance of issues to which the members are uniquely sensitive is more effectively communicated and described (Clark, 1992, 1996; Krauss & Fussell, 1996). Without an understanding of one another's mental models, members are apt to make arguments or proposals concerning group processes and products that are technically, politically, or otherwise unacceptable to those whose mental models they do not understand, thus contributing to confusion, conflict, or stalemate.

It is possible that the communication benefits we attribute to cross-understanding would also emerge if members had much knowledge (e.g., about the task or task situation) in common (e.g., Fussell & Krauss, 1989; Weigand, 1999). A recent study by Wu and Keysar (2007), however, suggests that overlapping knowledge can produce

misunderstandings unless individuals are aware of both the information they have in common and the information each individual uniquely possesses. In an experiment comparing pairs of individuals with either high or low amounts of overlapping knowledge, Wu and Keysar confirmed that communication was facilitated when individuals initially had high overlapping knowledge. The experiment also revealed, however, that when pairs of individuals were discussing new information learned by only one of the individuals, misunderstandings were more than twice as likely in the high overlapping knowledge condition than in the low overlapping knowledge condition. Thus, overlapping knowledge facilitated communication when individuals were talking about the information they had in common but increased misunderstanding with regard to new information that was uniquely held by one of the individuals (Wu & Keysar, 2007).

This finding shows that commonly held knowledge alone does not account for communication effectiveness (indeed, it can hamper communication effectiveness); communicating individuals must additionally understand what each individual does not know in order to avoid misunderstanding. Thus, *cross-understanding has a positive and independent effect on communication effectiveness in groups beyond that attributable to shared knowledge.*

Effects on Mental Models

When members are aware of what others know, believe, are sensitive to, and prefer, they are better able to inquire about the reasons underlying another's knowledge, beliefs, sensitivities, or preferences—for example, by asking for clarification or elaboration on matters related to that member's mental model (Kaplan & Miller, 1987; Larson et al., 1996; Stasser et al., 1995). Such extended discussion helps members to develop enriched interpretations of matters relevant to the task or situation, to better understand the "big picture," and to come to a consensus about the key assumptions underlying members' knowledge, beliefs, sensitivities, or preferences (Mohammed & Ringseis, 2001). In so doing, cross-understanding may also initiate changes in members' mental models. When members surface and discuss their unique knowledge or beliefs, it increases the likelihood that they will

discover or more fully understand relevant facts and cause-effect relationships. Understanding others' mental models might also help members frame their communications in ways that alter the others' beliefs, sensitivities, or preferences (Tversky & Kahneman, 1981), perhaps by stimulating divergent thinking or encouraging other members to consider information inconsistent with their initial preferences (Levine & Thompson, 1996). Thus, *cross-understanding contributes to making group members' mental models more comprehensive and useful for task achievement.*

Over time and across similar exchanges between members, the processes described above might lead members to adopt some beliefs, sensitivities, and preferences held by others, thus causing the mental models of members to become more similar. This does not mean, however, that groups that achieve high cross-understanding necessarily achieve *shared mental models* (cf. Cannon-Bowers et al., 1993). Oftentimes, there are areas in which a group member's mental model is subject to very little change, even though this member and the other group members come to understand each other's mental models quite well. For example, long-tenured but ideologically diverse legislators achieve considerable insight into the assumed facts, cause-effect beliefs, sensitivities to the relevance of particular matters, and preferences of their ideological opponents, but this high level of cross-understanding does not necessarily cause them to adopt for themselves the ideologically grounded features of their opponents' mental models. As a consequence of their task-related interactions, opponents' mental models may become more comprehensive and similarity might be reached in new areas, but—especially when deep-seated values are pertinent—cross-understanding does not result in achievement of shared mental models as this term is used in the research literature.

Effects on Collaborative Behaviors

By better understanding what others know, believe, are sensitive to, and prefer, members are more able to anticipate other members' behaviors and thereby more effectively coordinate their own actions with the actions of others. Insight into others' mental models also enables members to recognize when other members' mental models are different from their own,

alerts members to the possible need to adapt to this situation, and facilitates members' identification of appropriate adaptive behaviors (such as broadening their own mental model or sharing information that other members apparently do not possess but might need to possess in order to more effectively participate in the group's processes). Thus, by helping members anticipate and adapt to one another's actions, *cross-understanding facilitates coordination.*

In this section we described how cross-understanding affects members' communication and comprehension, the elaboration and revision of members' mental models, and members' individual and collaborative behaviors. In the next section we describe how, through these three mechanisms, cross-understanding affects two important group outcomes: member learning and group product quality.

OUTCOMES OF CROSS-UNDERSTANDING

In this section we explain how cross-understanding affects the quality of a group's product and the extent to which members learn new information relevant to the task or task situation. First, we explain how different *levels* of cross-understanding affect product quality and learning. Second, in response to the criticism that the field tends to ignore or inadequately treat the within-group distribution of independent variables (Harrison & Klein, 2007), we explain how different *distributions* of cross-understanding affect these two outcomes. In the discussion section we briefly explore relationships between cross-understanding and other outcomes that are less germane to our current theorizing than are learning and product quality but that may nevertheless provide the basis for future research.

