

Group Cognition: Collective Information Search and Distribution

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Abstract

This chapter reviews work on group decision making and problem solving. Included are topics both within and outside traditional boundaries of social psychology, such as collective induction, swarm intelligence models, jury decision making, information sharing, collaborative memory, gossip, brainstorming, and team mental models. The literature is discussed in terms of the collective information search and distribution model, which highlights group members' motivational and cognitive processes as well as the demonstrability of the group task. The 2×2 model distinguishes (1) motives that members hold for themselves from those they hold for the group as a whole and (2) motives related to acquiring knowledge from those related to facilitating intragroup and intergroup relations. The model assumes that each general class of motives has various subtypes and that group members can have multiple motives at one time. In addition to providing a useful framework for organizing the literature, the model suggests ideas for further investigation.

Key Words: group cognition, group decision making, group problem solving, jury decision making, collective induction, collaborative memory, gossip, team mental models

Although human cognition has typically been conceptualized and studied as an individual phenomenon, there is a long tradition of work focusing on how social factors influence diverse cognitive activities, including memory, reasoning, and problem solving. Important early contributions were made by such distinguished thinkers as Durkheim (1898), Le Bon (1895), McDougall (1920), and Mead (1934). It is only relatively recently, however, that the interface between cognitive and social processes has elicited substantial theoretical and empirical interest across a variety of disciplines, including social and developmental psychology, cognitive science, psycholinguistics, organizational behavior, sociology, and anthropology (for reviews, see Bar-Tal, 2000; Echterhoff, Higgins, & Levine, 2009; Levine & Higgins, 2001; Levine, Resnick, & Higgins, 1993; Mesmer-Magnus & DeChurch, 2009; Smith & Semin, 2004; Thompson & Fine,

1999; Tindale, Meisenhelder, Dykema-Engblade, & Hogg, 2001). Partly as a function of this disciplinary diversity, work on the social-cognitive interface has focused on a wide range of specific phenomena and has been discussed under many different rubrics, including common ground, distributed cognition, group cognition, intersubjectivity, shared reality, social constructionism, social representations, socially shared cognition, socially situated cognition, team mental models, transactive memory, uncertainty-identity theory, and the wisdom of crowds.

In this chapter, we focus on work by social and organizational psychologists and cognitive scientists dealing with group decision making and problem solving. There are many situations in which people's individual knowledge or experience is inadequate to support the judgments or decisions they must make. In such situations, people often draw on

information or perspectives provided by others. The exchange of information allows each member of a group to draw on more than his or her individual experiences and therefore may allow a group to outperform an individual. Even nonhuman animals use socially provided information to guide their choice of mates or decisions about where to feed (e.g., Dugatkin, 1992). For example, in some fish species, a female becomes more likely to mate with a male when she observes other females showing an interest in the male. Each female can only imperfectly perceive males' mate quality, so evidence regarding other females' interest can be useful. Laland (2004) reviewed the literature on social information use in animals, considering such questions as when to use information from others (e.g., when gathering individual information is difficult or costly, or when one's own outcomes are poor) and from whom to obtain information (e.g., from the majority, from similar others, or from others with the best outcomes). Thus, across a wide range of species, individuals do not obtain adaptively useful information solely by searching for it on their own. Rather, social sharing of information is a ubiquitous process.

This process (at least in humans) can occur when two or more people are working jointly on a collective task, are aware that others are working on the same task, and have access to one another's contributions. This access can be more or less direct and more or less extensive, ranging from verbal and non-verbal communications among members of face-to-face groups, through asynchronous e-mail messages between identifiable people who have never met in person, to centralized lists of task-relevant information posted by anonymous others.

Group decision making and problem solving have elicited theoretical and empirical attention for decades, and much has been learned about the processes and outcomes of collective effort on cognitive tasks (for reviews, see Larson, 2010; Moscovici & Doise, 1994; Stasser & Dietz-Uhler, 2001; Tindale, Kameda, & Hinsz, 2003). Although a number of theoretical frameworks have guided research on group decision making and problem solving, over the last 20 years information processing models have become increasingly influential (e.g., Brodbeck, Kerschreiter, Mojzisch, & Schulz-Hardt, 2007; De Dreu, Nijstad, & van Knippenberg, 2008; Hinsz, Tindale, & Vollrath, 1997; Larson & Christensen, 1993). A key assumption of these models is that group performance depends on members' acquisition and sharing of task-relevant information. In this chapter, we analyze these processes under the label

of "collective information search and distribution." Our analysis is based on three core assumptions:

1. We assume that, rather than occurring only in individual brains, cognition is distributed across individuals, groups, and tools (Smith & Semin, 2004; see also Resnick, Levine, & Teasley, 1991).
2. We assume that, in order to understand cognition as an emergent and distributed process, it is critical to understand why people are motivated to make contributions to joint cognitive activities and to take seriously others' contributions. In other words, it is necessary to analyze the interface between motivation and cognition (De Dreu et al., 2008; Levine et al., 1993; Thompson & Fine, 1999).
3. We assume that the relationship between group members' motivation and cognition is strongly influenced by their ability to evaluate the utility of their own and others' information, which in turn depends on the nature of the group task, in particular the extent to which this task is believed to have a demonstrably correct solution (cf. Laughlin, 1980; Laughlin & Ellis, 1986).

We take the first assumption for granted. In discussing the second and third assumptions, we begin by outlining our collective information search and distribution (CISD) model of motivation and cognition in groups. Next, we discuss the role that task demonstrability plays in influencing group members' evaluations of their own and others' potential contributions to collective cognition. We then review theoretical and empirical work on four classes of group tasks—problem solving, decision making, idea generation (brainstorming), and socially shared metacognition—in each case applying facets of the CISD model. Finally, we provide some broad conclusions of our analysis and suggest questions for further research.

Motivation and Cognition in Groups

An ambitious analysis of the relationship between cognition and motivation in groups was recently presented by De Dreu et al. (2008). These authors offered a motivated information processing in groups (MIP-G) model positing that cognition in groups is influenced by two kinds of motivation—social and epistemic. Social motivation is dichotomous: People may desire to achieve either prosself (individualistic/competitive) or prosocial (cooperative/altruistic) goals. In contrast, epistemic motivation varies continuously in intensity: People may be more or less motivated to attain a rich and

accurate understanding of the world. De Dreu and his colleagues view these two kinds of motivation as orthogonal and argue that they have different effects on cognition. Epistemic motivation affects group members' effort to acquire new information and their depth of processing (with higher motivation leading to more information and deeper processing), whereas social motivation affects (or biases) the nature of this information (with prosocial and prosocial motivation stimulating interest in information consistent with personal and group goals, respectively). The MIP-G model further stipulates that group members' motives affect information dissemination and integration at the group level, which (together with member input indispensability and decision urgency) determine the quality of the group's judgments and decisions. Finally, De Dreu and his colleagues offer suggestions about how social and epistemic motivation interact in influencing group-level information processing. They argue, for example, that the combination of prosocial and low epistemic motivation produces directive leadership and lazy compromising, whereas the combination of prosocial and high epistemic motivation produces collaborative reasoning and attention to others' ideas. Because the MIP-G model assumes that prosocial and prosocial motivation, as well as high and low epistemic motivation, are mutually exclusive, each group member can fall into only one of the four cells of the model—prosocial high epistemic, prosocial low epistemic, prosocial high epistemic, or prosocial low epistemic.

