Facilitation, GSS, and Training as Sources of Process Restrictiveness and Guidance for Structured Group Decision Making: An Empirical Assessment

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Structured decision techniques have been a mainstay of prescriptive decision theory for decades. Group Support Systems (GSSs) automate many of the features found in decision techniques, yet groups often choose to ignore both the technique and the technology in favor of more familiar decision processes. This research empirically tests propositions and hypotheses for a specific instantiation of Adaptive Structuration Theory. A controlled laboratory experiment tests the ability of three appropriation mediators (e.g., facilitation, GSS configuration, and training) to directively affect group decision making through guidance and restrictiveness. The experiment used a hidden-profile task and structured decision technique which directed group members to reach a decision by identifying the problem, choosing criteria, and selecting a solution. The results supported the proposition that appropriation mediators can increase the faithful use of structured decision techniques and that faithful use can improve decision quality. (*Group Decision Support Systems; Group Decision Making; Facilitation; Structuration Theory; Restrictiveness*)

The processes and outcomes of group decision making have been the focus of decades of research. Since groups are the basis for much organizational decision making, organizations have a vested interest in promoting effective group decisions. Information systems researchers have joined this effort by developing technologies to assist with group decision making (Wagner et al. 1993). Specifically, Group Support Systems (GSSs) have been developed to enhance group communication and the structuring of decision processes (DeSanctis and Gallupe 1987, Dennis et al. 1988). These systems largely enable and expand many of the decision-making approaches (e.g., parallel communication, sequenced decision structure) advanced by group decision theorists prior to GSSs. Some evidence supports the efficacy of GSSs to improve decision processes and outcomes in specific contexts (Dennis and Gallupe 1993); however, other research has reported varied support (Pinsonneault and Kraemer 1988, McLeod 1992, Benbasat and Lim 1993). This has prompted researchers to examine a host of contingency factors as possible moderators of GSS efficacy (e.g., Nunamaker et al. 1989, Mennecke et al. 1992).

Much prior GSS research has adopted a contingency approach where certain GSS or situational factors are believed to mediate group decision outcomes. Other perspectives have focused on the

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process of how a system is used as the mediator of outcomes. Poole and DeSanctis (1990) have observed that "no matter what features are designed into a system [GSS], users mediate technological effects, adapting systems to their needs, resisting them, or refusing to use them at all" (p. 177). Thus, some GSS researchers are looking beyond input-output based contingency theories to other process-oriented theoretical lenses aimed at better understanding the factors that mediate the manner in which groups use these systems.

In this research we use a controlled laboratory experiment to test propositions drawn from structuration theory. Specifically, we examine how facilitation, GSS configuration, and user training mediate the use of structured group decision techniques (heuristics) and group decision outcomes. The increased role of teams and reliance on group decision-making in modern organizational life presents a significant dilemma. Various decision techniques and technologies purport to offer a means for improving the quality of group decision activities, yet the manner in which these techniques or systems are used is believed to mediate their impacts. How then can organizations bridge the gap between the *availability* of decision-aiding techniques and technologies and helpful *use* of these to improve group decision outcomes? Silver (1990, 1991) addressed this issue for single-user DSSs through the forces of *restrictiveness* and *guidance*. We build on the work of Silver and others to define and empirically evaluate the idea of *process restrictiveness* for GSSs. In the group decision-making context, we define the term *process restrictiveness* as the *manner of limiting a group's interaction to the activities, sequences, and philosophies specified by a heuristic*.[1] Process restrictiveness offers a means for organizationally directed change in group decision making through the prescription of structures mandated by facilitation, a GSS, or user training. The article begins with a review of relevant group decision-making and technology literature. We then set forth a theory with broad propositions and specific testable hypotheses related to group decision quality. This is followed by the experimental design and procedures. The results and a discussion of their implications for future GSS research and practice conclude the article.

Group Decision Making, Heuristics, and Technology Support

It is widely believed that groups have the potential to make more effective decisions[2] than individuals. Groups often possess a greater variety of task-relevant knowledge, facts, and insight than individuals, and the pooling of these resources can lead to emergent knowledge or insight (Maier and Colleagues 1957, 1960, 1969; see Bettenhausen 1991 for a review). Yet groups often fail to reach their potential (Hall and Williams 1970). For example, "process losses," such as production blocking, mismatching group resources to task demands, and faulty information processing, have been advanced as impediments to effective group decision making (Steiner 1972). Similarly, communication-based reasons, such as failing to systematically distinguish between fact and opinion or failing to engage in the vigilant use of decision criteria are also associated with ineffective decisions (Hirokawa and Pace 1983, Hirokawa 1987). Solution-oriented decision processes may be another impediment to effective group decisions. Field studies have demonstrated that groups often have a predisposition for solution-oriented decision behavior which can restrict innovation, limit the number of alternatives considered, and perpetuate the use of questionable tactics (Mintzberg et al. 1976; Nutt 1984; see also Poole and Roth 1988a, 1988b; c.f. Weick and Meader 1993).

Numerous techniques or heuristics have been devised in an attempt to help groups avoid these presumably faulty processes (Hackman and Kaplan 1974, VanGundy 1988). Heuristics provide rules to pattern a group's decision process by prescribing and proscribing how group members should communicate and se-

[1] Similar to Silver's (1990) definition, a heuristic describes the "subset of possible activities" to which the group's interaction will be restricted

[2] Many terms have been used to differentiate between desirable (e.g., high quality, good, correct) and less desirable (e.g., low quality, poor, faulty, wrong) decisions. Each of these evaluative terms may be more or less appropriate to a particular type of group task. For consistency, the term "effective" will be used to refer to a desirable group decision based on the most applicable evaluation criterion for a particular task

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quence their interactions towards some objective (e.g., concisely defining the decision problem). Heuristics consist of structures which describe a particular *activity*, specify a *sequence* of activities, or describe a *philosophy* for communication. An example of an activity is to write ideas anonymously on note cards or to rank order a list of ideas. Sequence mandates that a particular activity must precede some other activity (e.g., idea generation precedes idea evaluation). A heuristic's sequence often implies separation (e.g., idea generation activities and idea evaluation activities should not be happening simultaneously lest neither activity reach its potential). A philosophical structure describes the general spirit or advice for patterning communication content, such as fostering an atmosphere of participation and tolerance. Each structure in a heuristic has been designed to overcome some believed deficiency in human information processing. Both the academic and popular press contain hundreds of heuristic prescriptions for improving group decision making (Doyle and Straus 1976, VanGundy 1988).

The procedural and philosophical guidance of heuristics has traditionally been delivered to groups via *training* or by a *process facilitator*. Training seeks to instruct group members in how to implement a heuristic's structures and why these structures are useful. Training may take the form of formal seminars, written instructions in books and pamphlets, or word of mouth among colleagues. Such training, however, only provides an *awareness* of the heuristic among the individual group members and in no way ensures that the heuristic's structures will be used by a group.

Another method for delivering heuristics is through a third-party process facilitator (or a group member who assumes this role). The presence of a process facilitator helps to separate the process and content aspects of group decision making. A facilitator devotes his or her full mental resources to constructively aiding the group's decision process while the group members focus on the content of the decision (Maier and Maier 1957, Hoffman and Maier 1959, Hall and Williams 1970). Since facilitation is an active intervention during the decision process, it is viewed as a more potent delivery mechanism than training (Bostrom et al. 1993). Other facilitator activities can include assisting with between-member relational behaviors and conflict resolution.

Once heuristics are made available to groups, two questions naturally follow: (1) to what extent are the heuristics actually used, and (2) do groups that use these heuristics produce more effective decisions than groups that are left to their own devices? Results to date neither *conclusively* support nor deny the relationship between the availability of heuristics, use of the heuristics, and group decision effectiveness. Most studies have supported the relationship between availability and effectiveness (e.g., Maier and Maier 1957, Maier and Hoffman 1960, Maier and Thurber 1969, Hall and Watson 1970, Hall and Williams 1970, Hackman and Kaplan 1974, Janis 1982) while others have not supported it (Maier and Thurber 1969, Hirokawa et al. 1988). One caveat for interpreting this stream of research, however, results from the inconsistent methods used by various researchers to deliver and mandate a heuristic's structures to a group. Few prior studies report reliable assessments regarding the degree to which group members really understood the objectives or structures of the heuristic, or more importantly, the degree to which the group actually engaged the heuristic's structures rather than alternative decision processes. In much of this prior research, groups in one treatment were directed to use the heuristic with only minimal or no process restrictiveness (i.e., the groups were free to fully use, partially use, or ignore the heuristic) during the decision process while others were left to choose their own decision procedures.