Levels of Cross-Understanding

The extent to which a group's cross-understanding is low versus high affects the efficacy of communication in the group, the extent to which members' mental models become more elaborate and useful for the group's task, and the extent to which members are able to collaborate effectively. Through these mechanisms the level of cross-understanding in the group affects group learning and the quality of the group's product.

Recalling that cross-understanding refers to the extent to which members possess an accurate understanding of the mental models of other members, we note that low cross-understanding can mean either negligible (an absence of or near absence of) understanding or inaccurate understanding. When understandings of other members' mental models are negligible or inaccurate, members' communications to other members are less likely to contain pertinent information or to be phrased most effectively (Clark, 1985, 1998). Members may fail to communicate information they uniquely possess, assuming incorrectly that others' mental models are similar to their own (*false consensus bias*; Nickerson, 1999; Ross, Greene, & House, 1977), or members may depend on demographic cues (such as gender) to make assumptions about others' knowledge and perspectives (Hollingshead & Fraidin, 2003; Thomas-Hunt & Phillips, 2004) and, consequently, may make erroneous assumptions about others' mental models. The associated misattributions of knowledge, beliefs, sensitivities, and preferences can lead to suboptimal task assignments and inefficiencies or failures in information processing and retrieval (Lewis, Belliveau, Herndon, & Keller, 2007). Thus, when the level of cross-understanding in the group is low, the quality, quantity, and validity of information surfaced during group discussions are also likely to be low.

In contrast, when the level of cross-understanding in a group is high, the quality, quantity, and validity of surfaced information are likely to be high. High cross-understanding reflects relatively extensive and accurate understandings among members about the factual knowledge, beliefs, sensitivities, and preferences of all other members. Research on the *discussion bias* suggests that when members know who the group's experts are, they expect these members to communicate their unique information; experts feel responsible for contributing unique information because they realize that no other member can do so (Franz & Larson, 2002; Moreland & Myaskovsky, 2000; Stewart & Stasser, 1995; Thomas-Hunt, Ogden, & Neale, 2003). Thus, when the level of cross-understanding in the group is high, members who uniquely possess certain knowledge, beliefs, sensitivities, or preferences are likely to surface that information, and other members are likely to solicit information from those members.

High cross-understanding also helps avoid the false consensus bias and stereotyping that can occur at lower levels of cross-understanding. High cross-understanding helps members realize that others' mental models are different from their own and, at the same time, mitigates the social categorization and stereotyping biases that might otherwise arise from diverse knowledge, beliefs, sensitivities, or preferences. At high levels of cross-understanding, members can use the understanding they have about a member's mental model when considering the validity or relevance of that member's knowledge, beliefs, sensitivities, and preferences, rather than make assumptions about the validity or relevance of knowledge using only cues associated with the member's social category. The improved communication produced by high cross-understanding would seem to attenuate considerably the negative effects of social categorization by mitigating misunderstandings and preventing the escalation of disagreements that arise from either members' diverse mental models or members' misperceptions of others' mental models.

The enriched communication produced at higher levels of cross-understanding also helps members clarify reasons, conditions, and assumptions underlying their beliefs and preferences. In contrast, when members have a negligible understanding of other members' mental models, they are less likely to provide a rationale for their own beliefs and preferences or to raise issues they regard as relevant. If members have inaccurate understandings of other members' mental models, their assessments of the veracity or relevance of information surfaced will also be inaccurate, and their ability to discover or more fully understand task-critical facts and cause-effect relationships will be reduced. Therefore, occasions for elaborating mental models and opportunities to learn task-relevant information are limited when the level of cross-understanding in the group is low.

The likelihood that members will adapt appropriately to the actions of other members is also lower when members have negligible or inaccurate understandings of other members' mental models. When the level of cross-understanding is low, maladaptive behaviors such as duplicating the efforts of others and dismissing the relevance of task-critical issues are more likely than when the level of cross-understand-

ing is high. Low cross-understanding also makes it unclear whether, and when, adaptive behaviors are necessary. For example, members may be unaware that new information is needed, even when the information resources of the group are insufficient. Without an accurate understanding of other members' knowledge, beliefs, sensitivities, and preferences, it is difficult for a member to anticipate the actions of other members and to interpret actions as they occur. Thus, the incidence of adaptive and coordinative behaviors in the group is lower when the level of cross-understanding in the group is low.

Through its effects on the efficacy of communication, on the elaboration of members' mental models, and on the collaborative behaviors of group members, the level of cross-understanding affects the quality, quantity, validity, and integration of members' knowledge, beliefs, sensitivities, and preferences. The surfacing and elaboration of task-relevant information have been shown to result in higher-quality products and higher member learning (Nemeth & Kwan, 1987; Peterson & Nemeth, 1996; Schweiger, Sandberg, & Ragan, 1986; Simons, Pelled, & Smith, 1999). Low cross-understanding reduces the effectiveness of information processing, makes misattributions more prevalent, reduces opportunities for elaboration of task-relevant information, and increases the likelihood of maladaptive behaviors. In so doing, *low cross-understanding threatens the quality of the group's product and limits member learning*. In contrast, high cross-understanding has positive effects on the quality and quantity of relevant information discussed, on the elaboration of task-relevant information, and on the collaborative efforts of members. By facilitating and encouraging members' efforts to surface, discuss, and integrate their different understandings and perspectives, high cross-understanding helps groups make the most of their diversity. Thus, we surmise that *high cross-understanding contributes to higher-quality group products and to increases in member learning*.

