COGNITIVE CONVERGENCE IN DEVELOPING GROUPS:
THE ROLE OF SOCIOCOGNITIVE ELABORATION

DISSERTATION

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By

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ABSTRACT

As managers increasingly rely on ad hoc groups to make and implement strategic decisions, understanding the development of group cognition becomes crucial. This paper develops a novel framework for understanding cognitive convergence, or the emergence of cognitive structure similarity, among members of newly formed strategic decision/implementation groups. A true experimental design was used to examine motivational factors in cognitive convergence during group intellective work. Newly formed groups solved a strategic decision problem under one of three accountability conditions. In the Recall condition, each member was told they would later be responsible for recalling their group's solution. In the Justification condition, members were additionally charged with justifying that solution. The control condition was a no-accountability baseline. Graph-theoretic network representations of participants' cognitive structures
relative to the strategic problem were derived both before and after group discussion.

Both accountability conditions increased the effort expended by groups in solving the strategic problem. As predicted, only the Justification requirement resulted in an increased exchange of ideas during group discussion. When group discussion was over, groups in the Justification condition exhibited greater cognitive convergence than those in the other two conditions. Their latent knowledge structures were objectively more similar, and they also reported a greater subjective common ground than did groups in either the Recall or Control conditions. In ancillary analyses, these converged structures exhibited more coherence than those in the other conditions. Direct implications for theory, research and practice are discussed.
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INTRODUCTION AND OVERVIEW

The formal study of groups in organizations dates back a half-century (Shea & Guzzo, 1993). Today, the interest in groups appears to be growing more rapidly than ever before, as organizations rely on project teams, focus groups, autonomous work groups, quality circles, multifunction work teams, and even team CEO's. Where individual performance was once of primary interest, teams now dominate the concerns of industry (Thurrow, 1983). For over a decade now, prominent figures such as Peters and Waterman (1982) have argued that "small groups are, quite simply, the building blocks of excellent companies" (p. 126). Incentives for understanding the nature of groups and teamwork increase with the popular emphasis on groups as an organizational vehicle. Organizational theorists implicate the development of cognitive similarity among group members.
as a key factor in group effectiveness, but this phenomenon has seldom or never been studied directly (see Klimoski & Mohammed, 1994, for review).

In this paper, cognitive similarity among members of groups and teams is considered as a product of group interaction. The discussion proceeds as follows. First, the supposed role of shared cognitive structures in group and team functioning is reviewed with examples. Then a theoretical platform for understanding cognitive convergence, or the emergence of similarity in cognitive structures among group members, is developed. The paper reports the methods and results of a study of motivational factors in cognitive convergence among members of developing groups. Discussion concludes with implications for theory, research, and practice.

Group Process and Product

Contemporary general models of group performance have their roots in Steiner's (1972) integration of much previous social psychological work on group effectiveness. Steiner (1972) modeled actual group productivity as the group's potential productivity minus losses due to faults in group
process. Group process refers to all behaviors occurring in a goal-oriented group, including both task-oriented and socio-emotional behaviors. Certain attributes of group process act to prevent the optimal combination of a group's resources for task accomplishment. Steiner's (1972) theoretical work provides the conceptual foundation for most organizationally-relevant research on groups since its inception (Guzzo & Shea, 1993). Discussion will show that cognitive similarity can be modeled as an output of group process, which varies according to the motivational states of group members. Studying the process by which groups accomplish cognitive convergence will enable future research on group cognition. The view of groups as information processors has an interesting literary history, which has recently resurged.

The Notion of Group Mentality

Much of the recent theorizing among group researchers consists of recognizing psychological constructs which have been traditionally considered at the individual level of analysis as group-level phenomena (Klimoski & Mohammed, 1994). Examples of "groupified" constructs include group
affect (George, 1990), collective efficacy (Bandura, 1986; Shea & Guzzo, 1993), transactive memory systems (Wegner, 1987), and group-level integrative complexity (Gruenfeld & Hollingshead, 1993). At the most basic level is the notion of group mind (McDougall, 1920).

The notion of group mind has enjoyed widespread popularity since the rise of social science (e.g., Durkheim, 1938; Fleck, 1935; McDougall, 1920). Objections to the concept parallel more general objections to defining groups as the level of analysis (e.g., Allport, 1925). The present discussion will avoid bogging the reader down in arguments regarding the ontological status of the group-level constructs.

However, it seems necessary to take a position on this issue on which to base the remainder of the discussion. Suffice it to echo that experimental practices designed to meet the assumptions of individualism in psychology have resulted in "a disembodied theory of cognition" which ignores the dependence of reasoning on the structure and dynamics of the environment (Norman, 1990). Computation in the field is not bounded by the cranium, but rather occurs
widely in open systems of people, artifacts, and organizations. The position taken here recognizes individual boundaries, but rejects the implicit assumption that computational and affective states exist only at the individual level (cf. Wilson, 1994). Further, the notion of group mind implies something beyond simple contagion of affect or computational states. Synergistic interactions between individual cognitions produce a *sociocognitive* phenomenon in groups "that exists in and along with the separate minds of the members, and over and above any sum of those minds created by mere addition" (McDougall, 1920).

The next few sections explain the importance of studying the development of shared cognition among group members. Discussion begins with a brief review of recent developments in the study of group-level cognition, with an emphasis on shared cognitive structures. It then develops a perspective on "group mind" in general, and shared cognitive structures in particular, as products of the interactions between group members based on theoretical work by Klimoski and Mohammed (1994). This will set the stage for an
experimental study on motivational aspects of cognitive convergence.
CHAPTER 2

GROUP COGNITION IN ORGANIZATION SCIENCE

In modern information-processing terms, group mind actually refers to the idea that groups of people can retain and process information in a way that transcends the cognitive facilities of individuals (cf. Klimoski & Mohammed, 1994). Research interest in the notion of cognition at the group level of analysis appears to have recently resurfaced. However, unless conceptual and methodological issues are resolved under an overarching framework for integrating views from diverse disciplines, another historic disintegration of research on group-level psychology is likely to occur.

Klimoski and Mohammed (1994) recently reviewed the literature on group-level cognition, responding to the general lack of coherence both within and among approaches, in addition to a dearth of empirical substantiation of the
They bring diverse literatures to bear on a conceptual treatment of the content, form, function, antecedents, and consequences of a construct called the "team mental model."

Klimoski and Mohammed (1994) embed the team mental model in an explanatory framework which is a variant of the family of input-process-output models (c.f., Steiner, 1972) which have directed the mainstream of group performance research (Shea & Guzzo, 1993). Investigators are referred to Klimoski and Mohammed's (1994) theoretical integration as a launching pad for further study of group-level psychological phenomena. This paper is intended as an outgrowth of this program, extending it by illustrating some key points with examples, and by investigating how shared cognitive structures can develop as the product of motivated interaction among team members. The following sections explicate what is meant by shared cognitive structures, before moving on to discuss literature on the role of cognitive similarity in performance contexts.
Mental Models and Cognitive Structures

The mental model can be considered as the basic unit of group cognition. Models can take many forms, including physical models (e.g., plastic models of the DNA double helix), display-type models (e.g., blueprints), or mental models (e.g., the reader's conception of a spaceship described in a story). Generally speaking, mental models are structural cognitive representations of the environment and its expected behavior (Holyoak, 1984). They are hypothesized to exist in the minds of individuals. Concepts regarding mental models have been developed extensively by social/cognitive psychologists (Johnson-Laird, 1983; Rouse & Morris, 1986). Most refer to either organized cognitive structures, or sets of interrelated conceptual categories organized into hierarchies of inclusion/abstraction (e.g., Rosch, 1978; Brewer, 1988).

This research follows existing theory which defines mental models in terms of cognitive structures. For example, Cannon-Bowers, Salas, and Converse (1993) view mental models as knowledge that is organized into meaningful patterns. Mental models are composed of knowledge
structures which specify the relations between units or categories.

Relational knowledge structures are measurable. One procedure for eliciting knowledge structure data from participants is to gather their judgements of relatedness among key concepts in the referent content domain (Goldsmith, Johnson, & Acton, 1991). The resulting proximity ratings can be used to analyze or represent participants' knowledge structures. Structural representation are derived from proximity data using scaling algorithms such as Pathfinder (Schvaneveldt, Durso, & Dearholt, 1989).

Empirical examinations of individuals' cognitive structures reveal that they are subject to change, such as an increase in specification with experience in a given domain (McClure, 1990), or a restructuring of the relational network resulting from a profound insight (Durso, Rea, & Dayton, 1994). Direct confirmation of restructuring requires an independent measurement procedure for determining cognitive structure. For example, Durso, Rea, and Dayton (1994) derived graph theoretic representations
from judgements of concept relatedness made by participants who considered a riddle. They found evidence of cognitive restructuring following a profound insight into the riddle.

