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Groups as Adaptive Devices: Human Docility and Group Aggregation Mechanisms in Evolutionary Context

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Camp 10 Ms. above the river Plate
Monday, July the 23rd, 1804—

> a fair morning—Sent out a party of 5 men to look to timber for Ores two other parties to hunt at 11 oClock Sent, G. Drewyer & Peter Crusett ½ Indn. to the Otteaus Village about 18 ms. West of our Camp, to invite the Chiefs & principal men of that nation to come & talk with us &. &., also the *panis* if they Should meet with any of that nation (also on the S. Side of the Plate 30 ms. higher up) (at this Season of the year all the Indians in this quater are in the Plains hunting the Buffalow from Some Signs Seen by our hunter and the Praries being on fire in the derection of the Village induce a belief that the Nation have returned to get green Corn) raised a flag Staff put out Some provisions which got wet in the french Perogue to Sun & Dry—I commenced Coppying may map of the river to Send to the Presdt. of US. by the Return of a pty of Soldiers, from Illinois five Deer Killed— one man a bad riseing on his left breast. Wind from the N. W. [By William Clark, Co-captain of the Corps of Discovery (Nebraska edition of the Lewis and Clark journals edited by Gary E. Moulton. All errors are original.)]

The text above is an excerpt from the journals of William Clark, who co-captained, with Meriwether Lewis, the expedition of the American West 1804 through 1806 (Moulton, 2003). President Thomas Jefferson ordered them to organize a corps to travel up the Missouri River to the Rocky Mountains and westward along possible river routes to the Pacific Ocean. Their 3-year journey with 33 crew members, later known as the Corps of Discovery, in totally unexplored territories provides vivid examples of recurrent adaptive tasks that groups encounter in unsophisticated natural environments. As evident in the quotation above, included in those adaptive tasks are securing food and fuel resources, finding shelters, acquiring knowledge about geography, animals, and plants, guarding against predators and enemies, possibly making allies with out-groups, and so on.

Although parallels between such modern, Holocene natural environments and the Pleistocene Environment of Evolutionary Adaptiveness (EEA) are at best speculative (cf. Potts, 1996; Richerson & Boyd, 2000), there is no doubt that humans have used (and will continue to use) groups to manage many adaptive tasks in our lives. Groups have been one of the most frequently used adaptive devices throughout hominid evolution and in modern human histories as well. Given this, social psychologists would be well served by revisiting various group behaviors and group phenomena from an evolutionary and adaptationist perspective, which in turn may provide for a common conceptual ground with evolutionary biologists interested in human social behaviors.

In this chapter, we aim to illustrate this approach, revisiting some of the core intra-group processes and group aggregation mechanisms in the light of adaptation. The adaptationist approach that we endorse in this chapter entails first specifying recurrent survival problems in our everyday, viz., ecologically representative, group settings. Then, it tries to disentangle specific design features of our cognitive and behavioral solutions, viz., strategies and heuristics, to those problems that enhance the fitness of individuals within the groups. As in the expedition by the Corps of Discovery, the lands awaiting us are largely unexplored. We hope that, along the way, we will also discover (or rediscover) many interesting themes and eventually find a new route to the conceptually refined "evolutionary social psychology of groups" (Kameda & Hastie, 2004; Krueger & Funder, 2004).

OUR WORKING MAP

A journey without a map can be quite dangerous, especially because the endeavor we will undertake is highly exploratory. Fortunately, our predecessors left us with a useful working map.

Efficiency in Group Performance as a Central Adaptive Question

As exemplified in the quotation from the journals of Captain Clark, group performance in recurrent adaptive tasks, such as hunting prey, gathering resources, finding shelter, monitoring against predators and enemies, and so on, directly determines the fitness of individuals within the groups. Questions concerning efficiency in collective performance are thus of central theoretical significance for understanding how humans, as fundamentally social species, achieve adaptations (Boyd & Richerson, 1985; Dunbar, 1992; Wilson & Sober, 1994). In a seminal work in the field of group psychology, Ivan Steiner (1972) provided a useful conceptual framework for studying group performance, although he did not explicitly link his framework to adaptation.

Steiner argued that, in order to evaluate a group's productivity, some performance baseline is needed for comparison. By positing a baseline for the group's optimal level of production under the assumption of some idealized coordination/combination of member resources, we can tell how well actual groups perform compared to the optimal baseline, figuring out empirically and theoretically potential causes that determine the actual group outcomes. In other words, such a baseline can serve as a heuristic device to help group research (Kerr, MacCoun, & Kramer, 1996; Kerr & Tindale, 2004).

One potential performance baseline frequently used in group research is the productivity level of the group's most competent member (Davis, 1969; Lorge & Solomon, 1955). For example, much of the early group research focused on intellectual tasks called "Eureka" tasks. As exemplified by some mathematical problems in the modern settings, an Eureka problem has a correct answer which is so intuitively compelling that, once someone offers it in a group, the group immediately recognizes its correctness. Thus, one normative baseline expected for a group is given by the performance level of the group's best member (or someone leading the group intellectually). Given our ordinary beliefs (e.g., "groups yield synergy", "two heads are better than one", and "the best and brightest serves as a group leader"), a group should yield performance that exceeds or at least is comparable to its most competent member's solo productivity. However, previous research has consistently found that usually groups not only fail to exceed such a baseline, but also often fall short of it. Such underperformance is rather counterintuitive, and has naturally been a major focus of small group research (e.g., Hill, 1982; Laughlin, 1999; Laughlin & Ellis, 1986; see Kerr & Tindale, 2004, for a recent comprehensive review).

Process Losses

To understand the gap between actual group performance and the productivity baseline, Steiner (1972) coined a term, *process losses*. Steiner argued that inefficiencies inherent in social processes are responsible for the group's failure to achieve "synergy," or even the performance level of its best member. Steiner (1972) also argued that process losses stem from one of two sources: *coordination* and *motivation* problems.

Coordination problems refer to difficulties in orchestrating members' various resources (knowledge, skills, and expertise) properly in a group setting. For example, if a member with poor eyesight were mistakenly assigned the role of lookout in the Corps of Discovery, then the group should be at serious risk. In many actual situations, however, members' expertise and skills are not directly observable, potentially leading to coordination failures. How to coordinate members' mental as well as physical resources is a key determinant of effective group performance.