Not all effects of high cross-understanding are helpful to the group. Of course, when each group member is motivated (either intrinsically or extrinsically) to make contributions he or she believes are relevant to the group task, high cross-understanding is likely to manifest itself in the communication, elaboration, and coordination

mechanisms described above and, consequently, to produce positive effects on learning and performance. If, however, members' motivations are closely tied to outcomes other than the quality of the group's product, high cross-understanding can have detrimental effects on learning and performance. As an example, if a member sees that including certain features in the group's product would benefit him or her or the department he or she represents, the member might use insights into others' areas of ignorance or naiveté to create or shape arguments that would convince those other members to include certain features in the product, even if those features might negatively impact the overall quality of the group's product.

High cross-understanding can also negatively affect group processes and performance if members who are highly motivated to gain (or preserve) their status use their knowledge of commonly held facts, beliefs, sensitivities, or preferences to pursue personal goals over the group's goals. Because commonly held information tends to be evaluated as more important, relevant, and accurate than uniquely held information (Wittenbaum, Hubbell, & Zuckerman, 1999), a member who understands which facts, cause-effect beliefs, sensitivities, and preferences group members hold in common can use that understanding to guide his or her own communications toward surfacing and repeating common information during group discussions. Because surfacing and repeating commonly held information are behaviors that are likely to be socially reinforced, a member may gain status in the group by doing so (Wittenbaum, Hollingshead, & Botero, 2004; Wittenbaum et al., 1999). Further, by choosing to focus on surfacing commonly held information, members tend not to surface uniquely held information, even though by withholding this latter information they might negatively impact group learning and performance.

Similarly, if members use their understanding of other members' mental models to emphasize information favorable to the preferences held by high-status members of the group, or to discuss and use primarily information that is congruent with preferences held by the majority, the group's processes and outcomes might suffer. While such behaviors affirm members' faithfulness to high-status group members or to the majority's values, by choosing to focus on sur-

facing and repeating selectively held information to gain these ends, members might not surface uniquely held information, even though withholding such information negatively impacts learning and product quality. Therefore, *whether the effects of high cross-understanding on learning and on the quality of the group's product are positive or negative depends on the motivations of the group members.*

Nonuniform Distributions of Cross-Understanding

The above discussion treated members' understandings of other members' mental models as if those understandings were uniformly low or uniformly high. In this section we examine three situations in which the distribution of members' understandings of others' mental models is not uniform but, rather, is multimodal or skewed. We begin with the *multimodal distribution*.

The understanding of others' mental models among some but not all members of a group can lead to the creation of subgroups, within which cross-understanding is high and between which cross-understanding is low. Within such subgroups high cross-understanding will enhance communication, encourage elaboration of mental models, and improve coordination. Low cross-understanding between subgroups, in contrast, can reduce information flow between members of different subgroups and can cause subgroup members to be dismissive of the validity or usefulness of information from members of the other subgroup. Thus, the overall effects of the multimodal distribution of cross-understanding on group outcomes such as product quality and learning are not immediately clear. It seems that the effects of multimodal distributions of cross-understanding are likely to depend also on the distribution of other attributes on which group members differ (Harrison & Klein, 2007).

Member differences can lead to the development of subgroups that are defined by the pattern of overlap among different demographic characteristics (Lau & Murnighan, 1998). When several diversity dimensions converge, the resultant "faultlines" can lead to divisiveness—reducing information flow between subgroups, prolonging conflict, and inhibiting reflection of others' perspectives (Gibson & Vermeulen, 2003).

While much of the research on faultlines has focused on the convergence of demographic diversity attributes (e.g., age, gender, ethnicity), some recent research additionally considers diversity characteristics, such as informational diversity (Homan, van Knippenberg, van Kleef, & De Dreu, 2007) and ideological diversity (Dyck & Starke, 1999), as contributing to the formation of faultlines. Diversity in members' understandings of other members' mental models is but another characteristic that might converge with other diversity dimensions to contribute to the development of strong faultlines. Recall that when cross-understanding is multimodal in its form, understanding of mental models between members of the same subgroup is high and understanding between members of different subgroups is low. If these subgroups overlap with subgroups that have formed on the basis of other member attributes, this is likely to strengthen those latter subgroups and thereby increase the likelihood that the negative effects of faultlines will emerge. Therefore, *when the subgroups within which cross-understanding is high and between which cross-understanding is low overlap with subgroups that have formed based on other member attributes, group product quality and learning are likely to suffer.*

If the subgroups within which cross-understanding is high and between which cross-understanding is low do not overlap with subgroups that have formed on the basis of other member attributes, this is likely to reduce the strength of those latter subgroups and limit their detrimental effects. In a study comparing the learning behaviors of groups with weak, moderate, and strong subgroups, Gibson and Vermeulen (2003) found that learning was most apparent in groups where subgroups were moderately strong—that is, in groups whose members had coalesced into subgroups based on *some* attributes but whose members overlapped on a few other attributes. Gibson and Vermeulen reasoned that the existence of a few common attributes allowed for open communication, adaptation, and convergence of opinions between subgroups. Cross-understanding will produce similar benefits; as noted above, cross-understanding improves the efficacy of members' communications, encourages the elaboration of members' understandings about the task and task situation, and improves coordination. Cross-understanding among some members of

different subgroups is therefore likely to mitigate the divisive effects of subgroups that have formed on the basis of demographic characteristics or other member attributes. Thus, *the greater the proportion of subgroup members who possess an understanding of the mental models of members of other subgroups, the weaker the negative effects are on product quality and learning of subgroups formed on the basis of demographic characteristics or other member attributes.*