Obviously, knowledge structure changes at the individual level are necessary if cognitive convergence is to occur at the group level. Although cognitive convergence has seldom or never been studied directly, researchers in training evaluation are beginning to use structural measures in an intriguing manner (cf., Kraiger, Ford, and Salas 1993). Structural assessment of trainee knowledge is conducted by eliciting a matrix of relatedness ratings from the trainee, transforming the matrix using scaling algorithms (e.g., Pathfinder) to derive a structural representation, and comparing that representation to an expert representation (Goldsmith & Kraiger, 1993). Researchers using Pathfinder-based indices of trainees' structural similarity to expert representations find that similarity develops through training (Kraiger & Salas, 1993; Kraiger, 1993). In a related manner, it should be possible to operationalize cognitive convergence as the emergence of structural similarity between teammates or group members.
The pragmatic interest in cognitive convergence begins with the functions of individual cognitive structures.

**Functions of Individual Cognitive Structures**

Cognitive structures are of pragmatic interest because they function in ways directly relevant to performance. Fundamentally, cognitive structures are central to the sense making process. They provide the bases upon which a person relates knowledge, attributes meaning, and fashions understanding of the environment (Gioia, 1986). Cognitive structures underlie an individual's conceptual framework, which enables the individual to explain, describe, and predict the states of systems. They determine how a person will interpret information from the environment, acting as screens for filtering incoming stimuli, selecting important information, and then guiding inferences made from that information (Johnson-Laird, 1983).

Individuals in performance contexts employ their mental models to predict future events, to determine the causes of events, and to generate alternative courses of action and choose among them (Rouse & Morris, 1986). For example, according to Wellens (1993), cognitive structures stored in
long term memory are responsible for shaping the "situation awareness" of aircraft pilots as they generate hypotheses, assess risks, and take actions in the cockpit in response to incoming information.

Given the critical role that cognitive structures play in individual performance, questions arise as to their role in group performance. The team mental model construct (Klimoski & Mohammed, 1994) implies that the cognitive structures of individuals should interact in a way which supports effective information processing at the group level.

**Why Study Cognitive Convergence?**

The purpose of this section is to justify studying the development of cognitive similarity among members of decision/implementation groups. Accordingly, some of the more provocative literature on shared cognition will be briefly highlighted. A fundamental assumption is that there are functional consequences for cognitive similarity in group performance. The first subsection lays a conceptual foundation for the suggestion that shared cognition supports group work in both strategic decision making and in the team
dynamics/performance of implementation. The suggestion of benefits for cognitive similarity will justify a study on 1) how cognitive convergence occurs, and 2) how it can be experimentally induced. This basic research is intended to initiate a program of research geared toward scientific conclusions about the causal roles of shared cognition in group performance.

Functions of Shared Cognitive Structures

Just as the efficient functioning of any information-processing system depends on the compatibility of its components, the functioning of a group should depend on the congruity of the cognitive structures of its members. Just what is implied by congruity is an interesting question in itself, and one which has only recently been addressed in any formal theoretical treatment. Klimoski and Mohammed (1994) list three types of "sharing" of cognitive structures among team members. In a distributed configuration of cognitive representations, individuals posses complementary mental models with no overlap. In contrast, an identical configuration of cognitive structures means that each member has exactly the same structure as every other. Finally, an

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overlapping configuration of cognitive structures implies a mixture of commonality and distribution.

Which type of configuration is best probably depends on the requirements of the task, or more broadly, the performance requirements of the group's environment. Neither of the absolute configurations seems practical for most tasks, however. For instance, one could speculate that mutually exclusive distributions of task-relevant knowledge would result in a fragile functional system. If one member were to be unable to participate in a given performance cycle for whatever reason, the capacity associated with that member's knowledge would be lost. This would be an especially serious problem in conjunctive tasks, where each division of labor must be fulfilled in order for the group to achieve task completion. Identical distributions of knowledge, at the other extreme, would be associated with a lack of creativity and an inability of the group to adapt to turbulent environments.

Nevertheless, some sharing of knowledge structures is routinely implicated in the group performance literature. A review of the research literature will obviate that
cognitive similarity is widely seen as a key factor in group and team functioning. Unfortunately, it appears much more popular to invoke cognitive convergence in post hoc explanations of group functioning than it is to measure it.

A Sample of the Research Record

Given the potential benefits of shared cognition in team and group functioning, the functional perspective suggests that members of successfully-performing groups will have likely developed some degree of overlap in their mental models. Further, one might expect to find a wealth of empirical evidence that shared cognition plays a positive causal role in performance. Despite the long history of group mind constructs, neither of the above propositions has been scientifically substantiated. However, there is a plethora of implication and innuendo on the part of writers, accompanied by some indirect evidence.

Klimoski and Mohammed (1994) review a large body of research literature dealing with notions of group mind, grouping them into two main content categories: team dynamics/performance, and strategic decision making. Research in both categories assumes that group process
mediates the achievement of the group's potential performance capability. The team dynamics/performance literature emphasizes the quality of member interactions as they engage in coordinated performances, while research in the strategic decision making domain emphasizes agreement in the assignment of meaning to information and in the content of solutions to intellective problems. The next sections illustrate the role of shared cognitive structures in both of Klimoski and Mohammed's (1994) literature divisions by briefly reviewing the major propositions of researchers, and discussing their implications for the role of shared cognition in performance contexts.

**Team Dynamics/Performance Domain**

To illustrate distributed information processing in teams, Hutchins (1988) gives the example of navigating large naval vessels. In naval operations, a continuous plot of the position of the ship is maintained in order to support decisions concerning its motion. Navigation occurs in a cycle which consists of plotting the ship's position, projecting the future track, and preparing to plot the next position. Operating the ship in restricted waters requires
that fix cycles occur frequently (i.e., more than once per minute), and at regular intervals. This large monitoring and computation workload is distributed across a team of (typically) six people.

According to the master procedure, navigation team members operate as interrelated units of exclusively distributed function. Each team member does his or her part of generating a fix only when certain conditions appear in the task environment (Hutchins, 1988). Coordination emerges because the conditions prompting each team member's actions are produced by the activities of the other team members. In theory, each person could operate on an exclusive mental model relating environmental conditions to appropriate responses.

In practice, however, it is essential that some degree of overlap between individual cognitive structures exist, in order to allow the system to recover from error. For example, regular periodicity of fix cycles, which greatly simplifies the computations required to track the ship's movement, depends (according to procedure) entirely on the time-keeper. Therefore, if the timekeeper were to miss a
mark, then the computational system would collapse, and the team would experience failure. Fortunately, social interaction between navigation team members develops shared cognition which allows them to support, and to participate redundantly in, each other’s roles. Hutchins (1988) observes that when the time-keeper misses a mark, the plotter has been known to cue the round, so that the system's periodicity is preserved (Hutchins, 1988). He explains that the robustness of the entire system depends on redundant knowledge between navigation team members. Viewing the team as a computational system, shared cognitions among team members amount to system redundancies which contain local component failures.

Hutchins' (1988) ethnographic study suggests, post hoc, that shared cognition allows human systems to recover from error. Speculating further, shared cognitive structures might support interactions such as informed interpersonal monitoring, cuing, and support of the activities of fellow members. At the team level, cognitive convergence gives rise to a collective automaticity of "self"-regulation on the part of the team. Social interaction guided by shared
cognitive structures augments the formal labor distribution, reducing local errors and preventing their manifestation in system wide error.$^1$

A number of researchers proceed from the assumption that shared cognitive structures enhance the quality of both teamwork and its performance outcomes (Cannon-Bowers & Salas, 1990; Cannon-Bowers et al., 1990, 1993; Orasanu & Salas, 1993). Commonality (overlap) among team members is thought to allow them to anticipate the information requirements of other team members, relative to the demands of the task (Cannon-Bower, Salas, & Converse, 1990).

*Anticipatory teamwork* is especially important to performance when working conditions prevent overt communication between members. The demands of a high workload, for example, tie up resources such as cognitive space, attention, and time which might otherwise be used for overt communication. Indirect evidence of this proposition can be found in a study by Kleinman and Serfaty (1989). They found that under conditions of high workload, successful teams maintained performance levels via a sharp reduction in overt coordination and communication. Shared
cognition among team members appears to have supported an "implicit coordination" strategy, whereby team members derived common expectations which allowed them to anticipate one another's actions and needs (Kleinman & Serfaty, 1989). The author's explanation is a provocative portrayal of cognitive convergence as a driver of team dynamics and performance. It is also post hoc speculation. As is typical of research in this domain, there was no measurement of cognitive structures in the study reported (Kleinman & Serfaty, 1989). Thus, no statistical conclusions about their involvement in implicit coordination can be drawn from this study.