The MIP-G model provides a number of important insights regarding information processing in groups. In this chapter, we offer a different, though complementary, analysis of how motivation affects cognition in social contexts. Our CISD model (Figure 30.1) posits two levels of motivational level crossed with two levels of motivational type.

Motivational Type	Motivational Level	
	Self	Group
Epistemic	1	2
Social	3	4

Figure 30.1 Collective information search and distribution (CISD) model.

Motivational level distinguishes motives that group members hold for themselves (self) from those they hold for the group as a whole (group). Motivational type distinguishes motives related to acquiring knowledge and understanding (epistemic) from those related to facilitating intragroup and intergroup relations (social). The CISD model distinguishes several varieties of both (1) self and group motives and (2) epistemic and social motives. Moreover, the model assumes that neither self and group motives nor epistemic and social motives are mutually exclusive and that two or more specific motives can operate simultaneously in each cell of the model. Thus, group members might have multiple motives in any or all of the four cells of the model—epistemic self, epistemic group, social self, and social group.

As suggested above, a variety of specific motives can exist in each of the four cells. For example, *epistemic self motives* (cell 1) include the desire for a firm answer to a question irrespective of the content of the answer (i.e., nonspecific closure; Kruglanski, 1989; Kruglanski, Dechesne, Orehek, & Pierro, 2009; Kruglanski, Pierro, Mannetti, & De Grada, 2006), the desire for an answer that satisfies one's existing preferences (i.e., specific closure; Kruglanski, 1989, 2004), and the desire for a "true" answer based on objective reality or social consensus (Festinger, 1950; Hardin & Higgins, 1996; Hogg, 2007). Moreover, in some cases, more than one motive can be operating at a given time. For example, a person might be simultaneously motivated to hold a particular position (e.g., because it fits his or her overall ideology) *and* to believe that this position is true.

A group member can also have one or more of the above goals for the group as a whole. To the extent that this occurs, the desire for nonspecific closure, specific closure, and/or truth can serve as *epistemic group motives* (cell 2) in addition to (or instead of) *epistemic self motives*. Moreover, in some cases, efforts to satisfy an epistemic self or group motive can have implications for the creation and/or satisfaction of the same or a different motive at the other level. In the above example in which a person is motivated to hold a particular position and to believe that this position is true, the person might try to convince others to adopt this position (i.e., seek social consensus) as a way of demonstrating to himself or herself that the position is indeed valid. (Note that this consensus will satisfy the person's need for validity only if he or she thinks that others' agreement is based on internalization rather than compliance; Kelman,

1958.) Thus, motivation for a specific closure at the individual level may stimulate motivation for the same specific closure at the group level, and achieving the second goal will be instrumental in achieving the first. In this case, the two motivational levels are very difficult to disentangle. This is also true if a group member personally wants to arrive at a correct answer and also wants the group to arrive at the correct answer. If the individual solves the problem and makes his or her solution available to the group, then the group will be correct as well (assuming the correctness is demonstrable). Epistemic self and group motives might merge for other reasons as well. For example, this is likely when members identify strongly with the group, resulting in depersonalization (Turner et al., 1987). In such cases, they will see themselves and others as relatively interchangeable members of the group and will take the group's epistemic goals as their own, failing to recognize any distinction between the two levels. For reasons such as these, and also because most theorists and researchers have not distinguished between the two levels, epistemic motives are sometimes difficult to assign cleanly to the self versus group level.

Let us now consider the distinction between *social self motives* (cell 3) and *social group motives* (cell 4). Several examples of each category can be identified. Social self motives include the desire to impress others (e.g., with one's cleverness, knowledge, sincerity, commitment to the group) in order to gain rewards of various kinds; the desire to prevail during a conflict; the desire to create social bonds with others in order to satisfy the need for inclusion (e.g., Baumeister & Leary, 1995; Levine & Kerr, 2007); and the desire to establish a satisfying social identity, which can derive from belonging to a minority as well as a majority group (e.g., Barreto & Ellemers, 2009; Tajfel & Turner, 1979). Some social group motives parallel those just discussed. For example, an individual could want his or her group to be highly regarded by other groups and to prevail in intergroup conflicts. Other social group motives are possible as well, including the desire that group members have harmonious interpersonal relations, work to achieve group goals, and remain in the group even when attractive outside alternatives exist. As in the case of epistemic self and group motives, efforts to satisfy a social self or group motive can have implications for the creation and/or satisfaction of the same or a different motive at the other level, and hence it can be difficult to disentangle motives at the two levels. For example, because an individual's ability to achieve a positive

social identity depends on his or her group's superiority to other groups (Tajfel & Turner, 1979), efforts to achieve the group goal of successful intergroup competition may be motivated, at least in part, by the self goal of enhancing one's social identity.

So far, we have discussed epistemic and social motives separately. However, as our model specifies, individuals can have *both* kinds of motives simultaneously. Moreover, in some cases, the two kinds of motives can serve the same overall goal. For example, social consensus, or shared reality, can be driven by both (1) the need to affiliate and feel connected to other people (social motivation) and (2) the need to achieve a valid and reliable understanding of the world (epistemic motivation) (Echterhoff et al., 2009). Similarly, group identification can be driven by both (1) the need to strengthen one's social identity by helping one's group shine in comparison to a rival group (social motivation; Tajfel & Turner, 1979) and (2) the need to reduce uncertainty about the self or things related to the self (epistemic motivation; Hogg, 2007).

An interesting feature of our multiple-motive framework is that actions that serve a particular motive at one level sometimes produce very different (and not necessarily intended) effects at other levels. This is nicely illustrated by cases involving self and group motives. Perhaps the best example comes from classical economics, which posits that individually self-interested economic agents produce a perfectly efficient allocation of resources as an aggregate effect at the group level. Another example is based on the observation that gossip is a universal human behavior (Foster, 2004). At the individual level, the primary motive seems to be to achieve entertainment and social connection by sharing information about others. Dunbar (2004) provides an evolutionary interpretation of this motive. He argues that humans have evolved to value gossip because it serves a critical function at the group level, namely spreading information about deviance within the group and therefore discouraging misbehavior and alerting group members to keep an eye on actual and potential deviants (cf. Kurzban & Leary, 2001; Neuberg, Smith, & Asher, 2000). He further asserts that this group-level function drove the evolution of our interest in gossip through group selection mechanisms. Similar evolutionary arguments can be made for other human tendencies. For example, our individual-level interest in attractive others as potential mates has been interpreted as an evolved preference that achieves the group-level goal of favoring the selection of mating partners with high genetic quality.