We turn now to considering two other nonuniform distributions, both skewed. A *maximally skewed* distribution exists in a group in which one member has a high level of understanding of the mental models of most or all of the other group members but there exists a low level of understanding among those other members—as when a manager forms a group by bringing together experts, each of whom has worked with the manager in other separate contexts but few of whom have worked with each other. In such a group one member is *cognitively central* (Kameda, Ohtsubo, & Takezawa, 1997) with respect to cross-understanding.

A member who is cognitively central with respect to cross-understanding can influence communication, the elaboration of task-relevant knowledge, and collaborative behaviors and, consequently, group outcomes. Specifically, a cognitively central member, by drawing on what he or she understands about others' mental models, can be especially persuasive by effectively tailoring his or her communications and influencing what information is discussed, repeated, and integrated into the group's product. The cognitively central member may prompt others to discuss information of which they are uniquely aware, or the cognitively central member may avoid eliciting certain information. In contrast, peripheral members (those among whom cross-understanding is low) are less able to elicit information from others who might possess task-relevant knowledge or perspectives. Thus, a member who is cognitively central with respect to cross-understanding has much greater influence over the quality and content of information surfaced, discussed, and used by the group and thereby tends to possess greater power. *When a group's cross-understanding is maximally skewed, the effect on the quality of the group's product and on learning depends on the motivations of the cognitively central member.*

The distribution of the group's cross-understanding is *smoothly skewed* if the group began life with one member and added additional members—one at a time—at fixed intervals. In such a group, each member's interactions with other members (and, thus, that member's opportunities to develop understandings of the mental models of other group members) are a function of the number of fixed intervals that has elapsed since the member joined the group, and cognitive centrality is closely related to seniority. Thus, *when a group's cross-understanding is smoothly skewed, the effect on the quality of the group's product and on learning depends primarily on the motivations of the more senior members.* Importantly, in this way the cross-understanding construct explains the influence of senior group members beyond whatever influence they possess by virtue of societal norms, hierarchical position, or accumulated contacts with resource controllers outside the group.

EXPLAINING INCONSISTENCIES IN THE LITERATURE

As noted earlier, the literature on group diversity and the literature on information processing and cognition do not allow for straightforward conclusions about the effects of diverse knowledge, beliefs, sensitivities, and perspectives on group processes and outcomes (van Knippenberg & Schippers, 2007). Here we describe three ways in which the cross-understanding construct can help explain inconsistencies in the literature.

Explaining the Absence of the Social Categorization Bias

The *social categorization perspective* on workgroup diversity suggests a negative relationship between group diversity and group performance (Williams & O'Reilly, 1998). This negative relationship is thought to be a consequence of members' bias favoring similar ingroup members over dissimilar outgroup members. This bias can restrict communication and undermine collaborative behaviors between members (Tajfel, 1981; Turner, 1982). Although studies supporting the social categorization perspective are numerous (see the reviews by van Knippenberg & Schippers, 2007, and Williams & O'Reilly, 1998), van Knippenberg and Schippers note that "sur- prisingly few studies . . . directly assessed social categorization processes, and results are inconsistent enough to raise doubts about the extent to which social categorization processes are in operation" (2007: 526).

It seems that the cross-understanding construct might explain the inconsistencies just noted. That is, given an instance where social categorization was in effect, groups whose members did not possess significant insight into the features of the socially categorized member's mental model (1) would assume, because of the absence of insight to the contrary, that the member's mental model features were those of the stereotype associated with the member's social category and (2) would consequently use and weigh information from the member with a bias associated with the member's social categorization. In contrast, members of groups with high cross-understanding, whose members would have insights into each other's mental models and therefore a basis other than social categorization on which to assess other members' knowledge, beliefs, sensitivities, and preferences, would be more able to assess correctly the validity or relevance of the information each member provided, regardless of each member's ingroup or outgroup status. In this case, although social categorization might be in effect, its negative impact on group performance would not occur. Thus, it appears that, through its influence on the social categorization bias, *the cross-understanding concept explains instances where social categorization might be expected to have a negative effect on group information processing and, hence, performance, but does not.*

Explaining the Absence of Diversity-Based Conflict

Besides noting that the results of studies of social categorization are inconsistent, van Knippenberg and Schippers also point out that "without supporting process evidence, some of the negative relationships between diversity and group process may also be interpreted as reflecting the consequences of *misunderstanding and disagreement* per se . . . rather than social categorization" (2007: 526; emphasis added). This observation calls attention to the fact that group diversity can lead to performance-degrading conflict (Jehn et al., 1999). But if the dysfunctional

levels of misunderstanding and disagreement in a workgroup are not so high that they outweigh the benefits from informational diversity, the group's diversity can be associated instead with high group performance (Bunderson & Sutcliffe, 2002; Jehn et al., 1999).