On the other hand, motivation problems refer to members' loss of motivation in a group setting. The best-known example in social psychology is the social-loafing phenomenon, where members decrease individual inputs when their rewards are made contingent on pooled group performance (Latané, Williams, & Harkins, 1979). For example, if acquired resources are equally shared in groups (as is hunted meat in many hunter–gatherer societies; Kaplan & Hill, 1985), then members might well exploit others' efforts while avoiding to incur risks in foraging in the wild environment (cf. Kameda, Takezawa, & Hastie, 2003).Given that such a free-riding opportunity is inevitably inherent in many collective-action situations (Kerr & Stanfel, 1993; Olson, 1965), securing members' contributions toward a common goal is another key determinant of group performance.

We believe that Steiner's (1972) classic classifications of process losses will serve as a useful working map for our journey. In the following, we will revisit the coordination problems and the motivation problems from an evolutionary and adaptationist perspective. Along the way, we may observe that some of the group phenomena or biases that were originally thought to be problematic are not so problematic in light of adaptation. Some of them may be by-products or even manifestations of adaptive cognitive and behavioral mechanisms in ecologically representative settings (Gigerenzer & Selten, 2001).

In any event, this is only a rough conjecture at this point. Not wasting words, we have to record truthfully what we will discover (or rediscover) along the way onto our working map.

COORDINATION PROBLEMS

How to coordinate members' resources is a key to effective group performance. Indeed, classic studies in group problem-solving showed that unstructured group interaction often fails to deploy the right members at the right time. For example, Davis and Restle (1963; Restle & Davis, 1962), who studied logical reasoning by ad hoc (i.e., temporary) groups, found that group interaction was better approximated by an "egalitarian model" than by an "hierarchical model"; rather than a member on the right track leading the discussion, all members participated almost equally in the group discussion. When the group task is of an intellectual Eureka type, such a process often leads to inefficient outcomes, although the consensus process per se may look highly "democratic." Likewise, in jury deliberation (another ad hoc group), jurors often compete for status. For the first few hours of deliberation, some jurors "show-off" their toughness for the purpose of establishing their prestige in the group, while sacrificing factual discussions about the case (see Hastie, Penrod, & Pennington, 1983 for the most comprehensive jury study to date). Sociologists have developed a framework to study how such a "power and prestige order" may develop in interacting groups (Ridgeway & Walker, 1995). These observations suggest that proper coordination of members' resources constitutes a major challenge for the functioning of groups. The question, then, is how to solve this problem?

One obvious solution may be establishing effective leadership. Competent leaders (such as Captains Lewis and Clark) may solve the coordination problems properly. Yet, competence may have to be demonstrated first for the person to be regarded as a leader in the group, making the issue somewhat circular; how is a person with good coordination ability selected as a leader in the group?—a second-order coordination problem.

Or, is the establishing of leadership the only way to solve the coordination problems? Besides the use of leadership, there may be some "wisdom of the group" that people adopt naturally, similar to the adaptive heuristics discussed in the literature of individual judgment and decision-making. Researchers identified various "fast and frugal" heuristics whereby individuals can make adaptive judgments and decisions quickly, while substantially saving computation costs (e.g., Payne, Bettman, & Johnson, 1993; Gigerenzer, Todd, & the ABC Research Group, 1999). Some group-level heuristics, comparable to these individual heuristics, may exist that circumvent coordination problems. As candidates for such group-level adaptive shortcuts, we will focus on two social psychological phenomena here—use of "meta knowledge" (Cannon-Bowers, Salas, & Converse, 1993), and operation of "social-sharedness biases" (Tindale & Kameda, 2000) in group interaction.

Meta Knowledge

Meta knowledge, in the present context, refers to knowledge that one or more members have concerning the group as compared to members' knowledge about the task per se. For example, knowledge of who knows what, who possesses which skills, which members fulfill specific roles, etc. would all be considered meta knowledge about the group. This knowledge could be shared among all the members, or known by only some of the members. Recent research has shown that such meta knowledge can be an extremely important component of effective group performance (Cannon-Bowers et al., 1993; Hinsz, 1995; Stewart & Stasser, 1995; Tindale, Kameda, & Hinsz, 2003). In particular, allowing this information to be shared among all the members enhances group performance (Helmreich, 1997; Rentsch & Hall, 1994). Training groups so that group members both realize and understand the roles played by other members has been shown to increase performance in cockpit crews (Helmreich, 1997) and surgical teams (Helmreich & Schaefer, 1994).

Transactive Memory One of the areas of meta knowledge in groups that has received a fair amount of attention is "transactive memory" (Wegner, 1987). Wegner argued that groups can store and process more information than individuals because they can share the responsibility of knowledge storage. However, in order to retrieve the information efficiently, a shared knowledge system must exist identifying who in the group knows what—a transactive memory system. Once such a system exists, each individual member only needs to store information for which they are responsible, easing the memory load on each member but increasing the total amount of information available to the group—cognitive division of labor.

A number of studies have shown that groups with a transactive memory system can outperform those without one (Hollingshead, 1998; Wegner, Erber, & Raymond, 1991). However, there is also evidence that such systems begin to form quite quickly through normal group interaction (Moreland, Argote, & Krishnan, 1998). Moreland et al. compared the performance of three-person groups trained as a group in assembling transistor radios to those groups whose members were trained in the task individually. The training period was only 30 minutes, yet groups trained as a group outperformed those where the members were trained individually. In addition, measures of shared knowledge of the task and differential expertise were shown to mediate the effects of the training manipulation. Thus, in only 30 minutes, groups had begun to develop a useful transactive memory system.

Statistical Cues About Relative Expertise There are also a number of statistical cues present in normal group interaction that group members could use to infer knowledge and expertise (Littlepage, Schmidt, Whisler, & Frost, 1995). Littlepage et al. found that member confidence and talkativeness both determined perceived expertise, though their relationship to actual expertise was rather tentative. Littlepage and Mueller (1997) also found that resorting to reason as an influence tactic led experts to be perceived as such and to be more influential.