Our analysis suggests a number of complexities regarding the relationship between motivation and cognition in groups. For example, as noted earlier, the distinction between self and group motives can be problematic when motives at the two levels are similar or identical (e.g., a desire to find the correct answer). Nonetheless, we believe that this distinction, coupled with the distinction between epistemic and social motives, provides a useful framework for analyzing group decision making and problem solving. In the following sections, we apply our CISD model to this task.

Role of Group Tasks

As noted above, our third assumption is that the relationship between group members' motivation and cognition is influenced by their ability to evaluate the utility of their own and others' information, which is affected by the collective task they are working on. Several typologies of cognitive group tasks have been proposed over the years (for reviews, see Larson, 2010; McGrath, 1984). The most influential typology is Laughlin's (1980) distinction between intellectual and judgmental tasks, which places heavy emphasis on "demonstrability." Intellectual tasks (e.g., algebra problems) have a demonstrably correct answer, and successful group performance involves obtaining this answer. In contrast, judgmental tasks (e.g., jury decisions) do not have a demonstrably correct answer, and successful group performance involves simply (or not so simply) achieving consensus on a collective decision. According to Laughlin and Ellis (1986), the necessary and sufficient conditions for a demonstrably correct response include (1) group consensus on the appropriate verbal or mathematical system for obtaining a correct answer, (2) sufficient information to deduce the correct answer using this system, (3) at least one group member who knows the correct answer and has the motivation and ability to demonstrate it to others, and (4) these others' ability to recognize a correct answer when it is presented. Relatively few cognitive group tasks meet these rigorous criteria, however. For this and other reasons, it makes sense to view such tasks as varying along a continuum ranging from low to high demonstrability, with most falling somewhere between these two extremes. In this context, it is important to recognize that demonstrability depends not only on task characteristics per se, but also on group members' abilities and motivations (Larson, 2010; Stasser & Dietz-Uhler, 2001).

Several efforts have been made to characterize group tasks in terms of their demonstrability (e.g., Hastie, 1986; Larson, 2010; Laughlin & Ellis, 1986; McGrath, 1984). It is generally agreed that tasks such as verbal Eureka problems, algebra problems, and object transfer problems (e.g., Tower of Hanoi) fall toward the high-demonstrability end of the continuum, whereas tasks such as choice dilemma problems, mock jury decisions, and attitudinal judgments fall toward the low-demonstrability end. Viewing cognitive group tasks as varying along a demonstrability continuum has proved useful for explaining both group processes and outcomes (for reviews, see Larson, 2010; McGrath, 1984; Stasser & Dietz-Uhler, 2001). For example, this framework has been used to clarify the social combination process by which individual group members' response tendencies combine to yield a collective response (Laughlin & Ellis, 1986) and the relative accuracy of groups versus individuals on problem-solving tasks (e.g., Gigone & Hastie, 1997a; Hastie, 1986; Kerr, MacCoun, & Kramer, 1996).

In our analysis of information search and distribution in groups, we distinguish between *group problem-solving tasks*, which have high demonstrability, and *group decision-making tasks*, which have low demonstrability. In addition, we discuss an important task type that is hard to place on the demonstrability continuum—*group idea generation (brainstorming) tasks*. Finally, we discuss what Tindale et al. (2003) call *socially shared metacognition*. Our goal is not to provide an exhaustive review of theoretical and empirical work on these task types. Rather, we seek to use the existing literature as a context for suggesting potentially interesting questions regarding information search and distribution in groups working on cognitive tasks. In addition, we seek to broaden the discussion of this topic, and the relationship between motivation and cognition more generally, by introducing examples of information search and distribution that are relevant to group cognition but have been neglected by social psychologists (e.g., swarm intelligence models, gossip).

Group Problem-Solving Tasks: High Demonstrability *Social Decision Scheme Theory*

In problem-solving tasks, some answers are clearly better than others. Usually, "better" is defined dichotomously, such that any proposed answer is regarded as either correct or incorrect (Larson, 2010). In high-demonstrability (i.e., intellectual) tasks, group

members have the relevant shared knowledge and skills to be able to verify the correctness of any proposed answer (Laughlin & Ellis, 1986). Such tasks give rise to specific patterns of group performance, which are conveniently described using the Social Decision Scheme (SDS) analysis devised by Davis (1973) and later elaborated by Davis and his colleagues (see Stasser, Kerr, & Davis, 1989). The composition of a problem-solving group is described by the number of members who individually prefer correct versus incorrect answers. For example, a six-person group may have anywhere from zero to six members who initially favor the correct answer. The SDS approach describes the probability that, given an initial distribution of member preferences, the group as a whole will eventually agree on the correct solution. For problems with *obvious* demonstrably correct solutions (e.g., Eureka problems, algebra problems, object transfer problems), this outcome will occur if one member initially proposes the right answer, a pattern termed *truth wins* (Laughlin & Ellis, 1986). In contrast, for problems with *nonobvious* demonstrably correct solutions (e.g., English vocabulary, general world knowledge, analogies), this outcome will occur only if two members propose the right answer, a pattern termed *truth-supported wins* (Laughlin & Ellis, 1986).

Collective Induction

Laughlin and his colleagues have studied a specific task with relatively high demonstrability, termed *collective induction*, in which groups seek to discover rules that can account for sets of observed facts (see Laughlin, 1999). In Laughlin's task, groups are given decks of 52 playing cards and told that the experimenter has devised a rule (e.g., "diamonds") that describes a sequence of cards. The experimenter initially puts down a card (e.g., the four of diamonds) conforming to the rule. Then, on the following trials, each group member records his or her individual hypothesis, after which group members collectively decide on a hypothesized rule (e.g., "fours") and then choose a card to test their hypothesis (e.g., the four of spades). The experimenter indicates whether or not the card conforms to the rule, and the cycle is repeated until time runs out. Although collective induction has a demonstrable (i.e., intellectual) component, it also has a nondemonstrable (i.e., judgmental) component. Determining whether any proposed rule is consistent or inconsistent with the currently available evidence is a demonstrable decision. (Of course, as the number of cards that have been tried increases, the

pattern of evidence becomes complex, and groups may make errors, such as mistakenly proposing a hypothesis that is inconsistent with already-obtained evidence). But groups must also assess which of several candidate rules that are all consistent with the evidence to try next, and that is a nondemonstrable decision. Laughlin and his colleagues find that if group members advocate different candidate rules, groups often select one to test based on the number of members supporting each one, a "majority wins" SDS rule that is characteristic of nondemonstrable tasks (discussed below). Still, because correct hypotheses will survive repeated trials (by definition, they will never be disconfirmed by future evidence) and incorrect hypotheses may be falsified, if a group member proposes the correct hypothesis, it is very likely to ultimately prevail (Laughlin, 1999).