In reviewing this research, Gouran (1982) observed that the benefits of heuristics can only be realized if a group adequately incorporates the "qualities of mind" represented by a heuristic. This view is supported by other research which documents that groups often abandon or only halfheartedly use heuristics (Poole 1991). Thus, a causal linkage between the *availability* of a heuristic and its *use* nor heuristic use and *effective decision outcomes* has not been clearly established.

GSSs may be one way of improving the delivery and group of heuristics (see DeSanctis and Gallupe 1987, Dennis et al. 1988, or Nunamaker et al. 1991 for extensive descriptions of these systems). Dennis and Gallupe (1993) report that some studies have found the structuring and facilitation aspects of GSSs to improve decision outcomes, though these findings have not been universal. Huber (1984) observed that the designers of

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GSSs seemed to approach their design task with a decision-aiding approach already in mind and implicitly created software tools which automated the activities found in manual heuristics.[3] GSS features (referred to as tools) embodied in current systems can be used to parallel the heuristic structures of activities and sequence. Thus, heuristic structures represent a set of rules (i.e., an informed set of guidelines) for using a GSS's tools in a group decision process.

GSSs vary in the manner in which group members gain access to the tools. Some systems (e.g., SAMM[4]) are user driven, thus the users can control the sequence and selection of tools. In other systems (e.g., GroupSystems[5]) a technical chauffeur—often in conjunction with a process facilitator—controls the sequence of access and selection of the tools. The number of tools and their level of malleability (e.g., anonymity switches, data transfer between tools) to various group decision situations has increased in recent years. Skillful configuration of the GSS tools and sequencing features offers a powerful way to deliver and impose the use of heuristic structures. In some cases, GSS implementation of heuristics has been much more effective than manual use of the same heuristic (Valacich et al. 1994).

In summary, some evidence supports the notion that heuristics can help groups improve decision making. Training, facilitation, and various configurations of GSS have been the primary means of delivering and implementing heuristics.

Guidance, Restrictiveness, and Appropriation Mediators

Much GSS research to date has been conducted in the *decision-making school* tradition (DeSanctis and Poole 1994). This perspective espouses either hard-line determinism (i.e., a certain effect follows the introduction of a technology) or more often a moderate contingency-deterministic view (i.e., certain situational factors interact with technology to mediate outcomes; see also Orlikowski and Baroudi 1991). The decision-making school sees heuristics, training, facilitation, and technology as *input factors* that can be manipulated to engineer remedies for human deficiencies in communication and information processing. It treats the group interaction process as blackbox (Sambamurthy and Poole 1992). Results to date from research in this tradition have produced some solid conclusions (e.g., electronic brainstorming groups outperform manual groups; Valacich et al. 1994) and numerous contradictions (see Benbasat and Lim 1993, Dennis and Gallupe 1993).

DeSanctis and Poole (1994) argue that theories from the contingency-deterministic view fail to recognize how groups may choose use the input factors in ways that differ from their intended use. Thus, manipulation of input factors alone cannot adequately account for variance in group outcome variables. DeSanctis and Pool further argue that the social-technical perspective, a different theoretical tradition, can simultaneously account for the deterministic effects of GSSs on group outcomes while recognizing that the process of technology use is a key determinant of technology effects (1994, p. 143). They have proposed Adaptive Structuration Theory (AST) which posits that advanced information technologies, such as GSSs, are *potential* sources of social structures (Poole and DeSanctis 1990). Likewise, tasks, group norms, and heuristics are also potential sources of social structures. Groups may use these structures in a faithful (i.e., use is consistent with a structure's design) or an unfaithful manner (i.e., use is inconsistent with a structure's design). The effects of these structures on group decision making are mediated by social interaction through which groups selectively choose and faithfully or unfaithfully use these structures (AST refers to this as the *appropriation process*). A variety of factors have been suggested as mediators of structure selection and use (see DeSanctis and Poole 1994, for an extensive explanation of AST).

In the following subsections we draw on AST and the social-technical tradition to theorize how facilitation, GSS configuration, and training may act as *appropriation mediators* through the forces of *guidance* and *restrictiveness* to influence specific *procedural dimensions* of the social interaction process, and ultimately, *decision outcomes*

[3] GSSs can be configured to provide level 1 (communication) or level 2 (decision modeling) support (DeSanctis and Gallupe 1987).

[4] Software-Aided Meeting Management (SAMM), University of Minnesota.

[5] GroupSystems is a registered trademark of Ventana, Inc, Tucson, Arizona.

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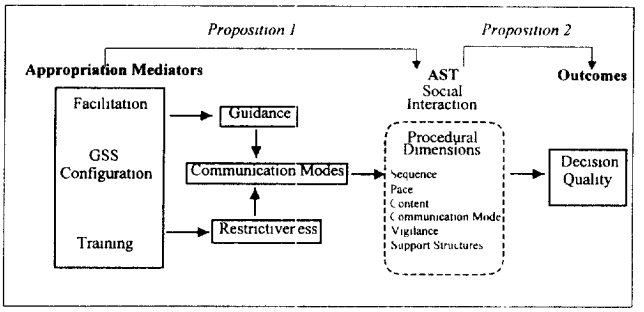
Figure 1 Process Restricted Adaptive Structuration Theory (PRAST)



(Figure 1). We refer to this theory as Process Restricted Adaptive Structuration Theory (PRAST), which is a specific instantiation of AST. Our objective is to understand how these appropriation mediators may be able to selectively bias the social interaction process toward faithful use of heuristic structures. Each component of the theory is described below. We begin with the forces of guidance and restrictiveness since they are the expression of efforts to directively influence the social interaction process, then we proceed to describe the other constructs of the theory.

Process Guidance

During a decision process groups intentionally and unintentionally make choices about their communication procedures and sequence of the decision activities. Silver (1991) defined decisional guidance for DSS as "how a decision support system enlightens or sways its users as they structure [make procedural choices for] . . . their decision processes" (p. 107). Similarly, Limayem (1992) extended this to the group decision arena as "the enrichment of decision models with cues that direct decision makers toward successful structuring and execution of model [heuristic] components" (p. 6). Guidance can take the form of *forward guidance*, which informs a group of what to do next during the normal progression of decision activity, *backward guidance* to help a group go back and resolve unfinished business from a prior activity, or *preventive guidance* to prevent disruption breakpoints that impede a group's decision progress (Limayem 1992, Poole 1983). The purpose of guidance then, is to lead a group through procedural obstacles in faithfully using a heuristic's structures.

Process Restrictiveness

In contrast to guidance, process restrictiveness focuses on preventing both unfaithful uses of a heuristic's structures and the choosing of alternate structures. The term restrictiveness has appeared with varied meanings in the IS literature. One view holds that restrictiveness is an attribute of the technology. In the context of a single-user DSS, Silver (1988, 1990) argued that a system is highly restrictive if the number of system-supported processes is small relative to the number of possible processes. He defined restrictiveness as "the degree to which and the manner in which a decision support system limits its user's decision-making processes to a subset of all possible processes" (1990, p. 53). Similarly, Nunamaker et al. (1991) describe the GroupSystems GSS as locally restrictive at the tool level. This perspective views the degree of restrictiveness as *innate to the technology* and is valid to the extent that a system is capable of impeding the use of other processes not supported by the system. Silver later notes that actual restrictiveness is a function of the interaction process between the system and the user.

Another view of restrictiveness is based on a particular heuristic. DeSanctis et al. (1989; see also Poole and DeSanctis 1992) extended Silver's definition of restrictiveness to the GSS arena. They defined restrictiveness as "the extent that the heuristic limits or channels the group's use of the resources inherent in the heuristic" (p. 132). Their definition assumes that restrictiveness is *innate to the heuristic* and that the heuristic has the ability to impede the use of other structures not prescribed in the heuristic. These authors also note that actual restrictiveness is more a characteristic of the manner in which the heuristic is used than a description of the heuristic itself. They conducted an experiment which varied restrictiveness by instructing groups to "adhere to the activities, sequences, and philosophy of the heuristic" (high restrictiveness) or to "select and use any of the heuristic's features in any manner or sequence" (low restrictiveness). They found increased decision consensus under the high restrictiveness treatment using a highly structured heuristic which contained both a philosophy and a sequenced set of decision activities. No actual measures of heuristic use were reported. They concluded that restrictiveness may only provide a meaningful

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advantage for group consensus when the complexity of the heuristic is overwhelming to a group.