Responding to conditions of high workload by reducing overt coordination implies a resource allocation model in which the benefits of explicit coordination are weighed against the costs of allocating resources away from other aspects of task performance. Shared cognition reduces requirements for explicit coordination, freeing resources to be applied more directly toward task performance.

It should be noted that conditions other than high workload decrease the feasibility of explicit coordination.
Extreme noise (e.g., heavy machinery; gunfire), the use of tactics requiring stealth or deception (e.g., faking a punt in football), or any other set of conditions interfering with open and free communication, increase a group's reliance on the tacit coordination made possible by shared cognitive structures.

Thus, one might expect to find evidence in the literature of a statistical association between the degree of mental model overlap and the dynamics/performance of teams. Unfortunately, as Klimoski and Mohammed (1994) conclude, empirical research has lagged far behind the popularity of cognitive similarity concepts. Most studies have merely invoked the concepts of shared cognitive structures in a post hoc fashion to aid in explaining differences between the performance of groups (e.g., Kanki, Lozito, & Foushee, 1989; Orasanu, 1990). Experimental research on the causal role of shared cognitive structures is needed, but cannot proceed until some technique for inducing the convergence of cognitive structures is developed. In order to develop such techniques, two advances are required: 1) a formal, coherent, and specific
theory of how cognitive convergence occurs must be developed, and 2) methods for measuring convergence of cognitive structures must be utilized in group and team research.

Of course, formal divisions of labor and procedural manuals/training could be considered as techniques for imposing shared cognitive structures minimally necessary for effective coordination. In domains where performance requirements can be anticipated (routine, well-defined tasks), training interventions bear obvious potential as a means of inducing shared cognitive structures among group members. However, as the Hutchins example illustrates, these often assume error-free functioning on the part of individuals.

More importantly, non-routine, ill-defined tasks such as resolving strategic uncertainties or implementing strategic initiatives require activities which cannot be foreseen with specificity. Group performance here requires group autonomy in the development of shared cognitive structures. Because there are no navigation manuals for strategic situations, groups in these situations must be
left to their own direction in developing shared cognition. Research in this domain has not yet demonstrated how cognitive convergence occurs.

**Strategic Decision Making Domain**

It is becoming increasingly popular among high-level managers to create strategic decision or implementation groups, on an ad hoc basis. These groups are often composed of members who have not been trained in a common language, as they usually have diverse functional backgrounds. As this trend continues, it will be increasingly important to understand how these groups develop their sociocognitive capacities. From the systematic empiricist perspective, the development of cognitive similarity remains neglected in the strategic decision making domain.

Researchers of group decision making assume that the individual's cognitive structures relevant to the decision at hand aggregate to form a sort of collective representation. Further, some theorists incorporate political processes into the development of shared cognition among group members, hypothesizing that belief structures are "negotiated" among group members (e.g., Walsh & Fahey;
Bonham, Shapiro, & Heradstveit, 1988). But the micro-logic of cognitive convergence remains unspecified. Generally, scholars have leaped to explicating various causal roles for shared cognitions in strategic decision making.

Granted, once some (threshold?) degree of cognitive convergence is achieved, it should enable or enhance group decision making, depending on the quality of the shared cognitive structure. For example, Innami (1992) hypothesized that an inclusive, balanced "group belief structure" would increase the quality of group decisions relative to a biased group belief structure. Collective cognitive structures may also create a context which affects the speed and flexibility of decision making (Walsh & Fahey, 1986).

Empirical evidence of the shared cognition effects is sparse in the decision making domain, but suggestive data exists. For example, Walsh, Henderson, and Deighton (1988) conducted a study on the effects of negotiated belief structures in 29 groups of graduate business students on decision making performance. They operationalized negotiated belief structure as realized consensus reached
through discussion of a breadth of perspectives on the
decision situation (realized coverage) in a business
simulation game. Results indicate that shared agreement
among key schematic dimensions predicted brand performance
(Walsh, Henderson, Deighton 1988). Of course, without the
experimental induction of shared cognition, causal inference
is complicated by alternative hypotheses of reverse
causation and third-variable causation.

Along similar lines, Innami (1992) studied the content
of group verbal interaction as it related to decision
quality, and concluded that group belief structures
determined quality. As is typical in this domain, Innami
inferred a role for shared cognition after analyzing group
communicative behaviors in relation to performance. No
direct measurements of cognitive convergence were taken.
What critical readers are left with is an unsupported
suggestion that cognitive convergence plays a role in
strategic decision making performance.

Another recent study suggests that shared cognitions
regarding the relative expertise of group members themselves
leads to increased performance in group decision contexts.
Libby, Trotman, and Zimmer (1987) studied the post-facto predictions of expert loan officers about the performance of real companies based on their actual case histories (identities disguised). Whether in ad hoc or practiced groups, the accuracy of group predictions depended on how closely the weighting of member opinions corresponded with actual member expertise (Libby, Trotman, & Zimmer, 1987). The effect was dependent on the degree of variation in expertise among team members. Libby et al (1987) suggest that shared knowledge regarding the distribution of expertise can be as beneficial in decision performance as shared knowledge of the task domain. But an examination of the statistical result on which they base this conclusion unearths some serious doubt. As is typical, there were no measurements of cognitive similarity made. Instead, the authors examined the correspondence between individual performance in a practice rating session, and the weighting (in multiple linear regression) of their individual ratings as statistical predictors of their group's ratings. In strict terms, the results (Libby et al, 1987) indicate that relatively accurate ratings made by groups tended to weight
most heavily on the ratings made beforehand by the group's more accurate members. The authors interpret this as an indication that in successful groups, expert members had heavy influence during decision making sessions. They make an additional implicit inference that "influence" indicates shared cognitions among group members regarding the relative expertise of each member. Without measurement operations to support these claims, it is impossible to determine whether their results reflect cognitive convergence about group member expertise, or a statistical artifact based on the inevitable correlations between accurate ratings.

Nevertheless, this study adds the suggestion that shared cognitions regarding the group itself, in addition to those about the problem domain, have functional consequences. (As a design choice, the research reported herein focusses on shared knowledge of functional relations between objects in a problem content domain, rather than between team members.)
CHAPTER 3

TOWARD A THEORY OF COGNITIVE CONVERGENCE

From the perspective of group development, cognitive convergence may reflect maturity, or a team's having "come up to speed" relative to its performance environment. Very few studies have been designed to test the effects of group history on how well groups utilize the intellectual resources of their members. Although researchers have asserted for decades that groups must go through a developmental process before they can be effective (e.g., Tuckman, 1965), construct-valid empirical evidence of the effects of group development is scarce.

The group performance model offered by Klimoski and Mohammed (1994, p. 429) features the team mental model as playing several roles. The team mental model moderates the effects of team capacity on team process, and also influences process directly. They model cognitive
similarity (and the other components of the team mental model) as an input in the transformation processes of groups and teams.

Broadly speaking, the collective leap among scholars to a focus on the role of cognitive similarity in group and team functioning begs a family of questions. By what process does cognitive similarity develop among cooperating individuals? How does cognitive convergence occur? What are the causal factors from which cognitive convergence results? One of the major tenets of this discussion is that cognitive similarity can be modeled as a product of group process, emerging over time from the social interaction between group members.

In social context, cooperating individuals are presented with information in the form of messages from others. Organizational communication routinely involves an inter-individual exchange of messages centered around issues relative to meeting task demands or resolving strategic problems. Working in groups exposes group members to messages from their coworkers, and such exposure bears the potential of altering group members' cognitive structures.
By casting cognitive similarity among group members as a group output in Steiner's (1972) input-process-output paradigm, a theorist is allowed some guided speculation regarding the processes behind cognitive convergence. According to Steiner's negative (not necessarily pessimistic) process model, process losses limit the output potential of groups. One principal source of process loss involves deficits of motivation. Motivation involves the intensity, persistence, and direction of behavior (Cofer & Appley, 1964; Farr, Hofmann, & Ringenbach, 1993; Kanfer, 1990; Young, 1960). Motivation is central to cognitive convergence theory because motivational deficits limit the potential for cognitive convergence among members of developing groups. Cognitive elaboration theory explains how.

The Formation and Alteration of Cognitive Structures

Cognitive elaboration theory specifies the process by which cognitive structures are formed or altered. Motivation plays a key role in the development of shared cognitive structures because individual cognitive structure change depends on individual cognitive effort. One famous
variant of cognitive elaboration theory, The Elaboration Likelihood Model (Petty & Cacioppo, 1986b), and its associated empirical base illuminate the role of motivation in cognitive structure formation and change at the individual level.