Another statistical property that seems to be important in expertise perceptions is cognitive centrality (Kameda, Ohtsubo, & Takezawa, 1997). Kameda et al. found that a member having a large amount of information that is also shared by others (i.e., cognitive centrality) led others to see him/her as more expert and leader-like. Such perceptions also led the cognitively central person to be more influential. Other task-specific factors (e.g., age for knowledge of history, physical fitness for physically demanding tasks, etc.) probably also play a role in appropriate situations (cf. Ridgeway & Walker, 1995). Exactly which cues are used in which situations is yet to be systematically addressed. Nevertheless, group members do seem generally to be adept at using ecologically valid cues to locate their more skilled or knowledgeable members (Littlepage et al., 1995).

Our Gossiping Mind: A Possible Social Engine for Sustaining Valid Meta Knowledge

To summarize, these observations suggest that meta knowledge, along with the use of ecologically valid statistical cues, often helps normal groups to deploy the right members for the right roles. Then, how and to what extent is proper meta knowledge developed, updated, and shared in those groups? We speculate that gossips or other "social broadcasting" mechanisms may play a key part in these processes. In a recent review article, Dunbar (2004) suggested that approximately two thirds of our freely forming conversation time is devoted to social topics, most of which can be given the generic label, gossip. Dunbar argues that gossip originally served a bonding function in social groups, which had its evolutionary origin in social grooming among primates. It also seems likely that such gossiping facilitates exchanging of information about other members' "personalities," constantly updating the shared meta knowledge in groups.

This thinking suggests an interesting hypothesis. There are some data suggesting that gossiping covers more diverse topics and is more frequent among women than men (see Jarvenpa & Brumbach (1988) for observations about a hunter–gatherer society; Parquette & Underwood (1999) for data about American adolescents). If this is indeed the case, women may play key roles in updating and sharing of transactive memory (Wegner, 1987). For example, compared to normal mixed-sex groups, artificial groups composed only of men may suffer from coordination problems more severely. Indeed, the Clark journals indicate that, in the early phase of their journey, status competition in the men-dominant Corps of Discovery sometimes led to serious failures in group coordination.

According to traditional social psychological accounts, these problems arise mainly because men are poorer at handling the "socioemotional" aspects of group performance, compared to women (cf. Wood, 1987). In contrast, the evolutionary reasoning suggests a more "cognitive" explanation: The problem may be caused by an overall decrease in quality and amount of gossiping in men-dominant groups. Social network analysis comparing information flows in mixed-sex groups and men-only groups may illuminate a critical route for development of valid meta knowledge in groups. In any event, given our nature as a gossiping animal, cultural transmission (Boyd & Richerson, 1985) of meta knowledge seems to be a desirable byproduct in normal groups.

Social Sharedeness

We have seen that meta knowledge, which seems to be sustained via various cultural transmission mechanisms including gossiping (Boyd & Richerson, 1985; Dunbar, 2004), provides one key solution to the coordination problems in normal groups. In this section, we discuss "social-sharedness biases" (Tindale & Kameda, 2000) as another key mechanism to cope with coordination problems, especially when groups make important decisions.

Robustness of Group Decision-Making Anthropologists suggest that group decision-making is perhaps one of the most-frequently used adaptive devices by humans, not only in modern industrialized societies, but also in traditional tribal societies. For example, Boehm (1996) reviewed ethnographic data about group decision-making in various tribal societies, including Mae Enga in New Guinea. The ethnography showed that, when making important decisions (e.g., whether to raid an adjacent tribe to solve land disputes), Mae Enga usually held meetings composed of adult men. "Big man" (the most powerful man in the tribe) typically serves as a chairperson of the meeting rather than a dictatorial authority.

With these ethnographic anecdotes in mind, let us first review briefly the experimental research on group decision-making. A recent social psychological conceptualization of group decision-making has viewed groups as information-processing systems (Hinsz, Tindale, & Vollrath, 1997). A central component of understanding how group-level information processing is distinguishable from individual-level information processing is "social sharedness" (Kameda, Tindale, & Davis, 2003). Social sharedness involves the notion that many relevant components of a decision task can be shared to greater or lesser degrees by the members of a group. Most importantly, the greater the degree of "sharedness," the greater the impact that component will have on the group processes and decision outcomes, which may be given the generic label, "social-sharedness biases"

(Tindale & Kameda, 2000). Much of the research literature on group decision-making can be seen as reflecting this basic phenomenon. Previous research has shown that social sharedness operates robustly at three different levels, viz., preference, information, and task representation.

Shared Preferences Probably the most well-validated aspect of social sharedness involves *shared preferences* (Davis, 1982; Kameda et al., 2003). In situations where no single-decision option can be proven to be superior on its own, groups often resolve differences among member preferences through majority or plurality type processes (Kameda et al., 2003; Tindale, 1993). By definition, majority/plurality processes favor the preference that is most shared among the group members. Such rules have been formalized in many circumstances (e.g., legal or corporate situations), but they also tend to emerge from normal group consensus processes (Davis, 1982). Research on groups for many different decision tasks in many different decision environments (including non-Western cultures) has found robust operations of majority/plurality processes (see Kameda et al., 2003 for review).

Shared Information Preferences are not the only aspect of group decision-making where social sharedness has been found. Another well-researched demonstration of the bias has involved *shared information* in groups (Stasser & Titus, 1985; Wittenbaum & Stasser, 1996). In attempting to isolate the effects of informational vs. normative social influence, Stasser and Titus (1985) created laboratory situations where group members initially shared some information but each member also possessed some unique or nonredundant information in the group. By carefully distributing the information, Stasser and his colleagues contrived situations where the entire set of information available to a group designated one alternative as objectively superior if pooled successfully during discussion; however, the information that was initially shared by all members favored a different alternative. This set-up is called the "hidden-profile paradigm" because the superior alternative is hidden in the skewed information distribution. Stasser et al. found that groups usually failed to pool all the information; instead, they spent far more time discussing the shared as opposed to the unique information, choosing the inferior alternative favored by the shared information. This effect has now been replicated dozens of times in many different decision domains (Gigone & Hastie, 1993; Larson, Foster-Fishman, & Keys, 1994).