The complex nature of group interaction suggests that neither definition of restrictiveness is sufficiently comprehensive for group decision making. For example, by Silver's notion of restrictiveness a DSS could enforce the assumptions of a regression model by disallowing the user access to the regression calculations when the data show evidence of multicolinearity. While a user might be able to circumvent this restriction by downloading the data and doing the regression on another computer or even by hand, the system could restrict access to the data. Either way, circumventing the system's restrictiveness is not easy because all interactions with the DSS occur via a computer-mediated communication mode (e.g., input and output devices). In the group context, however, information exchange between group members is one of the primary reasons for group decisions (DeSanctis and Gallupe 1987) and multiple communication modes are available for these exchanges. Both GSSs and heuristics lack the ability to restrict the information exchange process in all communication modes.

Communication Modes

The presence of multiple communication modes complicates the application of DSS research to GSSs. In the GSS context, a group's decision activities in the form of information exchanges may occur via three modes: verbal, gestural, and computer-mediated. The efficacy of guidance or process restrictiveness in the group context is dependent upon its ability to discern and to affect a group's decision process through these three communication modes. For example, consider a GSS-based meeting which had been designed to use the heuristic structures of specific activities in a specific sequence towards the goal of reaching group consensus. The designed activities might be a period of anonymous idea generation, followed by a verbal discussion to clarify and examine the assumptions of the ideas, and finally a cycle of anonymous voting and verbal discussion until consensus is reached. The sequence implies that evaluation is separated from generation and that an anonymous vote follows the discussion. The GSS could impose the sequence structure by disallowing access to the anonymous voting tool until after the brainstorming ideas had been discussed. However, a group has the ability to effortlessly switch to the verbal communication mode and take a verbal vote at any time—even during the idea generation activity. In doing so, the presumed benefits of the heuristic have been undermined. Consequently, the divergent activity of brainstorming may have been truncated, thus yielding fewer ideas for consideration. The assumptions which underlie those ideas were not examined via discussion, and group peer pressure was in no way impeded from possibly railroading the vote. Therefore, for maximal effect, we suspect that guidance and restrictiveness must be able to act on a group's decision process *in the same communication mode* used for a group's information exchanges.

Procedural Dimensions

The forces of guidance and process restrictiveness act on a group's decision process through their influence on six procedural dimensions. Procedural dimensions represent a subset of AST's social interaction process that is directly relevant to the use of heuristics. These dimensions are the *sequence* of the activities (e.g., choosing to generate ideas and then evaluate or engaging in concurrent generation and evaluation, etc.); the *pace* of the communication activities (i.e., how much time is spent generating ideas or discussing a vote before transitioning to another activity), which usually involves trade-offs in allocating a constrained quantity of time among activities; the *content* of the communication messages (e.g., faithful or unfaithful with current activity of the heuristic such as generating solution criteria, etc.); the *communication mode* (e.g., verbal, gestural, or computer-mediated); *vigilance* of engagement in the activity (e.g., degree of critical thinking in exploring assumptions, challenging assertions, proposing novel ideas, etc.); and selection of *process support structures* (e.g., flip chart, GSS brainstorming tool, voting tool, etc. (Nunamaker et al. 1991).). In the absence of guidance or process restrictiveness, a group has complete discretion in making its own choices for each of these procedural dimensions. Through these choices groups may fully use, partially use, or ignore the social structures made available through a heuristic or GSS. We now turn to identifying the sources from which the forces of guidance and process restrictiveness act on the six procedural dimensions.

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Appropriation Mediators

We theorize that *facilitation*, the *configuration of a GSS* (e.g., level 1 or level 2), and *training* may serve as *appropriation mediators* to guide and restrict groups as they make appropriation choices regarding the use of the sequence and activity structures in heuristics and intrinsic to GSSs. Appropriation mediators attempt to systematically reduce the appropriation choices available to a group along the six procedural dimensions. In relation to AST, they "tilt" or bias a group's choices and use of potential social structures towards those that represent faithful appropriation and away from those that would be unfaithful relative to the objectives a heuristic. Appropriation mediators are the means through which meeting designers can create guidance and process restrictiveness. Each appropriation mediator differs in its ability to affect the six procedural dimensions through the forces of guidance and restrictiveness. A mediator is *active* when it can intervene to direct or limit a group's procedural choices in the same communication mode in which those choices are carried out. For example, facilitation is an active mediator since a facilitator can monitor all three communication modes and can act to provide guidance or restrictiveness through verbal, computer-mediated, or even gestural communication. A mediator is *passive* when its guidance and/or restrictiveness advice is available to a group, but it cannot effectively intervene or limit the procedural choices due to its inability to act in the same communication mode in which those choices are carried out. GSSs and training are both passive mediators, though there are important differences between them. Through the use of decision modeling (e.g., sequenced agenda) displayed on a screen, a level 2 GSS offers a visually persistent form of passive guidance and restrictiveness that is always in front of a group. In contrast, training is a cognitive activity that is subject to the individual and collective recall of group members. Beyond formal instruction in decision techniques, organizational norms and other successful or unsuccessful historical experiences may affect the extent to which training is recalled and applied by group members. While both sources are passive in their ability to intervene in some communication modes, the uniform visual persistence among all group members of a level 2 GSS's guidance and restrictiveness argues that it would be a more influential mediator than training. In the following section we turn our attention to specific propositions for testing PRAST.

Propositions and Hypotheses

The following propositions and hypotheses assume the context of a group convened for the purpose of making a decision with access to a task-relevant heuristic and GSS. As depicted in Figure 1, PRAST contends that appropriation mediators act through guidance and process restrictiveness to signal groups with what to do next and to limit groups' options among the procedural dimensions. Each mediator can only guide and restrict the procedural dimensions based on the extent to which it can discern and act in the same communication modes as the social interaction process. The presence of any appropriation mediator is expected to bias the group's procedural choices in favor of faithful use of the heuristics' structures.

PROPOSITION 1. *The presence of an appropriation mediator(s) will increase groups' faithful use of a heuristic.*

Based on this general proposition from the model, we advance specific hypotheses for each appropriation mediator.

Facilitation. Facilitation can monitor and act through all three communication modes. A facilitator's verbal instructions can serve as an *active* form of both guidance and process restrictiveness should the group begin to make procedural choices that are inconsistent with a heuristic. For example, a facilitator can monitor the content of both the verbal and computer-mediated communication modes for any messages which are incompatible with the current activity (e.g., evaluation during idea generation, roll call voting rather anonymous voting, etc.). A facilitator can also draw on his or her expertise to interpret how a particular group action may or may not be consistent with the rules of a heuristic. We hypothesize:

H1A. *Facilitated groups will more closely follow a heuristic's structures (activities, sequences) than will unfacilitated groups.*

GSS Configuration. AST refers to a GSS's tools as its set of structural features. It also recognizes that these structural features have a spirit or "general intent" underlying their purpose. For example, the structural feature of anonymous voting is premised on the spirit that

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anonymity can minimize social pressures that suppress effective information sharing. We theorize that the configuration of a GSS's structural features can mediate the appropriation of a heuristic's activities and sequence structures. For example, the structures in a level 1 GSS are configured to provide communication support, while in a level 2 GSS these same structures can be configured to provide decision modeling via a heuristic (DeSanctis and Gallupe 1987). In both a level 1 and a level 2 GSS an anonymous idea sharing tool can be made available to a group for communication, but a level 2 system could also display an on-screen agenda of GSS tools. This agenda could restrict the sequence of activities and a group's ability to choose other process support structures (e.g., anonymous voting tabulation). A level 2 GSS, however, is capable of passive guidance and process restrictiveness only when groups choose to interact via the GSS's tools. For example, the pace of a group's interaction via a GSS can be guided by on-screen timers, but a GSS cannot restrict a group from continuing to interact in the verbal communication mode when the timer expires—effectively making the GSS's attempted restrictiveness impotent. Thus, level 2 GSSs have the potential to act as an appropriation mediator on the activities and sequences in the computer-mediated mode (Poole and DeSanctis 1992), but they have no ability to affect the verbal or gestural communication modes. Since the availability of a GSS often results in partial or full use of it and a heuristic, we hypothesize:

H1B. *Groups using a level 2 GSS configuration will more closely follow a heuristic's structures (activities, sequences) than will groups using a level 1 GSS configuration.*