Cognitive Models of Collective Search

As suggested above, in the most frequently studied group problem-solving tasks, any proposed solution is defined as either correct or incorrect. This means both that the value of any solution is measured on a dichotomous scale (right or wrong) and that only a single solution can be correct. In such cases, demonstrability means, as Laughlin and Ellis (1986) argued, that the group members can identify whether or not a proposed solution is correct. In other tasks, however, the value of proposed solutions can vary continuously and hence can be represented as values on an ordinal (and sometimes interval) scale.¹ Consider as an analogy brewing beers using different recipes (amount of hops and malt, type of yeast, temperature and time for aging, etc.). Each recipe yields a product that can be evaluated for its tastiness, allowing one recipe to be declared better than another. In such a context, demonstrability means that all group members can immediately agree on the relative value (quality) of each recipe (potential problem solution). Note that (1) the quality of a solution falls on a continuous scale—a solution is not simply "correct" or "incorrect," and (2) there is no externally provided constraint on the number of "correct" solutions or the maximal value that a solution may have. As a result, there can rarely be certainty about what solution is "best" because an as-yet-untried solution may always turn out to surpass the current best.

Models of group problem solving in such contexts have been developed outside of social psychology. They usually conceptualize the task as involving collective search, with multiple group members (agents) searching simultaneously for good solutions. For

example, Kennedy and Eberhart (2001) advanced the “swarm intelligence” model, inspired by social psychological theories of social influence. Many agents search in parallel for good solutions to a problem, with each potential solution conceptualized as a location in a multidimensional space. Each agent tries various solutions, learning the value of each location and keeping track of the location where it has found the best value to date. Each agent also sees information from a few “neighbor” agents about the locations they explore and the values they obtain. At each point in time, each agent chooses to explore a new location near its personal best-ever spot and its neighbors’ best-ever spots. Information about a particularly good solution found by one agent will flow to its neighbors, then to theirs, and so forth, eventually leading the entire population to converge on that solution. Metaphorically, think of a brewing company’s brewmasters trying promising recipes. Each initially searches a separate region of potential recipes (gaining the efficiency of parallel search), but they can communicate, so if one finds a good result, others can converge to carry out a more detailed and intensive search of similar recipes.

The swarm intelligence model has been influential within cognitive science, despite that field’s traditional focus on modeling individual-level cognition, and several cognitive science researchers are investigating related issues of collective cognition (Goldstone & Janssen, 2005; Rendell et al., 2010). Mason, Jones, and Goldstone (2008), for example, constructed an experimental situation somewhat akin to the swarm intelligence assumptions, but in a simple one-dimensional problem space. Participants using networked computers completed a series of trials, each of which involved choosing a number between 0 and 100 and receiving feedback about the numerical value of that guess (which they sought to maximize). On each trial, they also received information about the guesses and corresponding values from a specific set of other participants. Thus, as in the swarm intelligence model, once one group member identifies a particularly valuable location, others will learn that outcome and make guesses near that location on subsequent trials, and eventually the entire group will converge. To what extent should agents rely on their own independent personal exploration rather than imitating others’ responses? A number of studies and models have tried to answer this question. Recently, Rendell et al. (2010) investigated the success of agents with varying mixes of individual exploration and imitation of others in a complex and changing problem

environment and found that the best strategy used almost all imitation. The investigators attributed this finding to the fact that agents often use (and therefore demonstrate for others) the highest-value behavior they know, thereby filtering information in a way that benefits imitators.

A major conclusion in this literature, emphasized for instance by Mason et al. (2008), is that even with these simple assumptions about freely exchanged and perfectly demonstrable information, more communication is not always better. Specifically, if the problem space is complex (e.g., many potential solutions look reasonably good), too much communication among agents often produces suboptimal outcomes for the group as a whole. Agents may rapidly converge on the first “pretty good” solution that is found, leaving other regions of the space less well explored and potentially missing better solutions. Slower or less efficient communication (e.g., fewer communication links within the group) can help avoid this problem of overreliance on shared information (see Hinsz et al., 1997; Hutchins, 1991). On the other hand, in simple problem spaces, more communication aids the group in converging quickly on a high-quality solution.

Motivational Issues for High-Demonstrability Tasks

In terms of our CISD model, tasks with high demonstrability typically elicit epistemic motivation, particularly the desire to arrive at an objectively “true” answer. This motivation might involve the self (cell 1) and/or the group (cell 2). That is, group members might desire a correct answer because having such an answer satisfies their personal desire to be correct and/or their desire to belong to a group that is collectively correct. The relative weight that group members assign to these two epistemic motives can vary from member to member and from group to group. Moreover, as noted above, satisfaction of one motive can affect satisfaction of the other. For example, in revealing a demonstrably correct answer to others, a group member who has both epistemic self and epistemic group motivation substantially increases the odds that the group as a whole will converge on the correct answer. But motivational congruence of this kind is not always the norm. Even when members are motivated only by the desire to be personally correct, simple self-interest would motivate them to adopt demonstrably correct answers that others propose. However, self-interest would not give members an incentive to share their own good

answers with others. If our brewers searching for better beer recipes were not all employees of a single brewing company but rather lone entrepreneurs, they would have little reason to share information about outstanding recipes, unless, for example, they wanted to build relationships with others that would increase the likelihood of reciprocity on future occasions.

This example illustrates that social, as well as epistemic, motives can operate in high-demonstrability tasks (cells 3 and 4). For example, in the lone entrepreneur example of the brewers, individuals might not simply be indifferent to sharing demonstrably correct information but rather motivated to withhold such information (or even to share false information) in order to increase their competitive advantage in the marketplace. In contrast, other (more benign) social self motives, such as the desire to impress others with one's knowledge, might cause people to share demonstrably correct answers even when they had no epistemic group motivation. And certain social group motives, such as the desire that one's group have a better answer than a rival group, might lead to information sharing within the group even when epistemic motivation is low.

Group Decision-Making Tasks: Low Demonstrability

In contrast to the high-demonstrability tasks discussed above, many group decision-making tasks do not permit members to demonstrate conclusively to others the correctness of their proposed solutions. In Laughlin's terms, such tasks fall at the judgmental end of the intellective–judgmental continuum. Within social psychology, much of the relevant work involves tasks in which groups have to choose from among a small number of discrete alternatives. Prominent examples are research on jury decision making and information sharing in groups. Other work using low-demonstrability tasks involves collaborative memory and impression formation based on gossip.