It seems that the cross-understanding construct might explain the inconsistency of the observed effects of diversity on group performance. That is, given a diverse group whose members had a low understanding of one another's mental models, the members would be apt to make arguments or proposals concerning the group's processes and product features that were technically, politically, or otherwise unacceptable to those whose mental models they did not understand, thus contributing to performance-degrading conflict. In contrast, members of diverse groups with high cross-understanding would be able to use their insights into others' mental models to make more persuasive arguments and to create proposals that would lead to useful compromises or agreeable trade-offs, and in these ways enhance the group's decision-making capability and, consequently, its performance.

In high cross-understanding groups, although the potential for diversity-based, performance-inhibiting conflict might be present, the group's high cross-understanding would interfere with the occurrence of the conflict, and diversity's hypothesized negative effect on the group would be absent. As explained earlier, high cross-understanding might contribute to making group members' mental models more similar, thus reducing the potential *sources* of conflict. Thus, it appears that, through its positive influence on communication effectiveness and by its role in making members' mental models more similar, *the cross-understanding concept explains instances where diversity might be expected to have a negative effect on group decision making and, hence, performance, but does not.*

Explaining the Absence of a Shared Mental Model Effect

A third example of the usefulness of the cross-understanding construct deals with the puzzlement, described early in the paper, that *heterogeneity* of members' mental models is positively associated with group performance (e.g., Jehn et al., 1999) but that homogeneity of members' men-

tal models is also associated with group performance (e.g., Cannon-Bowers et al., 1993)—that is, that both diversity and similarity of members' mental models have been found to be positively associated with group performance.

Mental model homogeneity is thought to contribute to group coordination largely by enabling group members to anticipate the views and behaviors of other members, thus enhancing coordination (Cannon-Bowers et al., 1993; Wittenbaum & Stasser, 1996). *But cross-understanding contributes in this same way*; in that cross-understanding refers to the extent to which the group's members possess an accurate understanding of the mental models of other members, it facilitates the same anticipations as do shared mental models. That is, high levels of cross-understanding—like high levels of mental model homogeneity—also enable group members to anticipate the views and behaviors of other members and thereby enhance coordination. Thus, *cross-understanding competes with the shared mental model concept as an explanation for the group coordination that contributes to group performance.*

In particular, it seems that cross-understanding explains why a high level of coordination might be achieved even when mental models are diverse rather than "shared"—an outcome that, according to the shared mental model literature as a whole (Cannon-Bowers et al., 1993; Mohammed & Dumville, 2001), should not be observed. That is, coordination could be high if cross-understanding were high not only when members possessed shared mental models but also when they possessed diverse mental models. In this way the cross-understanding construct explains instances where "studies have failed to find significant relationships between measures of convergence (homogeneity or 'sharedness') of mental models and various measures of team performance" (Mohammed & Dumville, 2001: 95); *cross-understanding explains instances where diversity would be expected to have a negative effect on group coordination and, hence, performance, but does not.*

MEASUREMENT OF CROSS-UNDERSTANDING

To help researchers wishing to use and test the cross-understanding construct, we offer some suggestions for developing measures of cross-understanding. Recalling that cross-

understanding refers to the extent to which a group's members possess accurate understandings of other members' mental models, we describe two approaches for measuring the understanding that each member has about each other member's mental model. The first approach involves measuring a focal member's perceptions about the extent to which he or she understands the mental model of each other member. The second approach involves measuring the behavioral manifestations of each focal member's understanding of each other member's mental model.

Perceptual Approach

The perceptual approach involves measuring each member's perception of the extent to which he or she has an accurate understanding of each other member's mental model. Such a measure could be constructed using self-report survey items. This approach requires specifying the relevant content of a mental model and describing that content as part of a survey item. Earlier in this paper we suggested that content features relevant to the group's task and task situation include factual knowledge, beliefs, sensitivities, and preferences. Given these features of a mental model, survey items could be constructed to measure how well each member perceives that he or she understands what it is that each other member knows, believes, is sensitive to, and prefers. For example, regarding beliefs, "For each member of your group, to what extent do you think you understand what it is that this [focal] member believes with respect to the cause-effect relationships relevant to the task?" or, regarding preferences, "To what extent do you believe you understand what this [focal] member prefers, expects, or demands with respect to the group's products?" Several items, designed to measure the extent of understanding for each of the relevant mental model features, would be appropriate. A Likert-type scale with anchors labeled to reflect the range of "very little understanding" to "extensive understanding" could be used.

One advantage of the perceptual approach is that the measure would be fairly easy to construct. A disadvantage of the perceptual approach is that it would not adequately measure the *accuracy* of a member's understanding. High levels of cross-understanding are achieved when each member has an extensive *and* accurate understanding of each other member's mental model.

Behavioral Manifestation Approach

An alternative to the perceptual approach involves eliciting from each member a report about behaviors that he or she observes. These are behaviors that a focal member would be expected to exhibit toward the respondent—and that the respondent would be expected to observe—if the focal member had an extensive and accurate understanding of the respondent's mental model. Based on our conceptualization of cross-understanding, extensive and accurate understanding would be apparent (i.e., manifested) in the effective communication, knowledge elaboration behaviors, and collaborative behaviors described in our earlier discussion of the mechanisms explaining the effects of cross-understanding. The co-occurrence of these behaviors across mental model features would indicate that the member exhibiting the behaviors possesses an extensive and accurate understanding of the respondent's mental model.