Training. AST also contends that the use of structures will vary based on members' degree of knowledge and experience in using the structures, degree to which members believe that other members know and accept the use of the structure, and the degree to which members agree on appropriation choices (DeSanctis and Poole 1994, p. 130–131). Training in the faithful use of heuristics can be used to create knowledge and experience in the use of a structures. A shared training experience among group members can ensure that all members are aware that other members know how to use the heuristic. It can also provide a shared basis of common knowledge for agreement on appropriation choices. Ideally, training moves users from ignorance or simple awareness of a heuristic to an understanding a heuristic's structures. Training can only provide a passive form of guidance and process restrictiveness to a group through knowledge of a heuristic. It has no ability to actively restrict the use of a heuristic's activities and sequence structures during the actual decision process but enables the group members to self-impose process restrictiveness (i.e., limit their own process choices to those prescribed by a heuristic). In the absence of training, group members would lack common knowledge in applying the heuristic and would have less shared basis for agreement on appropriation choices. Assuming that individuals within groups will recall training and act on it in shaping their decisions among the procedural dimensions, we hypothesize:

H1C. *Trained groups will more closely follow a heuristic's structures (activities, sequences) than will untrained groups.*

Multiple Mediators. Thus far, the hypotheses have only addressed the presence or absence of a particular appropriation mediator, but multiple appropriation mediators could be used concurrently. For example, a trained group could use a level 2 GSS configuration or be facilitated. We believe the effects of two appropriation mediators will be additive, not in a linear way where 2 + 2 = 4, but in a directional way such that combining sources will increase faithful use over only one mediator. However, all mediators are not created equal. We believe that an active mediator alone will always be more effective than any single or combination of passive mediators. Likewise, an active mediator plus other active or passive mediators will be more effective any single or combination of passive mediators. This is expressed in the following pair of hypotheses for combining two and three mediators:

H1D. *Groups with an active mediator alone will more closely follow a heuristic's structures (activities, sequences) than will groups with one or more passive mediators.*

H1E. *Groups with an active mediator and any other mediator will more closely follow a heuristic's structures (activities, sequences) than will groups with one or more passive mediators.*

The second proposition in the model tests the relevant influence of the first proposition. Assuming that groups

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with appropriation mediators will more faithfully use a heuristic, then the real question of interest examines the relationship between actual use of a heuristic and decision quality. The previously reviewed literature documented some of the common pitfalls or faulty processes associated with group decision-making. The purpose of heuristic's activities, sequences, and philosophy structures is to help groups avoid the common pitfalls. While no heuristic structure can provide a certain path to effective decisions, sufficient empirical evidence was reviewed to posit a relationship between the availability of a task-relevant heuristic and decision quality. Given an assessment of the degree to which the structures were faithfully appropriated, we expect a positive relationship between use and decision quality in Proposition 2:

PROPOSITION 2. *Faithful use of heuristics should improve decision quality.*

This proposition is tested in relation to both the faithful and unfaithful uses of a heuristic.

H2A. *Faithful use of a heuristic's structures will be positively related to decision quality.*

H2B. *Unfaithful use of a heuristic's structures will be negatively related to decision quality.*

In summary, this section has set forth propositions from a new theory, PRAST, drawn from the social-technical perspective of Adaptive Structuration Theory. Specific, testable hypotheses were also advanced. The next section outlines an experiment to assess the predictive abilities of the theory.

Research Design

A controlled laboratory experiment employing a 2 × 2 × 2 full factorial design was conducted to test the hypotheses. The three factors were the appropriation mediators—facilitation, GSS configuration, and training. Each factor was operationalized at two levels, resulting in eight experimental treatments.

Independent Variables

Half of the groups were facilitated and the other half did not have a facilitator ("unfacilitated"). Facilitated groups used a third-party process facilitator to enforce the structures of the heuristic. Since guidance and restrictiveness were the topics of investigation, the facilitator's actions were limited to these functions. He did not engage in adaptive facilitation to help groups overcome procedural or relational obstacles (see Anson et al. 1995, Bostrom et al. 1993), nor were his comments rigidly scripted. Instead, he provided guidance though pointing the group back to the printed version of the heuristic and reading the directions for the activities as groups began each new activity (see procedures section below). He was essentially a verbal version of the printed heuristic who also had the ability to actively recognize when the group's communication exchanges deviated from the heuristic. The facilitator provided restrictiveness by interjecting verbal comments when the group tried to unfaithfully appropriate the heuristic, GSS, or choose an alternate social structure. The restrictive comments were typically in the form of "remember, the purpose of this activity is to generate problem statements not solutions" or "step B of the heuristic requires you to discuss the list of ideas before voting on them." The same facilitator was used for all groups to reduce variability from personality styles. The facilitator did not give guidance nor process restrictive comments regarding the procedural dimensions of pace or vigilance.

Similarly, half of the groups used a level 2 GSS configuration that displayed a sequenced agenda on each participant's screen. The agenda items exactly matched the activities in the heuristic and were enabled in a sequential manner as the group requested them, but only one item at a time. The other half of the groups used a level 1 GSS configuration and did not receive a meeting agenda on their screen. They were free to employ the GSS features in any manner they chose (i.e., they could use the GSS in faithful or unfaithful execution of the heuristic).

Training was manipulated at two levels. All groups received the same introduction to the heuristic identifying its five goals and sequenced activities (low training). Additionally, half of the groups also received training in how and why to use the activities, sequences, and philosophy of the heuristic, and they practiced using these structures on a training case (high training).

Task

The task for all groups was the hidden-profile School of Business Policy Task (SOB) by Wheeler and Mennecke

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(1992), which has five unique roles. Hidden-profile tasks distribute unique information among group members and are thought to more closely simulate many real-world settings in which task-relevant information is uniquely held by each group member. This type of task is called a hidden-profile task because "individuals in the group cannot see that the collective profile of information favors an alternative that to each individual appears to be inferior" (Stasser 1992, p. 56). The task possesses two important characteristics which make it relatively unique among GSS research: First, the distribution of information facilitates manipulation of the logical group size[6] to more closely approximate the physical group size. This has been identified as a major difference between the findings of laboratory- and field-based GSS research (Dennis et al. 1991, Mennecke and Wheeler 1993). Second, the task is conjunctive and therefore *requires* that all group members participate and share ideas for the group to identify and select a feasible solution. Free-riding by one or more participants is likely to deprive the group of important information and perspectives. Heuristics and GSSs are especially well-suited to supporting the requirements of conjunctive tasks. Additionally, as an ill-structured task, the SOB task does not explicitly state the problem for the group to solve (as is common with many tasks used for laboratory experiments). In fact, there are multiple problems in the case, though there is supporting evidence for the dominant problem in each of the roles. Groups needed to determine the nature of the problem(s), appropriate decision criteria, and a solution from the information contained in the five roles. All groups received the same task instructions and objective which was to write a recommendation memo to address possible problems at the business school.

[6] The logical group size refers to the degree of overlap of task-relevant domain knowledge among group members Nunamaker et al. (1989) note that "a physically large group from a common culture may have a high degree of overlapping domain knowledge that results in the group being logically small. Conversely, a physically small multicultural group exhibits characteristics of a much larger group because its members have multiple and often conflicting perspectives, points of view, diverse knowledge domains, and opinions that make it logically large" (p. 147) For a test of this see Valacich et al 1994

Heuristic

The heuristic was a five-step, multiple-activity group decision-making procedure that had been specifically tailored to the demands of the task through pilot testing. It incorporated the best literature-derived advice for how various heuristic structures help groups to overcome well-documented obstacles to effective decision-making. This included separation of divergent (idea generation) and convergent (choice) phases of group activity, a requirement to write out an agreed upon problem statement before working on solutions, and prioritization of specific criteria. The hidden-profile nature of the task necessitated much information exchange and convergence for a group solution since each person started with only a limited view of the problem space. The heuristic is summarized in Figure 2. While the task can be performed without acting on each requirement, pilot testing of the task and heuristic demonstrated that groups which did not first build consensus about the problem had greater difficulty in selecting a solution. The heuristic described the major goal for each step, described the activities to use in reaching that goal, and graphically depicted the divergent and convergent phases.