Shared-Task Representations Another form of the social sharedness, identified by Tindale, Smith, Steiner, Filkins, and Sheffey (1996), involves *shared task representations*. Shared task representations are "any task/situation relevant concept, norm, perspective, or cognitive process that is shared by most or all of the group members" (Tindale et al., 1996, p. 84). They argue that whenever a shared task representation exists, alternatives consistent with it are easier to defend, which leads to asymmetries in the consensus processes (see Laughlin & Ellis, 1986, for asymmetric "truth-wins" social processes in groups working on mathematical problems supported by shared algebraic axioms). Tindale et al. (1996) found asymmetries for a number of judgment and decision tasks where shared heuristic strategies (Kahneman, Slovic, & Tversky, 1982) lead groups to favor responses consistent with the heuristics. Similar effects have been found for shared norms of defendant protection in mock jury deliberation (MacCoun & Kerr, 1988).

Revisiting the Social-Sharedness "Biases" from an Adaptationist Perspective

The aforementioned research suggests that, when proper meta knowledge is not readily available in a focal-task situation, groups usually resort to or are guided by the "social-sharedness biases." Socially shared preference, information, and task representations tend to dominate social processes and determine final group outcomes (see Tindale et al., 2003; Tindale & Kameda, 2000 for recent reviews).

Admittedly, most previous research that identified these group phenomena was not carried out from the evolutionary and adaptationist perspective. However, given their robustness, these "biases" may be conceptualized as evolved adaptive mechanisms that enhance our average fitness in the group. In the following, we specifically focus on three such phenomena: conformity bias (e.g., Asch, 1951; Latané & L'Herrou, 1996; Latané & Wolf, 1981), majoritarian group decision-making (e.g., Davis, 1973; Kameda et al., 2003; Stasser, Kerr, & Davis, 1989a), and dominant role of shared information (e.g., Stasser & Titus, 2003). We revisit potential functions served by these "biases," considering how they can function as "fast and frugal" decision heuristics (Gigerenzer et al., 1999) and may circumvent the coordination problems in groups.

Conformity Bias In the social psychological literature, conformity to the majority occasionally has been characterized as a "morally undesirable" phenomenon (cf. Krueger & Funder, 2004). In studies from Asch's (1951) classic work through its criticism by Moscovici (1976), majority opinions have often been portrayed as wrong, distorting physical realities severely (Asch, 1951), or obsessed with outdated, conservative views (Moscovici, 1976); thus conforming to those incorrect majorities is not justified (cf. Martin & Hewstone, 2003). Likewise, in the growing literature on what economists call "herd" behavior (Anderson & Holt, 1997; Banerjee, 1992; Bikhchandani, Hirshleifer, & Welch, 1992), a spiral tendency in financial markets, viz., conforming to each other's behavior in a panic-striking manner, is often a catchy example of the phenomenon (e.g., Eguíluz & Zimmerman, 2000).

However, these images of majority influence as a misguiding force may be seriously misguided itself in the adaptationist sense. If the majority of the population held adaptively unfit cognitive/behavioral traits, they would be selected against, allowing minority mutants with more fit traits to proliferate in the population. Then, over time, the population will be occupied with the new majorities with the fit traits. In other words, evolutionarily speaking, it is much more likely that, on average, the population is composed of fit majorities than is composed of unfit majorities, which makes the conformity bias to the majority highly adaptive (Boyd & Richerson, 1985). Notice that, if a cognitive/behavioral trait achieves good performance *on average*, it is often evolvable; the perfect error-free criterion, though occasionally adopted in social psychology (Krueger & Funder, 2004), is not an adequate criterion for evolvability of a trait. In this sense, conformity to the majority position can be seen as a fast and frugal heuristic (Gigerenzer et al., 1999, 2001) that serves our adaptation quite efficiently.

Henrich and Boyd (1998), and Kameda and Nakanishi (2002, 2003) extended these ideas further by evolutionary computer simulations and by a series of experiments. They showed that conformity bias is theoretically evolvable *even in a more challenging environment*, viz., in a temporally fluctuating environment.

Recent studies on ice cores and ocean sediments suggest that the Pleistocene EEA was an environment with frequent climate fluctuations on submillennial time scales (cf. Potts, 1996; Richerson & Boyd, 2000). Notice that, in such a nonstationary, fluctuating environment, a population can be momentarily composed of *incorrect* majorities owing to the temporal environmental drift. If the adaptive environment has recently changed (e.g., climate change), the population is momentarily composed of majorities with outdated, unfit traits.

Nevertheless, Henrich and Boyd (1998) and Kameda and Nakanishi (2002, 2003) showed theoretically that conformity bias to majorities is still evolvable. Even if the adaptive environment may fluctuate over time (as was the case in Pleistocene EEA), conformity bias enables us to choose an appropriate behavior in the environment most of the time, without incurring much computation cost; individuals with conformity bias show greater fit on average than those without one. The economists working on herd behavior have also reached the same conclusion. They argue that the behavior itself originates from rational (adaptive) Bayesian calculation under uncertainty, although it *sometimes* could yield the incorrect panic-like chain reactions in a group (Anderson & Holt, 1997; Banerjee, 1992; Bikhchandani et al., 1992).

These theoretical analyses strongly suggest that the net-benefit criterion (focusing on average merit), rather than an error-free criterion (focusing on perfect functioning), favors the evolvability of conformity bias under uncertainty (cf. Festinger, 1954). As ecological evidence for this assertion, it is noteworthy that many "lower" animals that live in groups also possess conforming tendencies, including some fish, birds, and herbivores (cf. Heyes & Galef, 1996).

Majoritarian Group Decision-Making Essentially, the same argument applies to one of the most robust findings in group research—that group consensus is often guided by majority/plurality processes. Although groups do not necessarily take a formal vote, their decisions are well predicted by consensus processes guided by majority/plurality opinions at the outset of interaction (Davis, 1973; Stasser, Kerr, & Davis, 1980; see Kameda et al., 2003 for recent reviews).

Recently, several researchers have revisited adaptive efficiencies of group decision-making by majority/plurality rule directly. Sorkin and his colleagues (Sorkin, Hays, & West, 2001; Sorkin, West, & Robinson, 1998) approached this issue using a signal-detection approach. They showed, both empirically and analytically, that majority processes tend to maximize group performance in situations where ideal preference-weighting schemes are not available—i.e., the members lack meta knowledge about relative expertise on the task.