Cognitive Elaboration Theory

Cognitive structures change as individuals actively ruminate about information presented to them. Although merely attending to stimuli carries the potential of forming new cognitive structures, the process of forming structural cognitive representations is enhanced when subjects are encouraged to elaborate the material semantically (Hecker, 1993). Semantic elaboration leads to a more intense processing of the kind of information that is involved in structural schemata formation (Hecker, 1993). The formation of associative links between cognitions is the key process by which elaboration creates new cognitive structures (e.g., Hastie, 1980).

Recipients of messages in goal-oriented social contexts elaborate upon them by accessing relevant associations, images, and experiences from memory, and examining the
information presented in light of this stored information (Petty, Cacioppo, & Kasmer, 1988). Elaboration is a thoughtful process in which people attend carefully to the issue-relevant information presented, examine this information in light of their relevant experiences and knowledge, and evaluate the information along the dimensions they perceive central to the merits of the issue (Petty & Priester, 1994). The end result of elaborative processing of a message or message series is a cognitive representation that is well articulated and integrated into the person's existing cognitive architecture (Petty & Priester, 1994).

The Role of Motivation

The Elaboration Likelihood Model (ELM; Petty & Cacioppo, 1986b) represents a tradition of research examining the effects of messages on the cognitions of recipients. Although geared toward the study of persuasion (attitude change), it is useful here because it explicates the role of motivation in cognitive structure change. ELM is based on the functionalist notion that people want to form "correct" attitudes as a result of exposure to communication, because correct attitudes are adaptive
(Petty, Cacioppo, & Kasmer, 1988). More generally, "correct" cognitions and cognitive representations are desirable, and are ensured by elaborative rumination upon information encountered.

Cognitive elaboration upon a message requires considerable cognitive effort on the part of the recipient (Petty & Cacioppo, 1986b; Petty, Cacioppo, & Kasmer, 1988). People engaged in this effortful cognitive activity have been characterized as engaging in "systematic" (Chaiken, Liberman, & Eagly, 1989), "mindful" (Palmerino, Langer, & McGillis, 1984), "piecemeal" (Fiske & Pavelchak, 1986) and "deep" (Craik & Tulving, 1975) processing. ELM research has successfully used self-report measures of intensity to indicate individual cognitive effort (Andrews & Shimp, 1990). Objective indicators of effort, including time on task, (indicating persistence) have been used successfully in organizational research on effort and performance (Blau, 1993; Katerberg & Blau, 1983; Terborg, 1976, 1977).

Cognitive effort is a resource, and as such, it is finite in supply per unit of time. Therefore, it is neither adaptive nor possible for people to exert considerable
mental effort in processing all of the communications to which they are exposed. Indeed, people often act as "lazy organisms" (McGuire, 1969) or "cognitive misers" (Taylor, 1981). Motivation loss can result in reduced message processing under a number of different conditions. One such condition exists when it is made salient to a person that he or she is part of a group that is responsible for message evaluation (Petty, Harkins, & Williams, 1980). This point will be addressed later in more detail.

The central contribution of cognitive elaboration theory to cognitive convergence theory is the tenet that cognitive structure change depends on the person's motivation to elaborate upon messages. ELM studies support the view that conditions fostering people's motivation to engage in issue-relevant cognitive activity enhance the persistence of persuasion (see Cook & Flay, 1978; Petty, 1977, for reviews). When experimental conditions (or dispositional factors) enhance people's motivation to process issue-relevant information, the resulting attitudes are more resistant to counter persuasion and more predictive of behavior. ELM theorists explain the stability,
resistance, and predictivity of attitudes formed through cognitive elaboration by hypothesizing that they reflect new cognitive structures formed as a result of elaboration (see McGuire, 1964; Petty & Cacioppo, 1986(a), for reviews). Thus, cognitive elaboration theory, and the ELM and its empirical record in particular, support the working conclusion that individual cognitive effort underlies the formation and change of cognitive structures.

However, the ELM research program would constitute an inadequate platform from which to launch the present study, for three reasons. One is that ELM research, in its focus on attitude change, has made little attempt to measure the cognitive structures hypothesized to underlie those attitudes. Cognitive structures are of primary interest here, and this proposal outlines a method for studying how they develop through the interaction of cooperating individuals. Empirically speaking, this study attempts to demonstrate changes in participants' cognitive structures rather than to refer to them as hypothetical mediators of attitude change and persistence.
Second, ELM research operations have tended to focus on the responses of lone individuals to single, fixed messages contrived by experimenters. The present study is aimed at uncovering the process by which cognitive similarity develops among cooperating individuals. It requires bringing people together in a goal oriented context, and allowing them to interact in a relatively unconstrained manner.

Third, and most important for the next section, the ELM program is silent on issues of how and why cognitive convergence might occur among members of a working group. What is clearly suggested (and indirectly evidenced) in the ELM literature is that cognitive effort expended toward elaborative examination of messages results in cognitive structure change.

**Group Decision Making Process**

Much of this cognitive structure change should result in the development of cognitive similarity between group members. This is due to the basic nature of group decision making. Group decisions arise out of the exchange of beliefs and knowledge among individual members (Innami,
Organizational decision making involves the integration of individual viewpoints into a group decision (Lawrence & Lorsch, 1969). The group decision making process generally involves integration of individual cognitions.

Although there is a wide (if often implicit) consensus regarding the integrative nature of group decision making, little theoretical explication of the integrative process is available. Most conceptual treatments of group decision making are general and loosely organized, but there have been direct references to the development of shared cognition.

For example, Crowell and Scheidel (1961) referred to the "idea-in-the-making" among members of any discussion group. That is, groups reach judgements through a progressive, cooperative modification of shared ideas. Crowell and Scheidel (1961) assume that groups engage in a process of cooperative work in the building of a group judgement which represents the information, values, and thinking of individual members. They attempted to develop the first system of categories for analyzing the development
of common ideas in groups (1961). Crowell and Scheidel's system (1961) relates better to group-level information processing than earlier systems (e.g., Bales, 1950; Benne & Sheats, 1948; Carter, 1954; Curran, 1945; Steizor, 1949), which focused on interpersonal dynamics. It categorizes the content and interrelations of ideas (rather than of individuals) in terms of "thought units" generated by the group.

Building upon this work, Innami (1992) proposed a dual process model of group decision making in which information processing occurs simultaneously and in parallel at both the individual and group levels. At the individual level, group members offer and receive information reflecting "individual belief structures" in a social exchange of ideas. They evaluate the information presented, and modify their individual belief structures accordingly. At the group level, a decision-making group constructs a "group belief structure" by eliciting, evaluating, comparing, and finally integrating the belief structures of individuals. While Innami's (1992) speculations do not warrant dedicated empirical investigation without further theoretical
development, the dual process model serves to highlight that group decision making and the integration of individual cognitive structures are intertwined.\(^3\)

Importantly, Innami's (1992) theoretical discussion on the building of group belief structures emphasizes the exchange of ideas. Where ELM and other variants of cognitive elaboration theory prescribe effortful information processing, cognitive convergence theory incorporates the exchange of ideas into a sociocognitive elaboration process.

**Cognitive Effort and Cognitive Structure Similarity**

Making the reasonable assumption that many of the ideas exchanged in any group decision making session are integrative, the role of cognitive effort in the development of cognitive structure similarity becomes clear. Effortful elaboration on integrative arguments presented during the group decision making session should result in cognitive structure convergence among group members. An additional requirement for convergence is that group members maintain a high exchange of ideas during the discussion, as opposed to ruminating excessively over one's own ideas. Thus, cognitive convergence theory specifies the energy (effort,
persistence) and direction (exchange of ideas) of the process of sociocognitive elaboration.

Testable hypotheses begin to emerge. The degree of cognitive effort expended by group members as they come to a decision determines how similar group member's knowledge structures will be after a decision is reached—provided that a high exchange of ideas is maintained during the decision making session. A method for manipulating the degree of cognitive effort expended by individuals during group decision making would allow for an experimental design with its associated luxuries of causal inference.

Testing the Effects of Cognitive Effort

In order to test the general hypothesis that effortful processing on integrative arguments during group decision making leads to cognitive similarity among members, cognitive effort must be made to vary. Experimentally varying the degree of motivation among decision making groups is feasible because of two scientific facts: 1) members of groups are naturally subject to motivation deficits, and 2) these deficits can be remedied in select experimental conditions using a simple management technique.
Research programs from social and organizational psychology demonstrate that the cognitive loafing which normally occurs in laboratory groups can be reduced using accountability.