Jury Decision Making

The paradigmatic example of discrete decision making in groups is jury decision making. It may be that one verdict (not guilty or guilty) is “correct” in some absolute sense, but in the jury room the available information and group processes often do not permit members to demonstrate the correctness of verdicts. Therefore, group members are left to make arguments for their preferred positions, often using different criteria or weighting the same criteria

differently, which eventually results in a consensus that does not satisfy the criteria of demonstrability (Laughlin & Ellis, 1986).

Much of the work on jury decision making has been conducted within the SDS framework discussed above regarding group problem solving (see Stasser et al., 1989; Tindale et al., 2003). This research focuses on understanding the social influence process by which groups move from initial disagreement to final agreement on judgmental issues. An important generalization from SDS research on jury decision making is that initial faction size matters. There is strength in numbers, such that larger factions are more likely to prevail than are smaller factions. Thus, rather than a “truth wins” or “truth-supported wins” decision scheme (as occurs on intellective issues), groups making decisions on judgmental issues often follow a “majority wins” scheme.

Why is faction size so important on judgmental tasks? Four psychological processes may be involved (Stasser et al., 1989). First, because they have more available arguments for their position and can command more speaking time, larger factions may exert more informational influence than do smaller factions (Deutsch & Gerard, 1955). Second, because they have more power to deliver social rewards and punishments to other members, larger factions may exert more normative influence than do smaller factions (Deutsch & Gerard, 1955). Third, because group members engage in social comparison to evaluate the correctness of their opinions (Festinger, 1954), they feel insecure when they find themselves in a minority and may respond to this insecurity by conforming to the majority. Finally, because members are motivated to facilitate group locomotion toward such valued goals as reaching consensus (Festinger, 1954) and larger factions are closer to producing consensus than are smaller factions, larger factions may exert more influence.

Information Sharing in Groups

A major reason for using groups to make decisions is that they can potentially pool the unique knowledge of their members and thereby make better decisions than members acting alone. Research on information sharing in groups has used the hidden profile paradigm to test this assumption (see Stasser, 1999). For example, a group might have the task of deciding which of two job candidates is preferable, and before the discussion each member is given a set of facts, each of which supports either candidate A or candidate B. Although there are more total items

favoring A than B (making A the better choice), each member gets more pro-B than pro-A information, and the pro-B items are shared (known to all members), whereas the pro-A items are unshared (known to only one member). So, before the discussion, group members are each biased toward the weaker candidate (B), and unless they discuss their unshared information (which favors A), they will make a poor group decision. Unfortunately, plentiful evidence indicates that groups often discuss information that all members initially share and ignore unshared (unique) information, leading to poor decisions (see Brodbeck et al., 2007; Mesmer-Magnus & DeChurch, 2009).

One potential explanation for this state of affairs is sampling bias (Stasser & Titus, 1985), which means that even if each group member randomly selects an item of information to discuss, shared information is more likely to be mentioned simply because more members know it. Sampling bias is not the whole story, however. Among other things, it cannot account for the observation that shared information is more likely than unshared information to be repeated after it is mentioned (e.g., Stasser, Taylor, & Hanna, 1989). This differential repetition may have several causes (Larson, 2010). First, shared information is easier to remember than unshared information because group members have more exposure to it and perhaps find it easier to understand (e.g., Larson & Harmon, 2007). Second, shared information receives more social validation from the group and hence is seen as more accurate and trustworthy (e.g., Greitemeyer & Schulz-Hardt, 2003). And third, because shared information is socially validated, group members evaluate themselves and each other as more competent (a process termed *mutual enhancement*) when they discuss it (e.g., Wittenbaum & Bowman, 2004). These latter mechanisms suggest that motivational, as well as cognitive, factors may contribute to the bias toward discussing shared information. Recent analyses go further, arguing that group decision making is a mixed-motive situation and hence information sharing varies as a function of whether group members have self-oriented or group-oriented motives (e.g., De Dreu et al., 2008; Mesmer-Magnus & DeChurch, 2009; Steinel, Utz, & Koning, 2010; Tomas & Butera, 2009).

As suggested by the social validation hypothesis, shared information is higher in demonstrability than is unshared information. Therefore, it is not surprising that different processes unfold when shared versus unshared information is contributed in a group

setting. A unique feature of the hidden profile task is that high- and low-demonstrability information coexist within a single task, rather than (as is typical) characterize different tasks, such as algebra problem solving versus jury decision making.

In general, research on information sharing in hidden profile tasks assumes that the initial distribution of shared and unshared information in a group drives the content of the subsequent discussion, which in turn drives the group's collective decision. Other interpretations of the relationships between information distribution, group discussion, and collective decision have been offered, however. For example, Gigone and Hastie (e.g., 1993, 1997b) argued that information distribution influences group members' prediscussion decision preferences, which in turn affect both the content of the discussion and the collective decision (see also Winquist & Larson, 1998). Group members might favor preference-consistent information for discussion because they view it as more valid than preference-inconsistent information, because they wish to appear competent and self-consistent, or because they are following a conversational norm that they should explain the basis for their preference (Brodbeck et al., 2007).

Finally, it is important to note that the information sampling bias is not inevitable. For example, groups' tendency to focus on shared information is weaker when group members are informed about their own and others' expertise (Stasser, Stewart, & Wittenbaum, 1995; Van Ginkel & van Knippenberg, 2009), when leaders repeat unshared information (Larson, Christensen, Franz, & Abbott, 1998), when the task is presented as having a demonstrably correct answer (Stasser & Stewart, 1992), and when group discussion goes on for some time (Larson, Foster-Fishman, & Keys, 1994).

Collaborative Memory

The notion that memory is influenced by social factors has a long history in psychology and other disciplines (see Hirst & Manier, 2008; Werstsch & Roediger, 2008), and many terms have been used in describing and analyzing this influence, including collective memory, collective remembering, cultural memory, joint remembering, transactive memory, and collaborative recall. In this section, we focus on *collaborative memory*, in which people work together to recall information to which they were previously exposed (see Betts & Hinsz, 2010; Larson, 2010; Rajaram & Pereira-Pasarin, 2010). In so doing, we exclude work on how individual

memory is influenced by the real or imagined presence of others (e.g., the saying-is-believing effect; see Echterhoff et al., 2009).

In many situations, group members learn information individually but later collaborate in retrieving that information. For example, individual jurors are exposed to common trial testimony without being able to communicate among themselves but later must reach a consensus on that information as they deliberate on their verdict. Intuitively, it might seem that groups engaging in collaborative recall would perform better than nominal groups of the same size because only interacting groups can (1) stimulate their members to remember information that they otherwise would forget (reduce errors of omission), (2) correct any memory errors that members make (reduce errors of commission), and (3) immediately recognize and accept accurate memories if they are introduced. However, as in work on brainstorming (discussed below), the collective recall of interacting groups is typically worse than the recall of nominal groups (see Betts & Hinsz, 2010; Larson, 2010; Rajaram & Pereira-Pasarin, 2010). Moreover, rather than using a truth-wins social decision scheme, groups engaging in collaborative recall tend to use either a truth-supported wins or a majority/plurality scheme (e.g., Hinsz, 1990; Van Swol, 2008). These findings are consistent with our assumption that memory tasks are typically not high in demonstrability: One member recalling a correct item does not necessarily result in social validation and group agreement.