Figure 2 Heuristic Goals and Specific Sequenced Activities

Five Major Goals	Sequenced Activities
1) Identify the real problem	Generate problem statements (BW), discuss and clarify, reduce the list by voting (Vote), choose the best problem statement (Rank), write the problem statement
2) Identify many possible solutions	Generate solutions (BW), discuss and clarify
3) Identify and weight important constraints or opportunities	Generate opportunities and constraints (BW), discuss and clarify, reduce the list by voting (Vote), assign relative weights (Rate)
4) Reduce the list of potential solutions to ≤5	Review the list of possible solutions, reduce the list by voting (Vote)
5) Select the best solution	Compare the reduced list of possible solutions to the weighted opportunities and constraints (Score)

Note GSS Tool Abreviations BW = Brainwriting, Vote = Voting, Rank = Ranking, Rate = Rating, Score = Multicriteria Scoring.

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GSS Technology

The GSS for the experiment, VisionQuest™ from Collaborative Technologies, was a commercially available software package. It was selected for its flexibility in manipulating the level 1 and level 2 configurations. The Brainwriting, Voting, Ranking, Rating, Scoring, and Noncomputer-based (i.e., an agenda item with directions for a verbal activity such as discussion) tools were used in this experiment. All groups were trained in how to use the GSS tools and practiced using them. During the sessions, a chauffeur or technical facilitator enabled and disabled the sequenced GSS tools for the level 2 configuration groups and activated any tool which was requested by the level 1 configuration groups.

Subjects

The subjects were students enrolled in an introductory business school computer course at a large state university in the United States. Participation in an experiment was one way to complete a course requirement. Pilot testing of ten groups demonstrated that the students possessed sufficient domain knowledge, understanding, and motivation to perform the research task.

Four hundred and eighty subjects participated in 96 five member, ad hoc groups. A group size of five was selected to match the number of roles in the SOB task and because groups of this size have been sufficiently large enough to benefit from the parallelism and process support in GSSs (Nunamaker et al. 1991). Each group participated only one time. Separate chi-square tests were conducted for academic standing, gender, age, and major to check for possible demographic differences among the treatment groups. The results of these tests found no demographic differences between the treatments. Additional subject motivation included gift certificates to a favorite local restaurant for the groups that reached the best decisions.

Procedures

Subjects were recruited and randomly assigned to a group. These groups were randomly assigned to one of the eight treatments. The experimental procedures varied depending on the treatment to which a group was assigned. All instructions to the groups throughout the study followed a written script. The subjects reported to the behavioral lab at their appointed time and read a brief orientation to the experiment. The researcher answered any questions and then distributed the task. The five roles in the task were randomly assigned to the participants. The subjects had 10 minutes to individually read the task. All subjects received the handout introducing the heuristic and read through it. Subjects who were in treatments with high training additionally worked through a training case using the heuristic with a flip chart (no technology). Subjects who were in treatments with only introductory (low) training did not practice using the heuristic. The researcher answered any questions regarding how to use the heuristic.

Following either the high or low heuristic training, the groups moved to an adjacent cluster of personal computers (PCs). All groups received the a second version of the heuristic handout which added the name of a specific GSS tool beside each of the heuristic's activities (e.g., generate ideas was linked to the Brainwriting tool). The GSS tool familiarization was designed to convey operational keystrokes and the function of the GSS tool (i.e., to rank order a list of ideas). Tool familiarization was careful not to replicate the sequences mandated by the heuristic nor the agenda presentation of a level 2 system. The researcher paused for questions and answers after each tool.

The subjects then reread the case. The researcher then directed each group member to introduce his or her role in the SOB task to the others and this information was recorded on a chalkboard. This process served to set the tone for the meeting and to remind the group of their varied perspectives on the case. The group was instructed that they would have up to 55 minutes to use the heuristic to reach a group decision. The instructions to the group members stressed that their objective was to use the heuristic to reach a group recommendation and to write this recommendation on a reply memo.

The groups began to solve the case and received guidance and process restrictiveness from the various sources associated with each treatment. The researcher served as the system chauffeur for all groups and answered questions related to using the GSS. He did not give any process advice nor guidance. After the group had completed its reply memo, the subjects were debriefed, thanked for participating in the experiment, and dismissed. The entire experimental session usually lasted between 135 and 150 minutes.

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Dependent Variables

Faithful and unfaithful appropriations of the heuristic's activity and sequence structures were assessed by transcribing and analyzing a large random sample of the GSS transcripts and the researcher's lab notes. The random sample for coding consisted of 50% of the groups from each of the eight treatments (48 groups). The GSS transcripts listed the tools in sequence that were used by each group and the content of communication entered into the GSS. The lab notes recorded the beginning and ending time for each GSS tool and general real-time observations regarding what the group was doing. The coding scheme constructed a map of the group's decision process that included each activity in which the group engaged (e.g., voting, discussion, etc.), the sequence of activities, and the outcomes of GSS tool usage (e.g., number of ideas generated, tabulations of voting, ranking, etc.). These maps were compared to the activity and sequence structures prescribed by the heuristic to derive two measures of appropriation: *faithful uses* and *unfaithful uses* (Table 1). It should be noted that we used a narrower definition of faithful appropriation than advanced by DeSanctis and Poole (1994). Whereas they would see the choice of *any* voting tool to be faithful with the spirit of the heuristic or technology, here we view choices of tools that differ from the heuristic to be unfaithful. While various preference elicitation methods may yield similar outcomes, each type of method has certain advantages (e.g., point allocations express magnitude and allow ties where ranking does not) that may be important to the goals of a particular heuristic.

Decision quality was measured by scoring the groups' solutions on the two decision quality indices of the SOB task. Two coders, who were blind to both the hypotheses and treatments of the experiment, independently read each group's solution memo and identified the actionable solutions (i.e., a policy suggestion or mandate that could be implemented irrespective of quality or feasibility). These solutions were matched to the 289 known solutions from the SOB Policy Task Manual. The coders met and reconciled any coding disagreements. Thirty-seven new solutions were added to the SOB task and were scored in the same manner as the original 289 (see Wheeler and Mennecke 1992 for a description of the multi-criteria scoring procedures).

Table 1 Measures of Heuristic Appropriation Moves

Heuristic Structures	Faithful Appropriation Moves	Unfaithful Appropriation Moves
Activities	+ Using a prescribed activity	+ Using a novel activity, + Omitting a specified activity
Sequence	+ Using the next prescribed activity	+ Using an activity other than the next prescribed activity
	= Faithful Uses	= Unfaithful Uses

Note. Novel activities counted activities that were not part of the heuristic (e g , ranking the list of solutions, or choosing to invoke a round-robin verbal idea generating activity), whereas *omitted a specified activity* counted the number of prescribed activities that were not used during a group's decision process.

Each solution to the SOB task is scored on two indices. The first index assesses the degree to which a solution solves the multiple problems in the case on a scale of 0 to 100. A second and separate index scores the extent to which a solution is feasible within the multiple constraints of the case (also on a 0 to 100 scale). The two indices were added to produce a single measure of quality. Many groups' solution memos contained multiple, actionable solutions in the form of compound sentences. The decision quality score represented the average when multiple solutions were listed (range 1–6, average 2.1).

Manipulation Checks

Since the physical presence or absence of a facilitator can be taken at face value, the manipulation concern becomes the consistency of behavior from the facilitator for all facilitated groups. The facilitator was given very specific instructions about how and when to interject process restrictive comments. A single facilitator was used for all groups and the researcher monitored the consistency of his comments to the groups. The manipulation for GSS configuration was also self-evident with the level 1 groups receiving no on-screen agenda (almost blank screen) and free to engage any tool and the level 2 groups unable to alter the selection or sequence of tools from the on-screen agenda. Since the intent of training was to cognitively increase the subjects' under-

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standing of the heuristic, assessment of the manipulation was based on the subjects' displayed behaviors in actually using the heuristic. Both trained and untrained groups were equally free to fully follow, abandon, or partially use the heuristic. Groups with high training did follow the heuristic more closely than groups with low training (statistical tests are reported with H1c below). Additionally, the baseline and training only conditions represented an opportunity to assess the effect of training on faithful and unfaithful appropriation without the influence of other appropriation mediators. *T*-tests confirmed that trained groups exhibited more faithful appropriation moves and fewer unfaithful moves than did untrained groups ($p = 0.034$, $p = 0.005$, respectively). Thus, the manipulation is believed to have successfully created two different groups in relation to their familiarity with and ability to use the heuristic.

Results

Descriptive statistics and hypotheses testing are reported below.