**Motivational Deficits in Groups**

There is ample evidence from social psychological studies of the occurrence of a general motivation deficit among members of groups. This collective motivational deficit occurs independently of any objective potential for process loss due to distraction or ill-coordination (c.f., Steiner, 1972). The phenomenon consisting of reduced effort or performance on the part of individuals working as part of a group, as compared to working alone, has been labeled the "social loafing effect" (Ingham, Levinger, Graves, & Peckham, 1974). In the typical social loafing study, individuals are asked to generate some sort of measurable output either alone or in "pseudo-groups," in which they are falsely led to believe that they are performing in addition to others. Results indicate that loafing is a functional result of perceived group membership and also a positive function of the size of the group.
Group members may have a number of reasons to reduce their contributions of effort. Despite their shared interest in achieving some collective benefit, individuals normally do not share a common interest in paying the cost of attaining the benefit (Olson, 1971). Economically speaking, one's self-interest is maximized (in the short term, at least) by letting other members do the group's work. As individual incentives to contribute decrease with group size, motivation losses increase with group size (Latane, Williams, & Harkins, 1979). Weldon and Mutsari (1990) found that individuals who were led to believe that they shared responsibility with fifteen others for performance felt more dispensable than individuals working alone or in pairs. As a result of feeling less responsibility, they input less effort.

Research shows that motivational deficits occurring in groups specifically affect the degree of cognitive effort expended by group members. Research on "cognitive loafing" by Weldon and Gargano (1985, 1988) demonstrates that judges who believe that they share responsibility for the judgement task use less complex judgement strategies than judges
working alone. Petty, Harkins, and Williams (1980) demonstrated similarly that participants who were led to believe that they shared responsibility with others produced fewer elaborative thoughts, and were less sensitive to stimulus quality, than those made solely responsible.

Cognitive elaboration theory dictates that cognitive structure change depends on cognitive effort. As members of a group attack a decision problem cooperatively, the development of shared cognitive structures depends in theory on the amount of cognitive effort expended by individuals in elaborating on the information made common through an exchange of ideas. Given the general phenomenon of group motivational deficits, two parallel implications arise. From a scientific standpoint, using a known technique to increase levels of cognitive effort over baseline in a laboratory situation provides a controlled test of the role of cognitive effort in cognitive convergence. From a practical standpoint, there is considerable potential in developing a technology for enhancing the development of shared cognition among members of ad hoc groups. The fundamental technology already exists.
Accountability

The present discussion theorizes that cognitive convergence occurs among members of newly formed groups as a result of sociocognitive elaboration, in which group members engage in effortful interactive elaboration upon the information set generated in an exchange of ideas. Accountability supports a demonstration of the role of sociocognitive elaboration by serving as a basis for the experimental manipulation of cognitive effort. Experimental groups defined by accountability-based manipulations of cognitive effort will be contrasted in terms of the degree of cognitive convergence observed.

Detailed theoretical specifications of the nature and conditions essential to accountability are available elsewhere (e.g., Cummings & Anton, 1990; Tetlock, 1985). The primary purpose of this section is to introduce accountability manipulations appropriate for illuminating the role of sociocognitive elaboration in the development of shared cognitive structures among cooperating group members. A brief overview of accountability is given below.
Accountability is the condition of being answerable to an audience (Klimoski, 1992). Psychologically speaking, accountable individuals are given the expectation that they will have to justify their opinions, decisions, or actions to others. Investigators generally induce accountability by having individuals anticipate having to meet with another party and justify their decisions to that party (e.g., Klimoski, 1972; Schlenker & Weigold, 1989). Other studies have manipulated the publicness of the actor, or of the decision or action produced by the actor (Haccoun & Klimoski, 1975; Klimoski & Ash, 1974).

Although approaches to accountability differ, there is a broad consensus in the scientific literature regarding its effects on cognitive effort expenditures. Accountability increases the intensity and diligence of cognitive information processing (Klimoski, 1992). Most empirical evidence of accountability's effects on cognitive effort derives from analyses of decision process and quality. For example, accountability has been found to cause participants in laboratory research to devote more time to making their decisions (Weldon, 1981) and to produce opinions of greater
integrative complexity (Tetlock, 1983) relative to individuals not made accountable. In research on performance appraisal processes, it has been found that accountability increases interrater agreement and reduces halo error (Rozelle & Baxter, 1981). By inducing cognitive effort in those doing the appraising, accountability also reduces primacy effects (Tetlock, 1983), and reduces the propensity toward making the fundamental attribution error (Tetlock, 1985). In short, accountability can enable the sort of "systematic, mindful, piecemeal, and deep" processing prescribed by cognitive elaboration theory for the formation and alteration of cognitive structures.

Generally speaking, accountability increases the cognitive effort (energy, persistence) allocated by a group to an intellective task.

In order to induce cognitive convergence, however, this effort must be directed toward elaborating upon a particular domain of interest. For example, in order to induce cognitive convergence relative to the functional solution to a complex problem, effort could be directed to cooperative elaboration upon the functional relations between objects in
the problem domain. A manipulation that simultaneously increases and directs cognitive effort in group decision making should accelerate the development of shared cognitive structures relative to controls.

Standards of Accountability

The process of cognitive convergence requires sociocognitive elaboration, which is characterized by cognitive effort and a high exchange of ideas. The sections above articulate that accountability energizes information processing. By varying the prescriptions, or performance standards, inherent in accountability manipulations, it is possible to direct the energy as well (Klimoski, 1992).

This study contrasted two accountability manipulations. The first, Justification accountability, was intended to energize and direct the behavior of group members toward sociocognitive elaboration upon elements in the strategic decision domain. The second, Recall accountability, was designed to energize efforts in group decision making without directing them toward the exchange of ideas necessary for sociocognitive elaboration. Cognitive convergence theory requires both effortful processing and a
high exchange of ideas, while traditional cognitive elaboration theory emphasizes mainly effortful processing.

**Solution justification.** Requiring each group member to justify the group's solution should energize group member behavior, resulting in a relatively high level of cognitive effort allocated to the decision task. Under the demand to justify a group's solution, participants will expend extra effort in reaching that solution.

H1: Relative to controls, justification accountability will increase cognitive effort.

It should also focus participants' attention on the arguments supporting that solution. **Justification accountability** should interest group members in acquiring (and validating or scrutinizing) arguments in support of the group's solution. A high exchange of ideas in sociocognitive elaboration upon the problem domain will result in the development or alteration of relevant cognitive structures. As the group integrates individual viewpoints into a coherent solution, they each attend to the
same integrative arguments (produced in a high volume of idea exchange), resulting in a convergence, or similarity, of cognitive structures after the decision making session is over.

H2: Justification accountability will increase sociocognitive elaboration relative to both control or recall accountability.

H3: Justification accountability will result in greater cognitive convergence than either control or recall accountability.

Solution recall. Making each group member accountable for being able to reproduce the group decision should increase cognitive effort to a level comparable to that in the Justification condition. Similar in procedure to a training post test, accountability for decision recall preserves the autonomy of decision making groups with regard to how they structure their discussion and what options are developed and selected in forming a solution to a problem.
At the same time, solution recall accountability should have a general energizing effect on group decision making.

H4: Relative to controls, Recall accountability will increase cognitive effort.

However, recall accountability would not be expected to have dramatic effects on post-session cognitive similarity. This is due to the fact that although recall accountability may energize group members' activity, it focusses group members on the solution itself, rather than the arguments underlying it.

Cognitive elaboration theory asserts that it is motivated processing of the arguments supporting the solution which effect knowledge structure change. Sociocognitive elaboration involves the exchange of ideas in addition to effort in processing them. If group members are held accountable for simply recalling the solution itself, no incentive for sociocognitive elaboration is added. Therefore, no gain in knowledge structure similarity can be expected relative to a no-accountability control.
H5: Recall accountability will not increase the volume of sociocognitive elaboration relative to controls.

H6: Recall accountability will not increase cognitive convergence relative to controls.
CHAPTER 4

METHOD

Participants

A total of 464 undergraduates (256 males, 198 females) enrolled in an introductory psychology course at a large public Midwestern University participated as one of several options for partial course credit. The "average" participant was 19 years old, and had 17.2 months of work experience. Because group composition and variability in the extent to which previous relationships exist among group members are typical of temporary formal groups in industrial settings, these variables were measured but not constrained or manipulated. On average, each group member had been acquainted with each of the others for less than 2 months.

Each participant volunteered for the experiment individually, but was assigned to a group with three others when the experiment began. All participants were treated
according to the ethical guidelines of the American Psychological Association (1990).

Design

A true-experimental, one-way, between-subjects design with three conditions was employed. Thirty-seven groups of four participated in the control condition, 35 groups in the recall condition, and 44 in the justification condition.