Why is collaborative recall not more effective? The leading explanation assumes that group members disrupt one another's retrieval strategies during collective recall (e.g., Basden, Basden, Bryner, & Thomas, 1997). Individual memory is subject to a phenomenon termed *part-list cuing*, in which performance in recalling items from a list is harmed if people are given a few items from the list initially. Evidence suggests that, in group retrieval tasks, items recalled by others can cause this type of interference for individual group members, resulting in relatively poor collective recall (see Rajaram & Pereira-Pasarin, 2010). This phenomenon is analogous to production blocking in group brainstorming tasks. Other factors that may contribute to "collaborative inhibition" (Weldon & Bellinger, 1997) include group members' tendency to focus on shared rather than unshared information (Betts & Hinsz, 2010), caution in accepting others' recollections as valid (Larson, 2010), and failure to correct others' memory errors (Rajaram & Pereira-Pasarin, 2010).

A recent and fascinating finding suggests new directions for theory and research regarding collaborative recall. Miles, Nind, Henderson, and Macrae (2010) had participants and a confederate (posing as another participant) perform a dyadic motor task while repeating words they individually heard over headphones. Participants moved their arms up and down in synchrony with a metronome signal, while confederates were instructed to move either in-phase (i.e., mirroring the participant's movements) or anti-phase (i.e., moving down while the participant moved up, and vice versa). In-phase synchrony is known to create positive social outcomes and cooperative behavior in dyads (see Semin & Cacioppo, 2008). Participants were later administered a surprise recognition test for the words they had heard during the task. In the anti-phase condition, results demonstrated the usual memory advantage for "own" words (those the participant heard and spoke) over "other" words (those the confederate spoke). But in-phase synchrony eliminated this difference. These findings suggest that embodied cues (such as synchronized movements) can cause people to process information associated with others in the same ways they process information associated with the self, reflecting what has been termed *self-other overlap* (Aron et al., 1991). Although this study focused on individual memory rather than collective memory, it suggests intriguing questions about the operation of collaborative recall.

Impression Formation, Gossip, and Stereotyping

When people try to form impressions of other individuals, they often do so on the basis of limited amounts of information obtained from their own interactions with a target. Like many other situations of collective cognition, perceivers may also draw on information supplied by third parties, this time through *gossip*. A model of person perception incorporating socially shared information was recently developed by Smith and Collins (2009). Gossip from others can give us access to valuable information (e.g., about a target's rare but important and diagnostic negative behaviors) that we could not easily obtain on our own. As a side effect, as information about social targets is shared through the social network, individual perceivers' impressions become aggregated into a more or less consensual social reputation of the target.

In person perception, there are a potentially large number of items of information (i.e., behavioral observations of the target) that can be used to

support a person impression (such as thinking of the target as forthright and honest, but not interpersonally sensitive). Individual perceivers can acquire observations on their own or share them with others through gossip (Dunbar, 2004; Smith & Collins, 2009). As a result, a perceiver may have some information that is unique and unshared (personally observed) and other information that is shared with other perceivers (either through gossip or because they jointly observed the target's behaviors). Perceivers are free to question either the validity or importance of others' observations (or their own, for that matter), for example by ascribing the behavior to an irrelevant situational factor. Thus, the demonstrability of gossip information is low: Hearing what someone else thinks about the target, perceivers are not immediately forced to conclude that the gossip source is correct. As with collective search, perceivers can always gather additional information, either by interacting directly with the target or seeking additional gossip information. However, unlike the hidden-profile paradigm, the pool of observations is not fixed at the outset. Finally, gossip information is usually shared with specific others (similar to information search models) rather than broadcast to all group members as in a face-to-face group discussion.

One interesting complication is that gossip not only spreads information around but also changes it. Often information is simplified and exaggerated (Baron et al., 1997; Gilovich, 1987). A condition favoring this outcome is a shared expectation held by members of the group, such as a social stereotype about a target. This often leads to more communication of stereotype-consistent than stereotype-inconsistent information about the target (e.g., Lyons & Kashima, 2001; Ruscher, 1998; Thompson, Judd, & Park, 2000). This strength of this bias varies, however, and the motivations of group members are critical to understanding when stereotype-consistent information will dominate. Among the motives favoring transmission of stereotype-consistent information are the desire to develop consensus (shared beliefs) with others (Ruscher, 1998) and the desire to establish social relationships with others (Lyons, Clark, Kashima, & Kurz, 2008; cf. Echterhoff et al., 2009; Wittenbaum & Bowman, 2004). In contrast, the bias toward transmitting stereotype-consistent information may be reduced (and even reversed) when communicators are motivated to provide maximally useful information to others (Lyons & Kashima, 2003; see also Klein, Tindale, & Brauer, 2008).

Motivational Issues for Low-Demonstrability Tasks

The motivational issues associated with low-demonstrability tasks are even more complex than those for high-demonstrability tasks. This occurs in part because additional epistemic motives can arise in low-demonstrability tasks, including the desire for a firm answer irrespective of its content, the desire for an answer that satisfies one's existing preferences, and the desire for an answer that is "true" because it reflects social consensus (rather than objective reality). Moreover, more than one of these epistemic motives can be operating at a given time, and they can be self motives, group motives, or both.

Social motives may also play out differently in low-demonstrability than in high-demonstrability tasks. For example, when demonstrability is low, group members who have certain social self motives (e.g., desire to impress others with their knowledge, desire to prevail during a conflict) may be more likely to slant information they present to satisfy their own needs because they are not constrained to make demonstrably correct claims (cf. De Dreu et al., 2008). Moreover, members who have certain social group motives (e.g., desire for harmonious interpersonal relations) may be more likely to accept others' information rather than voice criticism or dissent because they evaluate this information using the criterion of plausibility rather than objective truth.

Interesting motivational issues arise in the case of exchange of gossip. Perceivers may spread around information about a target person so that the whole group becomes aware of and can benefit from it. That is, I might tell everyone how shabbily William treated Charlotte, with the goal of helping others avoid the mistake of trusting William in the future. But I might also want to keep some information about William (e.g., skeletons in his closet) to myself in order to manipulate him and so would avoid sharing this information with the group as a whole. In addition, I might spread positive information about a friend and let her know I did so in order to solidify my relationship with her. Or I might exchange gossip with a specific other in order to communicate that I like and trust him. Finally, I might spread only positive gossip about ingroup members and negative gossip about outgroup members in order to increase the perception of ingroup superiority and enhance my social identity.