Proposition 1: Mediators Increase Faithful Use

Proposition 1 and its derivative hypotheses predicted that the presence of one or more appropriation mediator sources would increase faithful use of a heuristic's activities and sequences structures. As one would expect, there was a significant negative correlation between faithful and unfaithful uses.[7] Therefore, both appropriation moves variables were included in a three level, factorial design MANOVA. Table 2 presents the means and standard deviations for all dependent variables and Table 3 summarizes the significant MANOVA effects for the use of heuristics tests.

There were two significant, two-way interactions. Facilitation and GSS configuration interacted ($F(2, 39) = 4.88$, $p = 0.013$) for both variables. Post-hoc comparisons using Tukey's Honestly Significant Difference test revealed that groups with facilitation, a level 2 GSS, or both of these had significantly more faithful uses than unfacilitated groups with a level 1 GSS. Similarly, unfacilitated groups with a level 1 GSS had significantly more unfaithful uses than those groups with either or both mediators. Facilitation also interacted with training ($F(2, 39) = 5.605$, $p = 0.007$), though only for the unfaithful measure. The Tukey test found that unfacilitated and low training groups had significantly more unfaithful uses than those with facilitation, high training, or both mediators. Additionally, groups with high training had significantly more unfaithful uses than those with both training and facilitation.

Table 2 Means (Std. Deviations) for Dependent Measures

Appropriation Mediators in Treatment	Faithful Moves	Unfaithful Moves	Decision Quality
Baseline (none)	4.00 (2.53)	19.67 (5.16)	145.37 (9.52)
Training Only	7.67 (2.66)	11.17 (2.64)	133.38 (19.49)
Facilitation Only	17.67 (6.50)	2.50 (2.26)	148.18 (11.93)
Level 2 GSS Config. Only	12.67 (9.00)	9.17 (8.91)	136.50 (20.63)
Facilitation + Training	20.00 (2.53)	1.83 (1.47)	144.92 (22.62)
Facilitation + Level 2 GSS	18.30 (7.42)	2.33 (3.01)	145.04 (21.07)
Training + Level 2 GSS	16.67 (6.77)	4.00 (5.06)	143.58 (13.95)
All Three Mediators	21.67 (1.97)	0.33 (0.82)	155.11 (23.32)

There were multivariate main effects for facilitation ($F(2, 39) = 25.871$, $p = 0.000$), GSS configuration ($F(2, 39) = 7.027$, $p = 0.002$), and training ($F(2, 39) = 5.523$, $p = 0.008$). In each case, the presence of the mediator increased faithful uses of the heuristic's activities and sequence structures and reduced the number of unfaithful uses. These findings provide support for hypotheses H1a, H1b, and H1c.

While the previous two-way interactions reported with the full factorial model lend some support for H1d, planned comparisons were used to test the hypotheses that mediator effects are additive subject to the recognition that active mediators are expected to be more effective than passive mediators. The planned comparisons contrasted the single active mediator treatment of facilitation with both the single and dual passive mediator treatments (i.e., level 2 GSS, training, or both) and found significant effects for both faithful use ($t(40) = -2.032$, $p = 0.049$) and unfaithful use ($t(40) = 2.699$, $p = 0.01$) in the expected direction. These findings provide support for H1d.

[7] Given n number of heuristic use appropriation moves during a particular group's decision process, each use is *either* faithful or unfaithful. Thus, as the number of faithful moves increases the number of unfaithful moves decreases and vice-versa

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Table 3 MANOVA Significant Effects for Heuristic Use

Type	Source	Variable	Univariate $F(1,40)$	Univariate Signif.
Main Effects	Facilitator	Faithful	32.527	0.000
		Unfaithful	52.79	0.000
	GSS Configuration	Faithful	9.677	0.003
		Unfaithful	14.413	0.000
	Training	Faithful	4.301	0.045
		Unfaithful	10.287	0.003
	Facilitator × GSS Configuration	Faithful	5.688	0.022
2-Way Interactions		Unfaithful	9.872	0.003
	Facilitator × Training	Unfaithful	4.67	0.037

H1e was also tested with planned comparisons which contrasted the dual mediator treatments involving facilitation and one or more other mediators (i.e., facilitation and level 2 GSS, training, or all three) with the single or dual passive mediator treatments (i.e., level 2 GSS, training, or both). There were significant effects for both faithful use ($t(40) = -4.131$, $p = 0.00$) and unfaithful use ($t(40) = 4.497$, $p = 0.00$) in the expected direction. H1e is also supported. Thus, the five supported hypotheses give substantial support for proposition one.

Proposition 2: Use Improves Decision Quality

Proposition 2 and its hypotheses expected that faithful use would be positively related to decision quality and that unfaithful use would be negatively related to decision quality. The hypotheses were tested by partitioning the data into three groups based on the mean of the faithful use score plus or minus one standard deviation (14.8 ± 7.8). A t-test of decision quality was conducted between the groups with the higher and lower faithful appropriation scores. The test supported the idea that groups with more faithful appropriation moves did in fact have higher decision quality ($t(22) = -2.46$, $p = 0.022$). The same procedure was used to partition the unfaithful scores (mean $= 6.83 \pm 7.4$) into three groups. Again, a t-test of decision quality demonstrated that groups with more unfaithful appropriations had lower decision quality than those with fewer unfaithful appropriations ($t(22) = 2.2$, $p = 0.038$). These results give statistical support for H2a, H2b, and Proposition 2.

Discussion

This research conducted an experiment for the purpose of assessing the predictive ability of a new theory, PRAST, that was drawn from the social-technical theoretical perspective. Specific hypotheses for the theory were advanced. A discussion of the experimental results for each proposition and the implications of these results are presented below. This is followed by a reflection on each type of appropriation mediator and the additive effects of multiple mediators.

Proposition 1: Mediators Increase Faithful Use

The proposition that the presence of an appropriation mediator(s) should increase groups' faithful use of heuristics is clearly supported. The main effects and two-way interactions demonstrate that appropriation mediators effectively increase faithful use and reduce unfaithful use in relation to heuristic's activities and sequences. It is also clear that the three appropriation mediators vary in their efficacy to influence faithful appropriation.

Facilitation had the largest effect of the three mediators and it had significant interactions with the other two. This is particularly interesting given the relatively *weak* form of facilitation used in this experiment. The type of facilitation common in organizational settings involves an adaptive response to a group's emerging needs. Clawson et al. (1993) surveyed organizations and identified the three most important dimensions for facilitation as planning the meeting; listening to, clarifying, and integrating information; and demonstrating

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flexibility. In this experiment the subjects likely attributed planning the meeting to the facilitator, but he clearly did not engage in Clawson's other two dimensions. Anson et al. (1995) doubted the effectiveness of scripted facilitation as used in some prior research and argued that adaptive facilitation is necessary to reap facilitation's benefits. In contrast, our research found that facilitation that is somewhat better than a scripted approach, but much less capable than an adaptive approach, can be effective at increasing faithful use of a heuristic.

As theorized in the model, a facilitator's ability to actively monitor and act in all three communication modes is believed to be the best explanation for these results. The guidance provided by the facilitator was largely reading the heuristic instructions to the group at the beginning of each activity—the very same printed instructions that each group member had in front of him or her. Process restrictiveness was also provided through verbal interventions. Since group interaction involves collective procedural choices, most of a group's procedural dimension choices were deliberated via the verbal communication mode. Thus, with facilitation there was a congruence between the mode of group procedural choice and the mode where the guidance and process restrictiveness were delivered.

To a relatively lesser degree, both the GSS configuration and high training also improved faithful use. Both of these appropriation mediators operated in different communication modes than the procedural deliberations of the group. For example, the level 2 GSS provided a passive form of guidance though on-screen activity instructions (same as the printed heuristic) as the first screen for each tool. Sequence was visible in the on-screen agenda which listed the previous, current (in bold), and future activities. Like the printed heuristic itself, these were passive directions that operated in a different communication mode from a group's verbal discussions of procedural choices. Similarly, training also was entirely passive and had to be recalled from memory to influence a group's procedural choices. We believe it was the active nature of facilitation versus the passive nature of GSS configuration and training that accounted for the larger effect for facilitation. In fact, the researchers observed that the printed heuristic (available to all groups), the level 2 GSS, or high training often influenced the group's procedural choices only after a group member *verbally* read the instructions or specifically recalled and then verbalized some aspect of the training. In sum, this evidence confirms that meeting designers can manipulate appropriation mediators to increase faithful use of heuristics. The effects of combining multiple mediators are discussed below.