Task

The strategic decision making task used was Johnson and Johnson's (1987, p.110) Winter Survival Exercise (Appendix A). The Winter Survival Exercise is nearly identical in form to NASA's popular moon survival exercise (Hall & Watson, 1970) which has been accepted as an analogue to the types of problems faced by managers (Bottger & Yetton, 1987). The Winter Survival Exercise presents participants with a written scenario involving a plane crash leaving survivors in a remote wilderness area near the northern U.S. border. Participants solve the problem by considering the plight of the survivors and rank-ordering 15 items remaining from the crash in terms of their importance to survival.
The Winter Survival Exercise was chosen for several reasons. First, although a reasonably face-valid solution can be generated with a minimum of effort and time, a high quality solution requires a complex set of interrelated decisions. Multiple and subtle uses exist for each item alone and in combination with other items. Consequently, the task itself constitutes a weak situation in terms of its demands for cognitive effort, allowing room for cognitive effort to vary with the accountability manipulations. In addition, pilot work reveals that the task is novel and moderately interesting, so that some cautious generalization to involving real-life situations seems reasonable. Pilot work also confirmed that virtually every participant was capable of some contribution to solving the Exercise. At the same time, there were no ready experts whose knowledge contributions completely dominated the group solution.

Finally, it happens that the Winter Survival Exercise results in a solution that can be analyzed quantitatively. Although decision quality is not the primary focus of this study, making this variable available allows interesting ancillary analyses. Decision quality is defined as the sum
of the absolute differences between the ranks assigned by participants for each item and those advocated by a panel of three wilderness experts: M. Wanvig (U.S. Army survival training instructor), R. Johnson (environmental education expert), and C. Rulstrum (author of *New Ways of the Wilderness*).

**Cognitive Structure Measurement**

In order to measure participants' cognitive structures regarding the content of the Winter Survival Scenario, participants were asked to make pairwise proximity ratings between all possible pairs of the survival items. The proximity rating technique essentially asks individuals to rate in terms of a constant scale the degree of relatedness between pairs of concepts or ideas. A participant's proximity ratings are summarized in a distance matrix which depicts the degree of relatedness for all pairs of concepts. In the present study, the 14 survival items were identified as key concepts in the problem domain. The survival items and their functions (survival uses) are the key to solving the Winter Survival Exercise, regardless of the (in)expert quality of the solution generated. Participants were
specifically instructed to consider survival items to be "..."'related"' according to their uses for survival in this Winter Survival Scenario..." In comparing two items, participants considered the uses they should serve. Items were related "...to the extent that their more important uses are the same or similar..." Therefore, with the Winter Survival Scenario in mind, participants based their proximity ratings on overall "functional relatedness" or relatedness in function.

Proximity ratings represent cognitive structure data because structural knowledge describes the pattern of relationships among concepts in memory (Preece, 1976). Constructs in an individual's cognitive structure are differentially related --some are closely related with others more distantly related. Proximity ratings are the most direct method for rating the semantic relatedness between concepts in an individual's cognitive structure (Jonassen, Breissner, & Yacci, 1993). Proximity ratings may also correspond roughly to predictions derived from network association models of cognition (e.g., Schvaneveldt, 1990). The basic theory is that proximity ratings tap the
availability of one concept given that another has been primed. A form was used to gather proximity ratings between survival items at two points in time for each participant: before and after group discussion. **Proximity Ratings Form.** A form was designed to prompt participants' pairwise ratings of the functional relatedness between key Survival items identified in the Winter Survival Exercise, using a nine point "relatedness" scale (1 = unrelated; 9 = related). The form is reproduced in Appendix B. This form elicited responses which were then analyzed to reveal participants' cognitive structures relative to the Winter Survival Exercise.

**Graph Theoretic Analysis of Proximity Ratings.** The Pathfinder scaling algorithm (Schvaneveldt, Durso, & Dearholt, 1989) was applied to the proximity rating matrices in order to reveal the latent structure of a given person's cognitive representation of a problem (Durso, Rea, & Dayton, 1994). Pathfinder produced a numeric network representation of each person's cognitive structures relative to the Winter Survival Exercise based on pair-wise ratings of the functional relatedness (proximity ratings) between key
concepts in the Winter Survival Scenario. In this method, the survival items were assigned the role of nodes in an associative network graph. The network graph is derived by determining and eliminating those relations in the data that violate the assumption of triangle inequality. In other words, Pathfinder searches through all possible paths of the network to find the closest indirect path between objects. A direct link between two nodes is retained only if the closest indirect path between the two nodes is greater than the proximity value for that pair of objects. Pathfinder was chosen for its capability of parsimoniously representing participants' cognitive structures, and for its record of empirical validity. Empirically derived Pathfinder graphs differ according to a subject's degree of insight into a problem (Durso, Rea, & Dayton, 1994), and have been used successfully to distinguish between novices and experts (Schvaneveldt, Durso, Goldsmith, Breen, Cooke, Tucker, & DeMaio, 1985). A detailed and comprehensive collection of writings on the uses of Pathfinder can be found in a book edited by Schvaneveldt (1990). A concise outline of the graph theoretic foundations of Pathfinder networks is given
by Schvaneveldt et al. (1988). Pathfinder analysis of a
given participant's proximity ratings provides a network
representation of that individual's cognitive structures
relative to the decision task domain. All Pathfinder and
related analyses were conducted using a PC application known
as KNOT (Interlink, 1992), with Pathfinder network scaling
parameters \((a, \bar{x})\) set to yield maximally sparse networks \((a =
n-1)\), which were also appropriate to the ordinal nature of
the proximity rating data \((\bar{x} = \infty)\).

**Cognitive Convergence Measures**

Cognitive convergence was measured in two general ways.
The first approach was objective in that it involved
correlational and graph-theoretic comparisons between the
proximity ratings of each possible pair of group members.
The second approach to measuring cognitive convergence was a
phenomenological one, in which group members rated the
degree of subjective common ground they were experiencing
within the group. Two versions of the objective approach
are discussed first.

**Average Proximity Rating Similarity.** Pearson product-
moment correlations between the raw proximity ratings
corresponding to each possible pair of members within a group were averaged to form a group-level similarity index. Raw proximity ratings themselves have been shown to be valid indicators of participant knowledge (Goldsmith, Johnson, & Acton, 1991).

**Average Pathfinder Network Similarity.** Pathfinder network representations (PfNets) based on proximity data are assumed to be less influenced by "noise" than are raw proximity ratings. They also represent configural aspects of knowledge (cf. Goldsmith, Johnson, & Acton) such that structural cognitive-convergence can be assessed by comparing the PfNets of group members. The "C" statistic (Interlink, 1992) indexes the degree of similarity between any two Pathfinder networks, allowing direct quantitative similarity comparisons between the cognitive structures of any two participants. "C" is defined here as the proportion of links found in two networks that are shared by both (i.e. cardinality of intersection divided by cardinality of union). Research suggests that using "C" and related indices to compare PfNets derived from two sets of proximity ratings adds value over comparing the ratings themselves.
For example, a study of classroom learning (Goldsmith, Johnson, & Acton 1991) indicated that student-instructor cognitive similarity as indexed by "C" was more predictive of semester performance than either raw rating data, or a structural approach using multi-dimensional scaling. Within members of developing groups, the "C" index averaged across all pairwise group member comparisons, labeled "Average Pathfinder Network Similarity", indicates group-cognitive similarity.

**Subjective Common Ground.** Cognitive convergence in the phenomenological sense was measured by prompting group members to rate each of 10 statements about their group in terms of the statement's accuracy. An example is item #2: "We have a group view which incorporates the views of members." Ratings were made using a 6pt. scale (1 = totally inaccurate; 6 = totally accurate). In case a participant felt unable to judge a statement, the participant marked a "0" for that statement. The entire scale as used is reproduced in Appendix C. (Reliability indices for all self-report measures are given in the Results section.)

After an examination of agreement between group members in
their subjective common ground ratings, (reported in the "Results" section below; see also Table 3), individual scores were averaged within groups to form the group-level variable Subjective Common Ground.

**Group Process Measures**

**Average Member Effort.** Six self-report items used by Andrews and Shimp (1990) in previous cognitive elaboration research were adopted in order to form an index of individual cognitive effort. Two items were added, using the same format, which referred directly to the Winter Survival Exercise. The resulting 8 items asked respondents to retrospect on their mental state during the group decision making session and to rate their amount of attention, degree of concentration, level of thought, degree of focus, level of effort, and the extent to which they carefully considered the information given. Andrews and Shimp (1990) found that the original six items had high internal consistency (alpha = .95), and further, that scale scores varied significantly with a manipulation comparable to those used here. The wording of items was adapted slightly for congruous reference to the group decision task.
to be used. Participants indicated their responses by circling one number on a 9-point scale with verbal anchors (particular to each item) at each pole. The scale is reproduced in Appendix D. (Items #1, #6, and #11 in Appendix D served as fillers and are discussed under "Perceived Difficulty" below.) After an examination of agreement between group members in their cognitive effort ratings, (reported in the "Results" section below; see also Table 3), individual cognitive effort scores were averaged within groups to form the group-level variable Average Member Effort. Average Member Effort represents intensity of group energy expenditure.