Group Idea Generation Tasks

Groups are sometimes used to produce creative ideas. The most frequently studied approach,

termed *brainstorming* by Osborn (1953), involves face-to-face groups in which members are instructed to produce as many ideas as possible, to come up with unusual ideas, to avoid criticism, and to combine and improve others' ideas. Because there is no opportunity to offer arguments or explanations for one's contributions, and evaluation of ideas is explicitly prohibited in brainstorming, demonstrability is irrelevant to this task.

The history of brainstorming research is mostly one of disappointing (and initially surprising) findings that brainstorming groups produce *fewer* ideas than do nominal groups composed of an equal number of individuals working independently. As Larson (2010) noted, "the early empirical literature is nearly monolithic in its repudiation of the group brainstorming hypothesis" (p. 81) (see also Mullen, Johnson, & Salas, 1991). These findings are particularly interesting in light of evidence that people who participate in brainstorming groups are more satisfied with their performance than are people who worked alone and think they would have performed worse if they had worked alone (e.g., Nijstad, Stroebe, & Lodewijkx, 2006; Paulus, Dzindolet, Poletes, & Camacho, 1993).

Both cognitive and motivational factors have been suggested to explain the ineffectiveness of group brainstorming. A major cognitive factor is "production blocking," which stems from the fact that group members must take turns presenting their ideas. While waiting for others to finish talking, members often forget their ideas and hence are unable to contribute them. Motivational factors include evaluation apprehension (fear that others will judge one's ideas negatively), social loafing and free riding, and performance matching (in which high performers match the performance of low performers). Although all of these factors may contribute to the ineffectiveness of group brainstorming, production blocking seems to have the strongest impact.

Recent efforts have been made to clarify the cognitive processes that underlie idea generation in group contexts. These include the associative memory matrix model (Brown & Paulus, 2002; Brown, Tumeo, Larey, & Paulus, 1998) and the search for ideas in associative memory model (Nijstad & Stroebe, 2006; Stroebe, Nijstad, & Rietzschel, 2010). For example, the latter model incorporates intraindividual cognitive processes involving long-term and working memory, knowledge activation, and idea generation, as well as interindividual processes that can produce *either* cognitive interference or cognitive stimulation.

So far, we have focused on the sheer number of ideas that brainstorming groups produce. What about the quality of these ideas? In general, the total number of ideas is positively (and strongly) correlated with the total number of high-quality ideas (Diehl & Stroebe, 1987). Given that brainstorming groups produce fewer total ideas than do nominal groups, it follows that they produce fewer high-quality ideas as well. The quantity-quality relationship seems to occur because people who generate many ideas engage in deeper exploration of relevant domain knowledge (Rietzschel, Nijstad, & Stroebe, 2007).

In recent years, efforts have been made to develop procedures to improve the effectiveness of brainstorming groups. One such procedure is electronic brainstorming, in which individuals type their ideas into networked computers that simultaneously display the ideas of other group members. This procedure avoids productivity losses due to production blocking, yet still allows members to access others' ideas as a potential source of inspiration. In groups of four or more members, electronic brainstorming is more productive than face-to-face brainstorming. Moreover, in groups of 10 or more members, electronic brainstorming is even more productive than individual brainstorming in nominal groups (Dennis & Williams, 2005).

Motivational Issues for Group Idea Generation Tasks

Although motives in all four cells of the CISD model may influence behavior in group idea generation tasks, it is likely that self motives are generally stronger than group motives. This is because there is no pressure for brainstorming participants to converge on a single response (in fact, the pressure is just the opposite—to generate divergent responses) and because individual rather than group productivity is typically highlighted as the goal of brainstorming. This bias is reflected in the social self motives that have been posited to reduce performance in face-to-face brainstorming groups, including evaluation apprehension, social loafing, and free riding. Epistemic self motives could also play a role in brainstorming if participants departed from instructions to generate "wild and crazy" ideas by trying to generate "good" ideas (e.g., that are easy to implement or likely to be effective). And group motives cannot be completely ruled out in brainstorming. For example, performance matching may be driven, at least in part, by the desire to maintain group harmony by making sure members'

performance levels are similar. And group members would be expected to work hard in generating novel responses if the ingroup were competing with an outgroup (cf. Munkes & Diehl, 2003).

Socially Shared Metacognition

Metacognition in decision-making groups can be defined as “how group members think about the ways they process and share knowledge” (Tindale et al., 2003, p. 390). Although such metacognition can take several forms (see Hinsz, 2004; Tindale et al., 2003), we focus here on two varieties that have received particular attention—transactive memory systems and team mental models.

Transactive Memory Systems

In contrast to collective recall situations in which all group members were exposed to common information and presumably were motivated to learn all of it, in other situations different group members were exposed to different information or were motivated to learn only a portion of common information. In order for the group as a whole to recall information effectively in the latter cases, it must develop a transactive memory system that clarifies who is responsible for acquiring, storing, and retrieving particular information (Wegner, 1987). An effective transactive memory system, which is based on a shared and accurate understanding of group members’ task-relevant interests and expertise, ensures that members not only will assume responsibility for particular kinds of information but also will know how these responsibilities are distributed within the group (i.e., who knows what). Evidence indicates that group members do in fact take responsibility for learning specific kinds of information as a function of their knowledge of others’ interests and expertise (e.g., Hollingshead, 2000) and correctly access information that other members have stored (e.g., Littlepage, Hollingshead, Drake, & Littlepage, 2008). Moreover, transactive memory systems have been found to improve group performance on a variety of tasks (e.g., Lewis, 2004; Moreland, 1999). Both team training and individual training, combined with information about others’ competencies, are more effective than individual training alone in creating transactive memory systems.

Team Mental Models

Researchers interested in understanding and improving team performance have devoted substantial theoretical and empirical attention to “team mental models” and related constructs (see

DeChurch & Mesmer-Magnus, 2010a, 2010b; Mohammed, Ferzandi, & Hamilton, 2010; Rico, Sanchez-Manzanares, Gil, & Gibson, 2008). Team mental models are defined as “team members’ shared, organized understanding and mental representation of knowledge about key elements of the team’s relevant environment” (Mohammed et al., 2010). Team mental models are broader than transactive memory systems in that they focus on a wider array of shared representations (e.g., tasks, equipment, working relationships) and on how these representations affect team processes (e.g., communication, coordination) as well as outcomes (Mohammed & Dumville, 2001). Evidence indicates that the mental model *sharedness* predicts both team process and team performance (DeChurch & Mesmer-Magnus, 2010a, b). Interestingly, the mental model *accuracy* does not have consistent effects on either process or accuracy (Mohammed et al., 2010). As in the case of transactive memory, team training facilitates the development of team mental models. Although attitudes toward other members (e.g., trust, liking) have been suggested as possible contributors to the development of team mental models (e.g., Fiore, Salas, & Cannon-Bowers, 2001), little work has been done to investigate their impact. Finally, there is increasing interest in the conditions under which *dissimilarity* in team members’ mental models enhances collective performance (e.g., Kellermanns, Floyd, Pearson, & Spencer, 2008; cf. Baron, 2005; Brodbeck et al., 2007).