Using Monte-Carlo simulations and behavioral experiments, Hastie & Kameda (2005) showed that majority/plurality rules tend to produce high levels of decision performance (as well as other desirable social-choice features: cf. Arrow, 1963; Mueller, 1989) with very little cost in terms of cognitive computation efforts. They argue that, compared to the conformity bias operating at the individual level, majoritarian decision-making serves as an even quicker and statistically more reliable aggregation mechanism at the group level. Hastie and Kameda (2005) speculate that, because of the adaptive efficiencies, majority norms may have evolved in many cultures, including hunter–gatherer societies (Boehm, 1996), as fast and frugal decision heuristic.

Interestingly, nonhuman animals living in groups also show majority-like group aggregation processes when they choose sites for foraging, nesting, and so on (honeybees: Seeley & Burhman, 1999; baboons and red deer: Conradt & Roper, 2003). These observations provide further evidence for the robustness of majority/plurality rules in ecologically representative settings. In passing, Captain Clark used the majority rule to decide where to set his winter camp when exploring the Northwest Territory in 1805. Everyone in the expedition, including servants and native guides, had an equal vote in the majority rule decision. This social choice procedure may have been adaptive as well as fitting the democratic ideals he cited in his journals (Moulton, 2003), given that no workable meta knowledge was available in this unfamiliar environment.

Dominant Role of Shared Information As reviewed earlier, group discussion tends to be dominated by shared information (e.g., Stasser & Stewart, 1992; Stasser, Talyor, & Hanna, 1989b; Stasser & Titus, 1985, 1987). Socially shared information is more likely to be attended to and even preferred (Wittenbaum, Hubbell, & Zuckerman, 1999) by members than is unshared information. Stasser views these group tendencies as problematic because they preclude groups from discovering "hidden profiles." When information is distributed among members in a skewed manner where a superior alternative is hidden, group tendencies to focus on shared information can yield inefficient group outcomes (see Stasser & Titus, 2003 for recent comprehensive review). This argument per se is well taken, but how robust is the hidden-profile phenomenon in ecologically representative environments?

The difficulty of discovering hidden profiles is heightened when members have no meta knowledge about who knows what (Stewart & Stasser, 1995). In normal groups, however, people typically have meta knowledge, such as the aforementioned transactive memory (Wegner, 1987). Even in ad hoc task groups such as juries or project teams, we often form expectations about other people's knowledge or expertise based on their professions, ages, sexes, etc. (Ridgeway & Walker, 1995). Although not perfect, these cognitive shortcuts provide some valid clues about who is likely to know what, potentially helping groups discover hidden profiles most of the time.

In some cases, it is nevertheless true that members could lack meta knowledge completely, engaging in adaptive tasks as equal status members without division of roles. As in the Clark journals, this is particularly true when groups are placed in an unfamiliar setting, exploring the local environment for adaptation. How serious is the hidden-profile problem in such a situation? Metaphorically, this is like a situation where randomly placed sensors collect environmental information in a mutually independent manner. It is easy to see that, in those settings, skewed information–distribution against a superior alternative (e.g., a good hunting site) is unlikely to occur; given mutually independent information search, a hidden profile could occur, but with an extremely small probability. Furthermore, shared information is often statistically more reliable (law of large numbers) than unshared information under such a circumstance (Kerr & Tindale, 2004; Tindale & Kameda, 2000). Thus, social mechanisms that place larger weights on shared as opposed to unshared information are adaptively beneficial on average, although they sometimes could yield errors. In this sense, the aforementioned "cognitive centrality effect," where members who share information with most others can exert greater social influence independently of their majority/minority preference status (Kameda et al., 1997), may be seen as another fast and frugal heuristic under uncertainty. By endowing an expert power to such members, groups can reach statistically reliable decisions (by law of large numbers) efficiently most of the time.

Modifying Our Working Map

Let us recapitulate what we have discovered (or rediscovered) so far for including in our working map. Meta knowledge, along with the use of somewhat valid statistical cues, usually provides efficient solutions to many coordination problems in normal groups. When proper meta knowledge is not available, then the social-sharedness biases often come to govern group interactions.

The three social-sharedness "biases" examined in some detail in this section serve a common adaptive function: They reduce the uncertainty involved in perceptions of the external world by capitalizing on *consensus* at various levels, cognitively and behaviorally. More specifically, conformity bias allows us to acquire fit behaviors efficiently in a current environment, even when the environment is nonstationary and fluctuates over time (Henrich & Boyd, 1998; Kameda & Nakanishi, 2002, 2003). Majoritarian group decision-making cancels out random errors in individual judgments and preferences, just as a sample mean provides an unbiased estimate about the population mean in statistics (Hastie & Kameda, 2005). Socially shared information is more likely to be statistically valid and reliable than is unshared information.

As evident in the earlier quotation from the Clark journals, holding valid environmental perceptions is an essential component of many survival tasks (e.g., identifying a good foraging site, knowing right geographical directions, and finding a safe shelter). In this sense, all these biases may be regarded as built-in adaptive tools that allow us to handle the *statistical uncertainty* inevitable in our perceptions of an unsophisticated natural environment. They may yield erroneous outcomes in some artificial cases where information/preference distributions are highly biased (e.g., contrived "hidden-profile" situation, Asch's incorrect majorities), but enhance our fitness on average in ecologically representative settings, while efficiently bypassing the coordination problems in group performance.[1]

MOTIVATION PROBLEMS

We continue our journey of (re)discovery to the next territory on our working map. Motivation problems have been a major research agenda in group psychology (Steiner, 1972). Researchers have identified various conditions that determine people's motivations in group settings, viz., factors yielding motivation losses (or social loafing: Latané et al., 1979) and factors yielding motivation gains (e.g., Kerr, 2001; Williams & Karau, 1991; Witte, 1989). Since excellent reviews are already available on this issue (Levine & Moreland, 1990; Sheppard, 1993; Williams, Harkins, & Karau, 2003), we do not repeat them here. Instead, we revisit the motivation problems specifically from a game-theoretic perspective. We argue that what behavioral ecologists call a "producer–scrounger" phenomenon (Giraldeau & Caraco, 2000; Kameda & Hastie, 2006) may underlie various motivation problems in groups, and speculate their implications for evolutionary adaptation.