**Time on Task.** As an objective indicator of effort level, Time on Task was used following previous research on effort and performance (Blau, 1993; Katerberg & Blau, 1983; Terborg, 1976, 1977). Specifically, the counter reading on an audiotape recorder represented time elapsed from the moment the experimenter prompted the group to begin discussing and solving the Exercise until any member of the group notified the experimenter that the group was finished. All counter readings were generated twice independently for
verification purposes. Time of Task represents group persistence in energy expenditure.

**Subjective Exchange Volume.** A third measure indexed sociocognitive elaboration by asking group members to retrospect and confidentially rate the behavior of their group and group members during the group discussion session. Participants indicated their agreement with each of 10 statements regarding the volume at which idea exchange occurred between group members, using a 6pt., Likert-type scale (1 = strongly disagree, 6 = strongly agree). Example items include #7: "We maintained a high exchange of ideas", and #10: "Some members of the group would not disagree in order to avoid conflict" (reverse-scored). The scale is reproduced in Appendix E. After an examination of agreement between group members in their cognitive effort ratings, (reported in the "Results" section below; also see Table 3), individual cognitive effort scores were averaged within groups to form the group-level variable Average Member Effort.
Other Measures

Finally, two ancillary measures were taken for future reference, although they are not a part of formal hypotheses here.

Decision Quality. Following past research (Rogelberg, Barnes-Farrel, & Lowe, 1992), the quality of an individual's or group's solution to the Winter Survival Exercise is expressed as the sum of absolute differences between the subjects' rankings per item and the expert panel's rankings. A relatively low score (little absolute difference between the experts' ranks and the participants' ranks) indicates a relatively effective solution. A relatively high score (large absolute difference between the experts' ranks and the participants' ranks) indicates a relatively ineffective solution.

Knowledge Structure Coherence. The proximity rating sets generated by individual participants after group discussion were analyzed for their coherence. Coherence analyses were conducted using PCKNOT (Interlink, 1992), resulting in a correlation-based index ranging from zero to one. Coherence computation assumes that relatedness between
a pair of items can be derived from the relations of the
items to other items in the set. For each pair of items,
the correlation of the proximities for those items with all
other items is computed, yielding an indirect measure of
relatedness for that pair of items. "Coherence" positively
indexes the internal consistency of a given rating set by
correlating the original proximity data with the indirect
measures (Interlink, 1992).

Perceived Difficulty. Items #1 and #6 embedded in the
cognitive effort scale (Appendix D) asked participants to
rate the difficulty of solving the Winter Survival Exercise.
Item #11 asked participants to judge the Winter Survival
Exercise's skill requirements.

Procedure

Initial Solution and Proximity Ratings. Participants
were greeted and asked to take seats around a table. An
experimenter presented them with the Winter Survival
Exercise accompanied by a packet containing a solution form
(Appendix A) and proximity ratings form (appendix B). The
experimenter read from a script (Appendix F includes the
major experimenter scripts) in introducing the Winter
Survival Exercise and asking participants to solve it individually using up to fifteen minutes to do so. After each participant completed their initial individual solution, the experimenter directed them to generate proximity ratings between key items from the Scenario using the proximity ratings form in the same packet. Participants were informed that 20 minutes had been allocated for initial proximity ratings. At this juncture, the experimenter promised to give an overview of the remainder of the experiment once proximity ratings had been collected. Participants were given no preview of the procedures until just before they began the group decision making session, which is when the manipulation took place.

**Accountability Manipulation.** The accountability manipulation was mainly instructional in nature, as the procedures variously described did not actually take place. Three versions of instructions were designed through extensive pilot research to provide a powerful and construct-valid manipulation of perceived accountability. The expectations of participants regarding their having to account for the group's upcoming solution to the Winter
Survival Exercise were the main target. The instructions were scripted (Appendix F) and are summarized below. In the control condition, participants were told that after the group recorded a solution, the experiment would "move on to something else." Further, participants were assured that none of the outcomes were associated with them personally (i.e., complete confidentiality was assured). In the recall accountability condition, participants were led to expect that after the group recorded its solution, they would individually report to an observation room to recall that solution in front of a panel consisting of the author and two psychology graduate students. Further, the panel would supposedly document their recall performance in their name for use by interested others in the psychology department. In the justification accountability condition, instructions were identical to recall except for the addition that participants were led to believe that they would be responsible for explaining and justifying their group's solution as well as recalling it. For power and construct validity in the manipulations, the instructions in the two accountability conditions were delivered by the author,
while the control instructions were delivered by an undergraduate assistant of relatively lower apparent status. This contrast was intended to increase the power of the accountability manipulations by increasing the salience of principle authority. Finally, in both accountability conditions, participants were asked to indicate consent (or non-consent) to these procedures by signing (or not signing) a consent form. Consent forms are reproduced in Appendix G. Pilot work had previously indicated that the combination of these techniques (all used previously by other researchers) strongly affects participant's expectations regarding their accountability for the group's decision.

Manipulation check. After hearing all instructions and immediately before being given the option to sign consent forms, participants responded to six questions ostensibly to provide an indication of how clearly the instructions were understood. The items were designed to provide a manipulation check without raising suspicions on the part of participants. The items require participants to indicate "yes", "no", or "don't know" to confirm or disconfirm statements regarding the supposedly upcoming procedures.
The questionnaire is reproduced in Appendix H. The 'correct' answer depends on the experimental condition. As the Results section below reports, chi square analyses of responses per condition indicated that manipulations were successful in shaping participant expectations of accountability. **Group decision making session.** After filling in an initial individual solution to the Winter Survival Exercise, providing proximity ratings, and hearing the (non)accountability manipulation instructions, participants conducted a tape-recorded group meeting in which they generated a group solution to the Winter Survival Exercise. The experimenter informed the group that there was a 45 minute time limit, but that they were free to conduct the meeting in any manner they wish, using as little or as much time (up to 45 min.) as they needed. The experimenter prompted the start of the meeting by suggesting that each group member introduce himself or herself by name. The group was provided with a form on which to record the group rankings of the survival items. The group session was followed by a 10 minute break, in order to avoid fatigue effects discovered in pilot studies.
Self reports, final individual decision, and final proximity ratings. The remainder of the experiment consisted of individual rather than group participation. Participants received a final packet upon returning from break. The first page of the packet consisted of the self-report cognitive effort scale described above (Appendix D); the second page consisted of the idea exchange volume scale (Appendix E); and the third contained the subjective common ground scale (Appendix C). The fourth page consisted of a form similar to that used earlier for recording individual and group solutions to the Winter Survival Exercise.

Written instructions asked participants to use the form to express their "personal, individual perspective on the Winter Survival Scenario" by completing their own solutions, which "may or may not differ from the group solution."

Complete confidentiality was assured in encouraging participants to express their own preferences. Finally, participants responded to a proximity ratings form identical to that used prior to the group session. Upon finishing, participants were thanked and debriefed.
CHAPTER 5

RESULTS

For some statistical analyses, the subjects were individual participants. Means and standard deviations of all individual-level variables are listed by condition in Table 1. For other statistical analyses, the subjects were working groups composed of four participants each. Means and standard deviations of all group-level variables are listed by condition in Table 2. "Group" refers here to a set of four participants assigned to work together on the experimental task, subject to one of three treatment conditions. Sample sizes varied slightly between analyses, because cases with missing data were excluded analysis-by-analysis rather than listwise.

Differences or associations observed in the sample were generally deemed significant if the probability of the associated test statistic occurring by chance was less than
five percent (p < .05). Planned analyses were run without compensation for "groupwise" error rates. In testing for significant differences between observed means, the assumption of variance homogeneity was first examined. The examination is reported here only in cases where significant heterogeneity of variance was detected. In such cases, a more stringent alpha level (p < .025) was adopted to compensate for possible bias (i.e., increase in Type I error) in comparing means (see Keppel, 1991, pp. 105-108). This approach was considered more desirable than using alternative tests designed to bypass the homogeneity assumption (e.g., Brown & Forsythe, 1974; James, 1951; Welch, 1951), as these tests have uncertain validity and in some cases are unwieldy (Keppel, 1991). Regardless of the alpha standard adopted for a particular analysis, estimated probability levels associated with the test statistic are included where available.

The experimental design of this study supports the attribution of post-treatment differences to the
accountability manipulations, assuming that the three treatment conditions contained equivalent subjects before manipulations took place. This assumption was tested at both the individual and group subject levels.