Motivational Assumptions for Socially Shared Metacognition

In the case of socially shared metacognition, epistemic motivation is likely to predominate. This is because transactive memory systems and team mental models are important in contexts in which group members work on collective tasks that require a high degree of coordination. On such tasks, members are motivated to ensure that both they and their colleagues understand the demands of the task and the capabilities of all the people who will be responsible for meeting these demands. These epistemic motives have both self and group components. In the former case, members want to ensure that they understand the nature of the group’s task and resources, their own task-relevant skills and responsibilities, and the skills and responsibilities of others. In the latter case, members want to ensure that everyone in the group shares their perceptions along these dimensions—in other words, that everyone is “on the same page” regarding who is responsible for

what. Moreover, members prefer demonstrably correct answers to the various questions that must be answered. When, as is often the case, these are not available, members must settle for less, for example, inferring others' ability from knowledge of their past training. Unfortunately, such inferences do not provide a firm basis for predicting whether others can meet the specific challenges the group faces.

This is not to say, of course, that social motives play no role in transactive memory systems and team mental models. For example, group members may be interested in impressing others with their knowledge and skills and in occupying the most prestigious and highest paying roles in the group. Moreover, in the context of intergroup competition based on task performance, members are likely to desire that their group have a *better* transactive memory system or team mental model than the opposition.

Conclusion and Future Directions

In this chapter, we reviewed theory and research on group decision making and problem solving with a special focus on collective information search and distribution. In so doing, we discussed work on topics that are well known to social psychologists (e.g., jury decision making, information sharing in groups, brainstorming) as well as topics that are not (e.g., animal social learning, swarm intelligence models, gossip, team mental models). Our analysis, which highlighted the relationship between motivation and cognition in groups, was based on our CISD model. The model posits two motivational levels—motives group members hold for themselves (self) versus those they hold for the group as a whole (group)—crossed with two motivational types—motives related to acquiring knowledge and understanding (epistemic) versus those related to facilitating intragroup and intergroup relations (social). The model distinguishes several varieties of both self and group motives and epistemic and social motives. In addition, it assumes that neither self and group motives nor epistemic and social motives are mutually exclusive, and it posits that two or more specific motives can operate simultaneously in each of the four cells of the model. Our analysis also assumes that the relationship between motivation and cognition in groups is influenced by members' ability to evaluate the utility of their own and others' information, which is affected by features of the collective task they are working on. In particular, we argue that the demonstrability of the task (i.e., the degree to which objectively correct answers can be specified)

is important (cf. Laughlin, 1980; Laughlin & Ellis, 1986).

The review leads to three broad conclusions. Perhaps most important is that across all the types of tasks discussed here, group cognition seems to depend more on collective information search and distribution than on individual information processing. Consistent with this argument, Woolley, Chabris, Pentland, Hasmi, and Malone (2010) recently identified a "collective intelligence" factor, paralleling the "g" factor of individual cognitive abilities, that explains group performance across a variety of tasks. Rather than reflecting the average (or maximal) intelligence of individual group members, collective intelligence is correlated with members' average social sensitivity and the equality of their participation levels (as well as the proportion of women in the group).

A second broad conclusion is that collective information search and distribution cannot be understood without carefully specifying the motives that drive these activities. As posited by our CISD model and related models (e.g., De Dreu et al.'s MIP-G model), cognition and motivation in group settings are inextricably interwoven, and any effort to explain cognition in the absence of motivation is doomed to failure.

A third broad conclusion is that task demonstrability plays a key role in shaping collective information search and distribution. Although demonstrability has long been recognized as an important determinant of group performance, we especially emphasize its relationship to motivation. For example, we argue that, on high-demonstrability tasks, epistemic motivation (particularly the desire to arrive at an objectively true answer) tends to take priority, although social motives (both self and group) can also be important. Moreover, we argue that the motivational issues associated with low-demonstrability tasks are even more complex than those for high-demonstrability tasks. This occurs because additional epistemic motives (e.g., desire for a firm answer irrespective of its content) can arise in low-demonstrability tasks and because certain social motives (e.g., desire to impress others with one's knowledge) can play out differently in such tasks than in high-demonstrability tasks. We note that one reason for the complexity of hidden-profile tasks is that information varies in demonstrability within a single task (with shared information being higher than unshared information). And finally, we suggest that a relatively unexplored kind of low-demonstrability task—exchange of gossip—raises a number of interesting motivational issues.

Our review also suggests potentially fruitful avenues for future research on collective information search and distribution. One key question raised by our CISD model is, What happens if different group members have different motives? For example, one member may want the group to reach an objectively correct solution, a second may want the group to adopt his or her preferred solution, and a third may want the group to avoid conflict and experience warm interpersonal relationships. De Dreu et al. (2008) discuss such group composition effects, suggesting, for example, that people with prosocial goals tend to convert those with prosocial goals, causing groups to develop a predominantly prosocial motivation. But many additional questions remain about how people with different motives influence one another. For example, interesting factional dynamics may arise when subsets of group members (e.g., numerical minorities and majorities) have different motives (cf. Levine & Kaarbo, 2001). Perhaps a numerical minority desiring nonspecific closure will be more likely to convince a majority to adopt this goal in a situation involving time pressure or noise (cf. Kruglanski et al., 2006).

Another issue that deserves attention concerns the effects of the network structure that links group members. Although much theory on collective cognition assumes that all group members are in a simultaneous communication with one another (e.g., are sitting around a table discussing an issue), this is often not true. Instead, people are typically linked to specific others in social networks (e.g., Kennedy & Eberhart, 2001). This is evident, for instance, when group discussion and decision making take place through a series of phone calls or e-mails, with each member communicating with some but not all of the others. We can therefore conceptualize information sharing and, more generally, social influence as flowing along the links in a social network. Properties of the network shape how information flows, how fast it “infects” the whole group, and so on. Mason, Conrey, and Smith (2007) reviewed work on the role of networks in shaping patterns of social influence, including the impact of the network structure on how rapidly the entire group converges to a single decision versus maintaining multiple viewpoints (see also Lyons et al., 2008). Future work on collective information search and distribution might profitably explore the effects of different network structures rather than continuing to assume that all members are communicating with all others.

Author Note

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Notes

1. Tasks in which the degree of correctness of a proposed solution can vary continuously, such as tasks in which a group tries to estimate a quantity along a continuum, have received relatively little attention in social psychology. See Stasser and Dietz-Uhler's (2001) discussion of collective estimation tasks and Larson's (2010) discussion of quantity estimation tasks.

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