Motivation Losses and Motivation Gains

First, let us briefly summarize several key findings about motivation problems. Since the early work by Ringelmann in the 1880s, numerous studies have examined people's motivation in group settings.

Motivation Losses A robust finding in these settings is social loafing, the phenomenon that members decrease their effort-levels when their inputs are pooled into a collective group performance. The best known example is a classic study by Latané et al. (1979), who coined the term "social loafing" to describe the motivation losses in group settings. In this study, college students were asked to shout and clap as loudly as possible, both individually and in a group setting. Exerting clever experimental controls, these researchers were able to show that a large portion of decrement in group performance was attributable to reduced individual effort, rather than to coordination losses (Steiner, 1972). Numerous studies thereafter replicated the basic finding, employing a wide variety of cognitive and motor tasks (see Williams et al., 2003 for review).

Motivation Gains Although still smaller in numbers, recent work began to focus on the other side of the coin, motivation gains, where members increase efforts when with others. Two phenomena have been demonstrated empirically, social compensation effect (Williams & Karau, 1991) and the Köhler effect (Hertel, Kerr, & Messé, 2000; Stroebe, Diehl, & Abakoumkin, 1996; Witte, 1989). Social compensation emerges when individuals work harder on a collective task in order to compensate for the expected poor performance of other group members (Williams et al., 2003). The Köhler effect, a closely related phenomenon, occurs when less-able members of groups increase their efforts when working at conjunctive tasks (where the poorest performance alone determines the group outcome: Steiner, 1972).

Riddle So, we have two sets of phenomena, motivation losses and motivation gains. How can we reconcile these seemingly contradictory findings in an integrative framework? Several researchers have challenged this riddle.

Karau and Williams (1993) argue that expectancy-value theories provide a useful framework to integrate the phenomena (see also Sheppard, 1993). This model suggests that individuals are motivated to work hard on a collective task only to the extent that they expect their inputs are instrumental in achieving group outcomes that they value personally. In group situations where individual inputs are pooled in an additive manner to determine final group outcomes (Steiner, 1972), each individual effort is instrumentally not so meaningful, leading to social loafing (i.e., free riding on other members' efforts). However, when one's input is critical to achieve desired group outcome, motivation gains, such as social compensation and the Köhler effect, are obtained.

We believe that the expectancy-value framework is a useful first step to understand the motivation problems in an integrative manner. To pursue this perspective further, we believe that it is necessary to conceptualize the notion of "instrumentality" (Karau & Williams, 1993) more formally. Karau and Williams (1993) defined instrumental behavior rather loosely, as behavior that achieves group outcomes that *an individual values personally*. From an evolutionary and adaptationist perspective, however, we must be more specific about how a given behavior increases one's *fitness*, rather than generally claiming that the behavior promotes the individual's attainment of some proximal (psychological) goal.

Toward this end, we introduce a game-theoretic framework, arguing that many motivation problems may be better understood as manifestations of the "producer–scrounger" equilibrium (Giraldeau & Caraco, 2000; Kameda & Hastie, 2006).

Game Theoretic Framework: A Quick Primer

Before going further, let us briefly explain a game theoretic framework. Perhaps the best-known game among social psychologists is the social dilemma game where individuals have two behavioral strategies, to cooperate or defect, in a collective-action situation (cf. van Vugt & van Lange, this volume). Among real-world examples included in this game category are provision of public goods (e.g., public-broadcasting service, parks), consumption of natural resources (e.g., air, fish), and so on. In many such cases, defection or free riding (e.g., not contributing to PBS) is more profitable than cooperation, making the efficient provision of public goods, controlled consumption of natural resources, etc. quite difficult (Hardin, 1968; Olson, 1965).

Dominant Strategy and Equilibrium As illustrated in the social dilemma game, we can formulate various interdependent structures existent among individuals as games. Such formalization allows us to examine how each of the strategies in the game performs against other strategies, in terms of net profit. A strategy that outperforms other strategies unilaterally in profit is called a *dominant strategy*. If we draw an analogy to biological evolution ("evolutionary games": Maynard Smith, 1982; Gintis, 2000), organisms with the dominant strategy gradually proliferate (producing many offspring), finally dominating the population. Such a stable collective state is called an (evolutionarily stable) equilibrium in that the strategy dominates while preventing for any other mutant strategies to intrude into the population (see Kameda et al. (2003) for a social psychological application of evolutionary games to development of social norms).

In some other games, like the producer–scrounger game that we will discuss below, several different strategies may coexist at the equilibrium, just as different subspecies coexist in natural environments in a stable manner. More precisely, those strategies make equal profit at the equilibrium, so none of them can dominate the others. This type of equilibrium is called *mixed equilibrium* in that several different strategies are mixed in the population.

Producer–Scrounger Game

Now, let us return to the original path in our journey. We had been at the entrance of the new territory, wondering why seemingly contradictory motivation phenomena (losses and gains) are observed in group performance. We will challenge this riddle from a game-theoretic perspective.

Trade-off Relations Inherent in Different Survival Tasks Social species living in groups share many adaptive problems with humans, such as foraging resources, finding shelters, and guarding against predators/enemies. These situations are essentially identical to the situations that the Corps of Discovery faced 200 years ago. Behavioral ecology (Krebs & Davies, 1993, 1997), the study of animal behaviors in their natural habitats, thus provides many useful insights for understanding how humans may solve these adaptive problems.

For illustration, let us consider group vigilance against predators. According to behavioral ecological models, the lives of many animal species are divided between foraging for food and avoiding predations by other animals (cf. Krebs & Davies, 1993, 1997). These two activities are often mutually excusive—extra effort in one reduces the effort available to the other. Therefore, when an animal forages for food, it must divide its time and attention between feeding and being vigilant for predators. Needless to say, such a trade-off applies to humans as well.