Proposition 2: Use Improves Decision Quality

Heuristics have been designed to help groups overcome limitations in human information processing or to avoid communication processes which tend to impede information sharing and critical thinking. While a deterministic relationship between heuristic use and decision effectiveness would ignore too many other important group variables (e.g., task difficulty, group capabilities), the bulk of prior research does support a relationship—though not causality—between heuristic availability and decision quality. Through the use of appropriation mediators, we expected the current experiment to provide new insight regarding the relationship between measured heuristic use and decision quality. Partitioning the groups based on their degree of faithful or unfaithful appropriation demonstrated that greater faithful heuristic use did yield higher decision quality. Similarly, groups with frequent unfaithful appropriations of the heuristic had lower decision effectiveness. Thus, the proposition that faithful use of a heuristic improves decision quality is supported. Groups that used the activities and sequence structures of the heuristic made better decisions than those that did not. Likewise, groups that frequently deviated from the prescribed activities and sequences in the heuristic (i.e., unfaithful appropriation) had lower quality decisions than groups with fewer deviations.

Other Explanations

A rival explanation for these results could be asserted from the contingency-deterministic theoretical perspective. This perspective would argue that the *presence* of input factors, such as facilitation, GSS configuration, and training, would improve decision quality. Such a view assumes that presence of an input factor can be equated with use. Therefore, one would expect to find significant main and possibly interaction effects on decision quality between the input factors without respect to measured appropriation. To test this assertion, we

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conducted a supplemental analysis that examined decision quality for all 96 groups in a three-level factorial ANOVA design. There were no significant effects at the 0.05 level.[8] Thus, in this experiment we find no support for the contingency-deterministic perspective that meeting inputs can, in and of themselves, be used to engineer quality group decisions (i.e., one important meeting outcome).

Limitations

Research design choices for this experiment may have also influenced these results. There are important differences between the current and prior research in terms of the task, heuristic, and context of using the heuristic. The hidden-profile task was created to induce some of the task complexity that is common in organizational settings and for which heuristics are advocated. Rather than beginning with a stated problem, as is common in many prior laboratory group tasks, there were multiple problems with a variety of confirming and refuting evidence presented in text and tables among the five unique roles. The task contained number of political and resource constraints (known only to each particular role until that subject shared it with the group) that bounded the feasible solutions to the problem. We also point out that the familiar context of the task for business school students allowed them to bring their own personal perspectives to bear on the group's deliberations. Like in real organizational settings, such perspectives could be noise to cloud the factual data available in the task. Thus, the task is both complex and communication-intensive, which may have made it especially suitable to a structured heuristic.

As listed in Figure 2, the heuristic was design to promote divergent periods of idea generation and information sharing and convergent periods toward consensus around five goals. This heuristic is more comprehensive than many used in prior research (i.e., has more steps to address the problem diagnosis, criteria and solution development, and selection than other heuristics; DeSanctis et al. 1989). This comprehensiveness required the subjects to use five different GSS tools with their work being passed between the tools. There were periods of GSS use and periods of verbal interaction. Thus, the use of a variety of GSS tools and a mix of both electronic and verbal communication periods differs from some prior GSS research. It is possible that the task, heuristic, and context of use combined to create a situation where faithful use of the heuristic and GSS structures were especially efficacious. Finally, the manipulation of appropriation mediators for the purpose of restrictiveness and guidance differs from research that manipulated only the availability of a heuristic. Thus, these important differences in research design should be considered when interpreting these results and making comparisons to other research.

While the controls and experimental procedures were designed to control for rival explanations, we cannot completely rule out the possibility that subject expertise with regard to the SOB task or other individual differences were disproportionately represented in the statistically significant treatments. We did not assess subject skill level with this task prior to random assignment, thus it is possible that varying skills with the task concentrated in some treatments and could be a rival explanation for the results. This concern is tempered by the fact that there were no demographic differences between treatments regarding academic standing, age, gender or major.

There are obvious limitations to generalizations from this research. This experiment employed ad hoc groups which were engaged in making a decision with no direct consequence to them. While the students appeared to understand the task and to actively participate, they are not typical of organizational decision makers. Furthermore, these students were novice users of this technology and this particular heuristic. As recognized in AST, additional experience with structures will likely influence the skill with which they are appropriated during a group decision process. By strict interpretation, the implications from this experiment should be limited to decisions made by technology-supported groups using some form of a heuristic. Our experience with many real, organizational groups, however, suggests that the lessons from these results are more applicable than strict interpretation would allow.

[8] To ensure consistency with the coded subset of data used to test P1 and P2, the same statistical tests were conducted on the 48-group random subsample used for testing the previous hypotheses. This test also found no statistical support for the contingency-deterministic explanation.

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Appropriation Mediators

PRAST theorized the relationship between appropriation mediators and procedural dimensions in terms of their ability to provide guidance or process restrictiveness. In terms of improving faithful use, passive appropriation mediators appear to meet the threshold for influencing groups' procedural choices.

We believe the level 2 GSS, as a passive appropriation mediator, was effective in increasing faithful appropriation by providing *procedural focus* for a group's activities conducted in the computer-mediated mode. It effectively restricted the sequence of access to the tools for the computer-mediated mode, but was ineffectual in restricting the content of the activities and philosophy of the heuristic in either the verbal or computer-mediated mode. This may account for its effect on faithful use of the heuristic's structures (H1b) and lack of a direct effect for decision quality (as was tested in the supplementary analysis). Thus, as a passive appropriation mediator, GSS configuration contributed to improving faithful choices in the electronic communication mode that it could affect.

Likewise, training also increased faithful use (H1c). Trained subjects practiced using the activities, sequences, and philosophical structures of the heuristic with the goal of activating self-directed guidance and process restrictiveness. As with the other appropriation mediators, the intent was to bias a group's selection of appropriation moves to favor those consistent with the heuristic. The training approach used in this experiment appeared to create an *awareness* of a group's procedural choices for selecting the activities and sequences advocated by the heuristic. The supplemental analysis, however, found no support for a direct effect between training and better decisions. As the other passive appropriation mediator, training appeared to be less effective than the level 2 GSS configuration at improving faithful appropriation.

It is also worthwhile to note that the faithful and unfaithful moves scores (Table 2) for both passive mediators are in a middle range between the baseline and multiple mediator treatments. Thus, we speculate that these passive mediators alone may have left the group in a most undesirable middle ground. These groups were caught between sufficient restrictiveness and guidance to preclude their abandonment of the heuristic for alternate decision processes and insufficient restrictiveness and guidance to adequately bias their appropriation choices.

In contrast to the passive appropriation mediators, facilitation was an active appropriation mediator that both increased faithful appropriation and reduced unfaithful appropriation. Facilitation was the only single source capable of restricting the activities and sequences of the heuristic in a consistent manner across all communication modes and therefore had the greatest influence on the group's procedural dimension choices. The results from facilitation in this experiment confirm the conventional wisdom that facilitation improves group processes (and ultimately outcomes), but quite surprisingly, runs counter to other empirical investigations of facilitation. Three prior empirical studies have employed various forms of facilitation (e.g., scripted, adaptive) in GSS environments and all failed to find strong evidence that facilitation improved decision quality (Dickson et al. 1993, George et al. 1992, Anson et al. 1995). There are numerous differences between these experiments which preclude direct comparison, but we argue that facilitation's strong effect on the variables of faithful and unfaithful appropriation gives new insight as to how facilitation can actually influence group outcomes.

We see two strong features of facilitation that likely explain its efficacy. The first is the facilitator's role to *discern* in real time the congruence of a group's procedural choices relative to the prescribed structures in a heuristic. A facilitator can then apply his or her skills in deciding whether or not to interject a process restrictiveness or guidance comment. Group members who are burdened with the content obligations of the discussion have fewer mental resources available for contributing to a group's decision process. Furthermore, group members are usually less skilled at process facilitation than a nongroup member who has been trained for the facilitation process. The second, again, is that both the facilitator's guidance or process restrictiveness comments and the group's procedural deliberations occurred in the same (verbal) communication mode.

Multiple Appropriation Mediators

As expected, the active mediator of facilitation alone or in combination with other mediators was more effective

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at promoting faithful use and reducing unfaithful use than any single or combination of passive mediators. We view this as confirming evidence that all mediators are not created equal and that active mediators have greater ability to affect a group's decision process than do passive mediators. As depicted in Figure 1, this points to the role of communication modes as a key issue in the relationship between appropriation mediators and group's procedural dimension choices. While additivity among the mediators did increase faithful and decrease faithful appropriation moves, the supplementary analysis found no evidence that more input factors (e.g., facilitation and a level 2 GSS) could improve decision quality. This is consistent with the decision quality findings of Anson et al. (1995).