To measure cross-understanding using this approach, one could construct measures asking each member to assess the behaviors of each other member with respect to *communication effectiveness* ("this member: chooses concepts and words that I understand; tailors communications to refer to concepts, terms, and perspectives that we have in common; makes arguments that are technically, politically, or otherwise unacceptable to me (reversed)"), *knowledge elaboration* ("this member: inquires about the reasons underlying my knowledge, beliefs, or preferences; often asks for clarification or elaboration on issues related to my knowledge, beliefs, or preferences; prompts me to surface and discuss what I know, believe, or prefer; helps me to better understand the group's task or task situation"), and *collaboration* ("this member: seems to anticipate what I will do or say; does a good job coordinating his/her actions with mine; seems to recognize when our knowledge, beliefs, and preferences differ"). Likert-type scales with anchors labeled to reflect the frequency of the behavior (e.g., the range of "almost never" to "almost always") could be used. Thus, with this approach the items indirectly assess "the extent to which this [focal]

member has an extensive and accurate understanding of my [the respondent's] mental model" by measuring the extent to which the focal member exhibits behaviors toward the respondent that are consistent with such understanding.

An advantage of the behavioral manifestation approach is that it is likely to be more reliable because it assesses something that members can observe, rather than something that members perceive. Another advantage is that the measure follows very closely the theoretical explanation of cross-understanding and its effects. One potential disadvantage is that the validity of the measure depends on the theoretical mechanisms for cross-understanding's effects being correct.

Strategies for Computing a Group-Level Measure from Component-Level Measures

Because both the level and the distribution of members' understandings are relevant for predictions about cross-understanding, any analysis involving cross-understanding must take into account the uniformity or nonuniformity of members' scores. In both the perceptual and behavioral manifestation approaches described above, each respondent would assess each other group member on the same set of items, yielding a total of $N * (N - 1)$ response sets, where N is the number of members in the group. If members' responses are relatively uniform in distribution, then a group-level cross-understanding score could be formed by averaging the members' scores. If the responses are not uniform, the researcher must understand the particular distribution (e.g., multimodal or skewed) of scores in order to interpret the effects of cross-understanding.

Network analysis represents one strategy that could be useful for examining the particular form of the distribution of members' scores. Network analysis could, for example, determine which members form cliques or subgroups. Some network calculations rely on binary rather than continuous scale data, however, so this strategy might require the researcher to set cutoff values (i.e., for high versus low understanding scores) to dichotomize members' scale scores. While one advantage of network analysis is that it can help identify theoretically relevant collections of members even in small groups, a possible disadvantage is the loss of

potentially important information by dichotomizing scale scores. An alternative or complementary analytical strategy would be to visually inspect members' scores, looking for subgroups of members such that within each subgroup members' scores are high and between subgroups members' scores are low. Analysis of variance (ANOVA) techniques could be used to confirm statistically significantly different scores between subgroups of members. If statistically significant differences between subgroups do not exist, then cross-understanding could be reliably estimated by the mean of members' scores. If differences do exist, then members' scores must be analyzed in combination with other measured variables (e.g., members' motivations, other diversity attributes) for the effects of cross-understanding to be understood (see the earlier discussion of subgroups and faultlines).

DISCUSSION

"There is general agreement that groups are certainly more complex than most of our theories and methods would suggest. The difficulty has [been] and continues to be, "how can this complexity best be analyzed and understood?'" (Kerr & Tindale, 2004: 642). We suggest that the cross-understanding construct can be useful for better analyzing and understanding this complexity.

Contributions

The paper contributes to the research community in four ways. First, it sets forth and elaborates the construct of cross-understanding and distinguishes this construct from TMSs and perspective taking. Second, it describes how different levels and different distributions of cross-understanding affect group performance and learning. We have argued that low cross-understanding is associated with low group learning and performance and that high cross-understanding is generally associated with high group learning and performance. Importantly, we predict these effects will hold irrespective of whether members' mental models are similar or diverse: high cross-understanding mitigates the negative impact of the discussion bias favoring commonly held information (a bias that would otherwise be quite strong when

members' mental models are initially similar), and high cross-understanding allows members of diverse groups to make the most of their diversity by encouraging members to surface, discuss, and integrate their different understandings and perspectives. High cross-understanding can, however, have negative effects on group processes and performance when members are motivated to use their understanding of others' mental models to either (1) create or shape arguments that will lead to group product features favorable to them or their unit, rather than features that enhance the quality of the group's product, or (2) surface and discuss primarily information that will increase their social standing rather than contribute to the group's task.

Some interesting implications emerge from our analysis of the effects of nonuniform distributions of cross-understanding. In the case of a multimodal distribution, it seems that cross-understanding can benefit groups with strong subgroups that have formed on the basis of demographic characteristics. Specifically, cross-understanding between members of different subgroups can mitigate against the divisiveness that might otherwise occur when subgroups are present. However, if the subgroups within which cross-understanding is high and between which cross-understanding is low overlap with subgroups that have formed based on other member attributes, this is likely to strengthen attribute-based subgroups and thereby increase the likelihood that the negative effects of faultlines will emerge.