The behavioral ecology literature suggests that many animals' behaviors under the trade-off may be approximated by a cost–benefit model (e.g., Lima, Valone, & Caraco, 1985). Laboratory experiments as well as field observations of many species (e.g., rodents, birds) suggest that, if the animals live *solitary* lives, individual optimization models essentially approximate their allocation decisions. The times allotted for being vigilant and feeding yield approximately a maximum joint fitness to the individuals most of the time (Houston, McNamara, & Hutchinson, 1993).

Complications that Arise in Groups On the other hand, if animals live in groups, like humans, game-theoretic aspects complicate the allocation decisions (Pulliam, Pyke, & Caraco, 1982). Often, social foragers can enjoy "aggregation economies" or benefit of grouping, compared to solitary foragers. In a group, there are many eyes searching for predators (engaging in risk monitoring activity). Thus, each animal can spend more time feeding, engaging in "intake" activity.

However, exactly these features yield an incentive for free riding. "If many others are already on watch, why should I bother? Let others guard us from risk while I'm eating 100% of the time." Giraldeau and Caraco (2000) named generically such an interdependent structure (including the vigilance-foraging situation) a *producer–scrounger game*. In the producer–scrounger game, if there are many "producers" of *public or collective goods* that are beneficial to others as well as self (e.g., contributing to collective vigilance by engaging in the monitoring of predators), each individual is better off starting to exploit others' efforts (e.g., eating 100% of the times). However, if there are many "scroungers" (on another's monitoring efforts), each individual is better off starting to produce (e.g., being vigilant). For instance, if no one around serves as a sentinel, gain from one's own risk monitoring exceeds its cost (making sure you will not be eaten is better than eating).

Emergence of Mixed Equilibrium Notice that, different from the social dilemma game (cf. van Vugt & van Lange, this volume), defection is *not* a dominant strategy in the producer–scrounger game. The net profit of one strategy is not fixed (i.e., neither strategy is a dominant strategy), but is dependent on the frequency of the other strategy in a group. That is, if there are too many players with one strategy, each individual is better off starting to adopt the other strategy; increase in the frequency of one strategy in a group makes that strategy less profitable, while making the other strategy more profitable.

Since the two strategies are mutually constrained in terms of profitability, we can expect a mixed equilibrium to eventually emerge in the group (Gintis, 2000; Maynard Smith, 1982). At equilibrium, the group reaches a stable state where producers and scroungers coexist. In a context of foraging under risk, the group is composed of two types of individuals in a stable manner, those who engage mainly in risk monitoring at the expense of foraging, and those who exploit others' monitoring efforts and mostly concentrate on foraging (Kameda & Tamura, in press).[2]

Motivation Problems Revisited from a Game-Theoretic Perspective

Note that, in the above game-theoretic formulation, each individual cooperates (i.e., producing collective goods such as serving as a guard) if and only if cooperation is *instrumental* for the individual's (*not* the group's) fitness. More formally, one cooperates if the cost of cooperation (e.g., giving up feeding) is less than the benefit of cooperation (e.g., avoiding predation)—when the act of cooperation pays off. Depending on the result of cost–benefit analysis, individuals may work hard toward the group goal (motivation gains) or simply loaf around (motivation losses). And, most importantly, the instrumentality of one's input per se hinges on how other group members behave. If there are many producers in a group, individuals are better off starting to scrounge, while if there are too many scroungers, individuals are better off starting to produce. The result is a mixed equilibrium where producers and scroungers coexist in the group in a stable manner (see Kameda & Hastie, 2006 for a more comprehensive discussion).

Thus, we can formalize "instrumentality" of one's input (Karau & Williams, 1993) unambiguously by the notion of producer–scrounger game. There have been several empirical studies (mostly from our own laboratory) that examined the usefulness of these ideas to explain human behaviors in group settings.

Collective Vigilance Against Predators or Enemies Kameda and Tamura (in press) tested the aforementioned feeding-vigilance trade-off directly. They implemented a collective foraging situation under risk in a laboratory. Six individuals participated as a group in the experiment. The individuals faced the feeding-vigilance trade-off, viz., earning experimental reward (money) by solving individually as many calculation problems as possible while guarding against a common risk that their accumulated reward could be deprived. Kameda and Tamura (in press) recorded how often each individual in a group served as a sentinel against the common risk. The results confirmed their predictions. Over time, the group became divided between producers who engaged in costly risk monitoring and scroungers on those monitoring efforts, eventually approaching the game-theoretic equilibrium.

Free Riding in Social/Cultural Learning In another study, Kameda and Nakanishi (2002, 2003) tested the producer–scrounger phenomenon in a social/cultural learning context. As argued earlier, social/cultural learning is an effective way to reduce uncertainty about the environment, helping individuals adopt an adaptive behavior cheaply. Individual learning by trial and error is often costly. However, it is exactly this feature that may yield an incentive to free ride. If many others engage in costly individual learning, each individual is better off skipping the individual learning and free riding (scrounging) on others' learning outcomes.

Note that such a free-rider problem poses almost no serious adaptive consequence if the environment is stationary; if someone in the group engages in individual learning just once, the single learning conveys all the necessary information for the entire group. However, if the adaptive environment is fluctuating (Henrich & Boyd, 1998; Potts, 1996; Richerson & Boyd, 2000), periodic updating about the environmental knowledge via individual learning is critical. This poses a producer–scrounger dilemma.

On the basis of these notions, Kameda and Nakanishi (2002, 2003) implemented a nonstationary, fluctuating adaptive environment in a laboratory. The results clearly supported their predictions. Over time, the group became divided between "information producers" who engage in the costly individual learning and "information scroungers" who just rely on others, eventually approaching the mixed equilibrium.

Modifying Our Working Map Again

Although these studies did not address traditional group-performance settings directly (but see Kameda, Tsukasaki, & Hastie, 2006, for a description of how this phenomenon functions in group decision-making), we strongly believe that the notion of producer–scrounger equilibrium may be critical to integrate various social psychological findings about motivation problems in groups.