Thus, when choosing among appropriation mediators, one conclusion is clear: choose an active mediator whenever possible since it did the best for promoting faithful use. The costs of providing additional appropriation mediators, however, must be carefully considered relative to their marginal contributions. While not part of the formal hypothesis testing, it appears that the combination of two passive mediators (high training and a level 2 GSS) is the best second choice to an active mediator (see Table 2). Thus, if cost or implementation issues require the use of passive mediators then multiple sources are advantageous in promoting faithful use which was related to higher decision quality in this experiment.

Social-technical Theories

The evidence from this experiment sheds new light on the problem of contradictory findings in GSS research (Dennis and Gallupe 1993). Much of that research has been designed in the contingency-deterministic theoretical tradition that attempted to engineer group outcomes by manipulating input factors. Our supplementary analysis did not find any support for this perspective.

In contrast, PRAST draws on the social-technical theoretical perspective to recognize that groups make choices regarding their use of social structures (e.g., GSSs, heuristics) and may choose to use them in a manner which differs from a structure's intended purpose. PRAST is a specific instantiation of DeSanctis and Poole's (1994) AST. It predicts how appropriation mediators can be used to bias a group's interaction process toward faithful use of the social structures. The significant role of the faithful use variable supports Sambamurthy and Poole's (1992) assertion that contradictions in prior GSS research should be investigated by including mediating variables in process-level analyses (p. 247).

While the evidence here supports the idea that appropriation mediators increase faithful use of heuristics and that faithful use improves decision quality, it also demonstrates that an absence of these effects is *not* a deterministic impediment to reaching quality decisions. The curious relationship between decision processes and decision quality is illustrated in the following account of how one of the baseline groups conducted its decision process—recall that the baseline groups were free to fully use, partially use, or ignore the heuristic and GSS.

> The group requested the following sequence of GSS tools Brainwriting, Voting, Brainwriting, Voting, Rating, and Ranking (compare this to the heuristic in Figure 2) The first Brainwriting transcript reveals that the subjects began the decision process by considering possible solutions All 25 entries in the Brainwriting transcript were proposed solutions. The researcher's notes recorded that the group spent five minutes generating these solutions and then 10 minutes verbally discussing them They voted on each idea (a binary yes or no vote) and then spent 15 minutes discussing the vote The notes commented that it was a "very vigilant discussion" with some members correcting assertions by other members The group then spent about six minutes in a procedural discussion regarding what to do next They requested a second Brainwriting tool, but directed each person to verbally share their ideas while one person was designated as the group's scribe to enter these ideas in the second Brainwriting tool Two solutions and the word "faculty" were entered. The group requested a second Voting tool, but did not use it They requested a Rating tool, but canceled the request before the chauffeur activated it The group finally used the Ranking tool to rank the three entries from the second Brainwriting tool They ranked, viewed, and discussed the results, and then ranked again.

This group did not explicitly engage in problem definition, in criteria definition, or in comparing potential solutions to predetermined criteria as prescribed by the heuristic. The challenge to GSS researchers is in understanding how this group's decision process ultimately yielded one of the best solutions in the list and placed the group among the top ten groups based on decision

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quality. Clearly, this decision was not a product of following the heuristic nor of faithfully using the GSS tools. In fact, the group's decision process was almost the *antithesis* of the activity and sequence structures advocated by the heuristic and enabled by the GSS.

Conclusion

Implications for Research

From the social-technical perspective of PRAST, the three appropriation mediators operated as anticipated and improved faithful appropriation of heuristics. In reviewing prior research on heuristics and decision quality, we questioned the relationship between heuristic availability, actual use, and decision quality. In this experiment, we demonstrated that appropriation mediators can improve faithful use and that use can improve decision quality. We believe that while the appropriation mediators were effective in guiding groups down well structured decision paths for making decisions (e.g., agree on the problem, select criteria, choose a solution) and restricting them away from known group pitfalls (e.g., solution-focus, ignoring decision criteria), the means of *doing the heuristic right* (i.e., activities and sequences) may sometimes overwhelm the intended process improvements of *doing the right things* (i.e., vigilant information processing and critical thinking; see Hirokawa and Rost 1992, Gouran and Hirokawa 1983 for a discussion of vigilance in decision-making groups). Thus, future GSS research would likely benefit from a more holistic approach to the six procedural dimensions rather than focusing solely on activities and sequences.

Adaptive facilitation that addresses the substantive, procedural, and relational obstacles encountered by groups (Hirokawa and Gouran 1989) would likely increase the strength of the facilitator effect (see Anson et al. 1995 as one example). But providing skilled facilitators can be expensive, impractical for ad-hoc meetings, and difficult for different time or different place meetings. Current GSSs provide efficient task and process support for the information exchange process (Nunamaker et al. 1991) and provide valuable tools in the hands of skilled meeting designers. But the fact of modern organizational life is that many decision-oriented meetings are ad-hoc and will not have the luxury of skilled design. Therefore, GSS researchers should consider how GSSs can move beyond providing *process support* structures to *process enabling cues* to promote vigilance in information processing. One example would be embedding facilitation-like expertise into the system itself. At present, we are likely many years away from machine intelligence capable of reproducing and applying the expertise of a skilled facilitator. The results from this experiment, however, point out that even a weak and relatively structured form of facilitation can have positive effects on both heuristic use and decision quality.

Just as Connolly et al. (1990) argued for GSS designers to include an "electronic carper" to "inject a hostile comment or critical question whenever it detected some number of consecutive agreements" (p. 701), future GSSs with multimedia workstations might include audio messages that replicate the guidance and process restrictiveness comments from a facilitator. For example, switches in a GSS idea-generating tool might inform the GSS of the intended purpose for the activity such as generating statements of the problem or proposing actionable solutions. The GSS could periodically make announcements such as "remember to propose your ideas as statements of the problem" or "remember to link your solutions to the problem statement." These messages could be triggered via simple timers or more sophisticated algorithms which respond to the pace of new ideas being entered or which recognize specific words as cues for certain comments. Another switch might turn off the audio and direct these comments to a textual window on each participant's screen, though the results of this experiment more strongly support the effects of active audio versus passive on-screen text.

As specified in the model (Figure 1), we believe that the appropriation mediators work through the forces of guidance and process restrictiveness to inform and constrain groups' procedural choices. Future research could also include measurements of perceived guidance and perceived process restrictiveness to help discern how these forces shape groups' procedural choices. Other sources of social structures in the AST model might also be identified and tested as possible appropriation mediators of faithful use.

Hidden-profile tasks are useful for simulating some real types of organizational decision-making

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meetings. Other types of tasks, for example where most information is commonly known to all group members, will likely have different communication requirements. Future research on other types of tasks may yield a different efficacy for each of the appropriation mediators.

Implications for Practice

While the relationship between heuristics and decision quality is not deterministic, evidence from prior research attests to their ability to help groups avoid common decision making pitfalls (see Van Gundy 1988 for a review). When meeting designers plan a meeting, they can know that the use a level 2 GSS, training, or especially facilitation can help the group faithfully use and minimize unfaithful use of a chosen heuristic. Meeting planners should plan for addressing the full range of procedural dimensions as they design a meeting. Meeting designers should be consciously aware of the multiple communication modes in which groups exchange information and not limit their designs by primarily thinking about only one of the communication modes. Finally, meeting designers should also be aware of how prior group or organizational norms may be a powerful, though less visible, source of guidance and process restrictiveness as groups make choices among the six procedural dimensions.

PRAST, with its focus on appropriation mediators, did predict directed improvement in decision quality through faithful use. Future investigations of the role of process restrictiveness and guidance may give new insights regarding how GSS can help to directively improve group decision making. Future research on technology support for group decision making may also benefit from other process-oriented theoretical lenses such as vigilance (Gouran 1982) or sensemaking (Weick and Meader 1993).

If the goal is to directively improve the use of heuristics and their positive effect on decision quality, facilitation—even the weak form of facilitation used in this experiment—is without a challenger. We must continue to refine our theories of technology-supported group decision-making as we further untangle how the forces of guidance and process restrictiveness, appropriation mediators, heuristic structures, and communication modes interact to impede and promote directed change in group decision-making activities.

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