Our analysis of the maximally skewed distribution of members' understandings indicates that a member who is cognitively central with respect to cross-understanding can control what information is discussed, repeated, and integrated into the group's product. It follows that cross-understanding can be a source of power in a group, operating in addition to or in lieu of social or expert status to affect information exchange and performance (Thomas-Hunt et al., 2003). Our discussion of the smoothly skewed distribution suggests that the influence of senior group members follows from their greater understanding of less tenured members' mental models.

A third contribution of this paper is that it describes how the cross-understanding construct provides explanations for certain inconsistencies in the literature. For example, our analysis suggests that cross-understanding can

explain instances where the social categorization bias stemming from group diversity would be expected to result in negative outcomes, but does not, and that it can also explain instances where the conflict stemming from diversity would be expected to have adverse effects on group outcomes, but does not. Further, we show how cross-understanding can explain instances where mental model diversity would be expected to result in poor coordination, but does not.

Finally, the paper contains a rare example of the formal treatment of the effects of the distribution of a cognitive group property on group processes and outcomes (cf. Harrison & Klein, 2007). Our analysis suggests that the pattern of members' understandings influences both the direction and strength of the effects of group diversity on group outcomes.

In addition to contributing in these four general ways, the paper may help researchers to further understand some particular group phenomena. As one example, members of the information systems and organizational communications communities have encountered and are working to extend, understand, and integrate a variety of empirical findings and authoritative conclusions concerning the effects of computer-mediated communication versus face-to-face communication on a variety of group outcomes (Baltes, Dickson, Sherman, Bauer, & LaGanke, 2002; Gibson & Gibbs, 2006; Hinds & Bailey, 2003; Kerr & Tindale, 2004; Kraut, Steinfield, Chan, Butler, & Hoag, 1999; Martins, Gilson, & Maynard, 2004; Mathieu, Maynard, Rapp, & Gilson, 2008; Powell, Piccoli, & Ives, 2004; Wittenbaum et al., 2004). Because cross-understanding influences members' communication and comprehension, the elaboration and revision of members' mental models, and the allocation and coordination of group activities, and thus influences group learning and performance, it seems that use of the cross-understanding construct might help researchers studying virtual groups better understand the effects and efficacy of different varieties and combinations of virtual team features identified in the literature, such as group *structure, process, technological support,* and *experience* (see the reviews by Espinosa, Slaughter, Kraut, & Herbsleb, 2007; Martins et al., 2004; Powell et al., 2004).

Consider, for example, *experience.* Experience both with the task and with the team has been found to be positively associated with the

performance and other outcomes of virtual groups (Espinosa et al., 2007; Martins et al., 2004; Powell et al., 2004). A common explanation for the positive association between experience and virtual team outcomes is that, across time, interpersonal experiences enable members to learn to work with other team members (Baltes et al., 2002; Faraj & Sproull, 2000; Hinds & Bailey, 2003; Wilson, Strauss, & McEvily, 2006). Put differently, learning—about others' knowledge, trustworthiness, and other behavioral tendencies—is a mediating variable between simple time of exposure among members and team performance. Recall, however, that our earlier theorizing concerning the effects of different levels of cross-understanding on members' communication and comprehension, on mental models, and on collaborative behaviors indicated that learning is positively influenced by cross-understanding. It seems, then, that including cross-understanding in studies of the effects of team experience on virtual team performance would lead to richer, more elaborate, and more theoretically grounded explanations for why experience among team members influences group performance.

Certain technical characteristics (e.g., visibility, audibility, synchronicity) of virtual teams' *technological support systems* have been shown to influence team performance (see the reviews by Driskell, Radke, & Salas, 2003, and Martins et al., 2004). In general, technologies that allow for more information-rich communication among members have positive effects on virtual team performance. Cross-understanding allows members to better comprehend and interpret the relevance, importance, and validity of information provided by other members. In this way high levels of cross-understanding might amplify the positive effects of information-rich communication technology and compensate for the shortcomings of information-lean technology. Thus, it might be that cross-understanding influences the strength and form of the relationship between some group support technologies and some virtual team outcomes. Considering the effects of cross-understanding such as those just described might not only contribute to the understanding of virtual teams but also provide useful direction for their management and for the design of their technological support systems.

Extensions Through Further Research

The paper's contribution to current theory can be further elaborated or extended in several ways. One avenue for future research would be to study the difficulty and effectiveness of different approaches to rapidly increasing cross-understanding. Rapid development of cross-understanding would be of considerable importance for groups operating in or attempting to manage crises. Rapid development might also be critical when the quality of the group's product is of great consequence. In such situations it would be very important that the group not become frustrated with its lack of progress because of its lack of cross-understanding, since its frustration could cause it to lose interest in its task and to lower its aspiration level regarding the quality of its service or other product.

A second avenue for future research would be to study changes in the heterogeneity of group members' mental models. We noted earlier that although cross-understanding might contribute to making mental models more similar, in some situations the homogenization is starkly limited (e.g., in the case of ideologically based beliefs or preferences). What factors associated with cross-understanding, such as its initial levels and distributions, influence the homogenizing process and outcomes? Studies seeking to answer such a question seem likely to inform researchers about how the cross-understanding construct could contribute to theory concerning the development of consensus and shared mental models.