To recapitulate, "instrumentality" (Karau & Williams, 1993) of one's input in a group setting hinges on how other group members behave. If there are many producers in a group, individuals are better off starting to scrounge, while if there are too many scroungers, individuals are better off starting to produce. As a consequence, we have a mixed equilibrium where producers and scroungers coexist in a stable manner—as we often experience in our own everyday lives. In other words, both motivation losses and motivation gains in groups may be captured under *a single game-theoretic framework* where the notion of instrumentality is formally definable (cf. Kameda & Hastie, 2006).

CONCLUSION

We have explored two territories related to group performance in our journey of (re)discovery. We started out with a working map based on Steiner's (1972) classic classification about process losses, viz., coordination problems and motivation problems. What have we been able to add to our working map by this journey?

First, some of the group phenomena or biases that were originally thought to be problematic may not be so problematic in the light of evolutionary adaptation. When the net-benefit criterion, rather than the error-free criterion, is adopted (Gigerenzer et al., 1999; Hastie & Rasinski, 1987; Kameda & Hastie, 2004; Krueger & Funder, 2004), many of the group "biases" may now be seen as by-products or manifestations of adaptive cognitive and behavioral mechanisms in ecologically representative settings. Among those are various social-sharedness effects, such as conformity, majoritarian group decision-making, and the dominant impact of shared information/knowledge. These "biases" help groups to circumvent coordination problems (Steiner, 1972) without sacrificing adaptive efficiencies, by capitalizing on consensus at various levels (Festinger, 1954). We conjecture that other group "biases," which we were not able to cover in this journey, may also be endowed a totally new status in the light of adaptation.

Second, various motivation problems (losses and gains) may be understood as a manifestation of the producer–scrounger phenomenon. Individuals are neither automatic cooperators nor defectors who always behave in the same manner, but determine whether to produce or scrounge by a cost–benefit analysis. That is, they act "instrumentally," if we use the terminology of Karau and Williams (1993), depending on how others behave in a group. As a result, producers and scroungers may coexist in many real-world human groups, as often found in avian species (Giraldeau & Caraco, 2000) and in other taxa (cf. Krebs & Davies, 1993, 1997). Interestingly, Kameda and Nakanishi (2003) showed, both theoretically and empirically, that despite the producer–scrounger problem group life can still yield better mean outcomes (i.e., fitness) than solitary lifestyle. Although free riding is unavoidable in groups, groups can still yield "aggregation economies" compared to solitary individuals.

Finally, our journey may have some implications for what is called group-level selection. Because of our unique reliance on groups (e.g., group decision-making and problem-solving) and our peculiarly "groupy" psychological characteristics (e.g., docility to social norms: Simon, 1990), some evolutionary theorists argue that group-level selection (selection between groups) may indeed have played a substantive role in hominid evolution. Natural selection may have operated at the group level as well as at the (conventionally assumed) individual level in hominid evolution, yielding "ultrasocial" human traits (Boyd & Richerson, 1985; Fehr & Henrich, 2003; Sober & Wilson, 1998; Wilson & Sober, 1994).

The plausibility of group-level selection is currently the topic of vigorous debate in evolutionary biology (see a special issue of *American Naturalist*, 1997 Supplement, Vol. 150, Issue 1), and is sometimes even regarded as "heretical" in evolutionary biology. However, we believe that we should not discard this notion hastily when we think about human evolution. Group phenomena we have observed in the first half of this chapter, viz., human docility (or conformity) to majority social norms, dominant roles of shared knowledge, group decision-making, and so on, reduce within-group phenotypic (i.e., behavioral) variances, whereas they enhance between-group variances (Boyd & Richerson, 1985). All these mechanisms facilitate individuals belonging to the same groups to behave in a similar manner. In other words, these "groupy" human traits (which, as we saw in previous sections of this chapter, have adaptive grounds at the *individual* level) enhance the chance of group-level selection substantively, compared to species living solitary lives. Thus, the group-level selection may not only be logically possible but also plausible in human evolution.

This is the end of our journal. Although we have tried to record our (re)discoveries along the journey as truthfully as possible onto our working map, we are afraid that some of them may have been misplaced. We wait for future work to correct those errors. Also, we must admit that our working map is still sporadic. We hope that our map, although incomplete by far, will serve as a useful milestone for other explorers in these and adjacent new territories, and that many observers will also join us in this truly exciting endeavor, which is an ever evolving journey.

ACKNOWLEDGMENTS

This work chapter was supported by the Grant-in-Aid for Scientific Research 14310048 from the Ministry of Education, Culture, Sports, Science and Technology of Japan to the first author, and by Grant #SES 0136332 from the National Science Foundation to the second author. We are grateful to Mark Schaller, Douglas Kenrick, Reid Hastie, Yoshuke Ohtsubo, Daisuke Nakanishi, Taiki Takahashi, Ryo Tamura, Takafumi Tsukasaki, and Daisuke Nakama for their helpful comments on an earlier version of this manuscript.

NOTES

1. Solving statistical uncertainty is critical for reasons other than holding valid environmental perception. For example, high statistical uncertainty in food-provision (e.g., uncertainty in meat supply) is a recurrent adaptive problem in many hunter–gather societies. Kaplan and Hill (1985) argued that a communal-sharing norm, a norm that designates uncertain resources as common property to be shared, is a collective solution to this problem. Using an "evolutionary game analysis" (Gintis, 2000; Maynard Smith, 1982, see the next section), Kameda, Takezawa, and Hastie (2003) showed that such a norm is indeed evolvable as a consequence of individual-level fitness maximization under statistical uncertainty. They also showed empirically that our modern minds are sensitive to uncertainty information, as exemplified by "psychology of windfall gains" (Kameda, Takezawa, Tindale, & Smith, 2002).
2. This situation is similar to a "Hawk–Dove game" (Maynard Smith & Price, 1973) where two players (e.g., animals) are in conflict over a valuable resource. In the original Hawk–Dove game, two strategies are defined. The "hawk" strategy is to escalate battle until injured or the opponent retreats. The "dove" strategy is to display hostility but retreat before injured if the opponent escalates. Different from the prisoner's dilemma (social dilemma) game, there is no dominant strategy in the Hawk–Dove game. Net payoff to one strategy is dependent on the frequency of the other strategy in the group. A mixed equilibrium emerges eventually, where the Hawks and the Doves coexist in the population in a stable manner (see Gintis, 2000; Maynard Smith, 1982 for details).

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