Research examining distributions (beyond the multimodal, maximally skewed, and smoothly skewed distributions examined earlier) of the understandings individual members have of other members' mental models is a third avenue of work that might generate useful findings. For example, consider a two-level distribution, in which members of one subgroup (the focal subgroup) have a high understanding of the mental models of all group members, whereas the nonfocal group members have a low understanding of all group members. Studies directed at determining what factors or conditions in such groups have which effects on which group outcomes might lead to findings of theoretical interest or practical application.

A fourth possibility for future research is investigating how cross-understanding of partic-

ular components of members' mental models might differentially impact group processes and outcomes. Of particular interest is cross-understanding of members' preferences. Preferences—especially those associated with ideologies or deeply held beliefs about what is morally appropriate—tend to be impossible or at least much more difficult to modify than are perceptions of factual knowledge, cause-effect relationships, and sensitivities to certain issues. As we noted, cross-understanding may therefore not contribute to making group members' mental models with respect to preferences more similar, and strong disagreements among group members might be more likely as a result. When members' preferences differ, members will tend to resolve those differences through bargaining, compromising, or coercing those whose preferences deviate from their own. It appears that high levels of cross-understanding could contribute to both the quality of the group's choices among these processes and the quality of its choices of tactics for implementing the processes, but except for the choices of bargaining tactics, these important matters are largely unstudied. Research examining how cross-understanding influences behaviors and outcomes in groups facing conflict over preferences therefore seems to be especially worthwhile.

A fifth avenue for future research would be to examine cross-understanding's effects on important group outcomes other than product quality and learning, such as time for task completion and satisfaction. The time it takes for task completion is an outcome that is often of critical importance in groups ranging from crisis management teams to ad hoc groups designing a departmental budget and facing a corporate headquarters' no-excuses deadline. The influence of cross-understanding on the time for task completion would appear to depend on (1) the level and distribution of the group's cross-understanding, (2) whether the group can seek outside resources if its progress is stalled because of lack of information, and (3) whether the situation permits the group to give up creating a product of the quality initially sought. Regarding low cross-understanding, for example, interacting members having an initially negligible understanding of others' mental models will tend to develop more understanding over time, but members with inaccurate understandings must first discover that their assumptions about

others' mental models are wrong before they actively engage in learning efforts. Thus, while negligible understanding lengthens the time for task completion, inaccurate understanding lengthens the time even more.

Another group outcome of broad interest is the satisfaction or dissatisfaction group members derive from participating in groups such as those we consider in this paper. On the one hand, if members perceived the group's product to be of high quality, if the experience caused the members to feel that their views were heard and understood by the group, or if the experience enhanced learning—that is, if the experience enhanced "the capabilities of members to work together in the future" or "contributed to the growth and personal well being of team members" (Hackman, 1990: 6–7)—it seems likely that the members would be satisfied with their experience (Hackman, 1990, 2002). Following arguments made earlier, cross-understanding would tend to contribute to each of these outcomes and in this way would contribute positively to members' satisfaction. On the other hand, if cross-understanding contributed to members' identifying strong differences in preferences (or even differences in perceptions of factual knowledge, cause-effect beliefs, or sensitivities), members might come to question their competence or their acceptance by the group and become dissatisfied, especially if these differences led to overt conflict.

Implications and Summary

Although we articulated the cross-understanding construct for use by the research community, it has implications for managers as well. For example, Cannon-Bowers et al. (1993: 236) noted that there may be an optimal degree of shared knowledge in any group. This suggests a group-staffing riddle: how to staff the group to obtain both (1) the likelihood of a high-quality group product that would follow from staffing the group with members having diverse mental models and (2) the likelihood of smoothly coordinated processes that would follow from staffing the group with members having shared mental models. This riddle might not be easily solved (see our earlier discussion of the Wu and Keysar [2007] work). A resolution of this riddle might be found, however, by reframing it as how to staff the group to obtain both (1) the likelihood

of a high-quality group product that would follow from staffing the group with members having diverse mental models and (2) the likelihood of smoothly coordinated processes that would follow from staffing the group such that it had a high level of cross-understanding. We see a clear advantage to staffing the group with personnel possessing high levels of cross-understanding as well as diverse mental models, since members of such a group could capitalize on their diversity to generate high-quality products and could also capitalize on the smoothly coordinated processes that cross-understanding is likely to enable.

The cross-understanding construct seems to be a useful contribution to the organizational behavior research community, particularly to those researchers interested in group cognition, group processes, and group performance, or in learning and decision making at the individual and organizational levels of analysis when these processes involve groups. In these ways cross-understanding appears to be a useful construct for analyzing and understanding certain inconsistencies in the research literature and for better understanding some particular group phenomena. In that cross-understanding influences the efficacy of communication and the elaboration of mental models (and thereby influences individual learning), the cross-understanding construct might also be a useful contribution to those organization theory researchers interested in the propagation speed and distortion of beliefs, ideas, rumors, and other intellectual phenomena commonly conveyed through interpersonal communication networks within and among organizations. Further, through its focus on insight into the beliefs, sensitivities, and preferences held by interacting individuals, the cross-understanding construct might be useful to those organization theory and strategic management researchers interested in the development of interorganizational phenomena, such as alliances, acquisitions, mergers, and organizational networks.

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