**Equivalence Before Manipulations**

At the individual level (please see Table 1), subject demographics were equivalent across conditions. One-way analyses of variance (ANOVA's) detected no differences between conditions in either average individual Age (in years) ($F[2,458] = 0.26, p = .773$), Work Experience ($F[2,455] = 0.80, p = .448$), or Practice Decision Quality ($F[2,457] = 0.14, p = .874$). Additionally, chi-square analysis detected no differences in gender (proportion of males/females) between conditions ($\chi^2 = 0.86, 2 \text{ df}, p = .651$). Thus, treatment conditions were equivalent in terms of the individual characteristics measured before manipulations took place.

Equivalence before manipulations was generally confirmed at the group level as well. (please see Table 2.) For example, the average Practice Decision Quality among members of a group represents the quality of the group's
resource base, from which the group draws in solving the Winter Survival Exercise. One-way ANOVA detected no difference in group-average Practice Decision Quality across treatment conditions ($F[2,109] = 0.12, p = .885$). On a related vein, groups were also essentially the same in terms of their members' initial knowledge structure coherence. One-way ANOVA detected no difference in group-Average Knowledge Structure Coherence across treatment conditions ($F[2,106] = 0.29, p = .7459$). Gender composition of groups was also examined, on the assumption that groups of homogeneous gender compositions might realize certain efficiencies in cognitive convergence. All-male and all-female groups were coded "0"; mixed-gender groups were coded "1". Chi square analysis indicates that group composition (homogeneity vs. heterogeneity) was not significantly associated with experimental condition ($\chi^2 = 0.67$, 2 df, $p = .715$).

Previous acquaintance between group members could also facilitate cognitive convergence. Each individual's total Previous Acquaintance was computed by summing their three estimates of the number of months they had "personally
known" each of the other three group members (please see Table 1). One-way ANOVA, in violation of the variance homogeneity assumption (Lavene's statistic $F[2,461] = 10.07$, $p = .000$), detected no significant difference in total Previous Acquaintance between conditions ($F[2,461] = 2.86$, $p = .059$). Although both the definition of this variable and its analysis are problematic, there is little reason to suspect a substantive confound between accountability condition and previous acquaintance. As Table 1 indicates, the observed mean for Previous Acquaintance is lowest in the Justification condition, where cognitive convergence is expected to be highest after treatment. Clearly, this potential confound would operate in the opposite direction of experimental treatments, making hypothesis testing substantially conservative. Accordingly, this (apparent) particular failure of random assignment will not be treated as a serious threat to the internal validity of hypothesis testing.

This position is justified upon examination of the group-level data indicating knowledge structure similarity between group members. At the group level, analyses of
group member similarity indicate that groups were equivalent across conditions before the manipulations took place. Overall, the initial average inter-member cognitive structure similarity per group was unrelated to experimental condition (please see Table 2). This was true whether the group indicator was the average inter-correlation between members' raw proximity ratings ("Avg. Proximity Rating Similarity", $F[2,106] = 0.04, p = .963$), or the average similarity between PfNets based on those proximity ratings (Avg. PfNet Similarity, $F[2,106] = 1.66, p = .195$). In terms of cognitive convergence, groups began on equal footing across conditions.

On a final note, there were no confounds between treatment conditions and experiment logistics variables that would affect dependent variables (e.g., participant arousal and fatigue vary with time of day, and also have implications for motivation and cognitive performance). One-way ANOVA indicates that military hour of session start was unrelated to treatment condition (means are in Table 2, $F[2,113] = 0.96, p = .388$). Treatment condition was also unrelated to time remaining in academic term ($F[2,113] = \ldots$)
0.21, \( p = .811 \), which, according to experimenter lore, is a strong predictor of the general motivational characteristics of participants. Finally, both the identity and gender of the assistant experimenter were unrelated to treatment condition (\( \chi^2 = 8.98, 12 \text{ df}, \ p = .705 \), for identity; \( \chi^2 = 1.13, 2 \text{ df}, \ p = .570 \), for gender).

In conclusion, random assignment procedures succeeded in distributing both subject characteristics and experiment logistic variables evenly across treatment conditions. According to the logic of true experimentation then, post-treatment differences will be attributed to the accountability manipulations. Discussion turns next to the analyses of the strength and validity of the manipulations themselves.

**Manipulation Checks**

Instructional manipulations strongly affected participants' expectations of being answerable for the group decision making session. Specifically, those who were told that they would be individually accountable for recalling their group's solution (i.e., Recall and Justification conditions combined) were more likely to agree that they
were responsible for recall ($\chi^2 = 389.98$, 1 df, $p = .000$)
and to report expecting a recall requirement ($\chi^2 = 375.26$, 1
df, $p = .000$) than those who were not (Control condition).
Participants told that they would be individually
accountable for justifying their group's decision
(Justification condition) were more likely to agree that
they were responsible for justification ($\chi^2 = 368.68$, 1 df,
$p = .000$) and to report expecting a justification
requirement ($\chi^2 = 360.38$, 1 df, $p = .000$) than those who
were not (i.e. Control and Recall conditions combined).
Finally, participants in the Recall and Justification
conditions (combined) were more likely to believe that their
performance would be associated their names than those in
the Control condition ($\chi^2 = 177.84$, 1 df, $p = .000$).
Clearly, the instructional manipulations had their intended
effects on the experienced responsibility, expected
performance demands, and perceived identifiability of
participants.

**Reliability of Measures**

The experimental self-report measures of Average Member
Effort, Subjective Exchange Volume, and Subjective Common

80
Ground were subjected to reliability analyses. Table 3 lists the number of items, number of response options, internal consistency, and inter-rater agreement for each scale. Regarding internal consistency, Cronbach's (1951) alpha was estimated, with Nunnaly's (1967) criterion of .60 for scales still under development as the standard. As is shown in Table 3, alpha's ranged from .82 to .89, indicating strong internal consistency. Thus, scale scores for individuals were formed by summing across individual items within a scale, and then dividing by the number of items.

Further reliability analyses justify aggregating individual scores into group-level variables. In producing each measure (Average Member Effort, Subjective Exchange Volume and Subjective Common Ground), each of four group members produced multiple item ratings of a single target (the group). Averaging across group member's ratings assumes that rater's were in basic agreement about the group. Within-group interrater agreement was estimated by comparing the observed variance between raters to the variance expected if ratings were exclusively due to random error (James, Demaree, & Wolfe, 1984, 1993).
"proportional reduction in error variance", named $r_{wg}$ (James, Demaree, & Wolfe, 1993), ranges theoretically from zero, indicating no improvement over random responding, to 1.00, indicating perfect agreement. As Table 3 shows, the mean within-group interrater agreement was acceptable for both the Subjective Exchange Volume ratings and the Subjective Common Ground ratings ($r_{wg} = .87$ and $.69$, respectively), and it was quite high for Member Effort ($r_{wg} = .94$). Thus, group-level scores for each of the three measures were formed by averaging (computing the arithmetic mean of) the ratings of individual group members.

Hypothesis Testing

Hypotheses refer to group-level phenomena and involve both group-level measured variables and individual-level measured variables averaged per group. Means and standard deviations for each variable subjected to ANOVA or t-test are listed by condition in Table 2 (please refer to this table for the remainder of the Results section unless otherwise indicated). Pearson's $r$ correlations between measured variables used in hypothesis testing are reported in Table 4 (please see Table 4).
As explained earlier, the intensity of energy expended by group members during the group decision making session was measured by the Average Member Effort; persistence of energy expenditure is indicated by Time on Task. The correlation between these two facets of energy was suggestive but not significant ($r = .21, p = .08$). Further, these variables displayed slightly different relations to accountability condition (please see Table 2).

**Average Member Effort.** Hypotheses 1 and 4 predicted that both the Justification and Recall conditions would be characterized by higher cognitive effort than the Control condition. Results for Average Member Effort are mixed. One-way ANOVA detected a significant overall effect for experimental condition on Average Member Effort ($F[2,113] = 6.46, p = .002$). However, t tests indicated that Average Member Effort was heightened over Control only in the Justification condition ($t = 3.64, 79 \text{ df}, p = .000$, one tailed), not in the Recall condition ($t = 0.60, 70 \text{ df}, p = .277$, one tailed). In sum, the Justification requirement increased Average Member Effort as expected; the Recall requirement did not.
**Time on Task.** Results for the objective indicator of effort were exactly as predicted by Hypotheses 1 and 4. One-way ANOVA, in technical violation of the homogeneity of variance assumption (Lavene's statistic $[2,68] = 3.90, p = .025$) detected a significant strong overall effect for experimental condition on the amount of time groups allocated to the decision making session ($F[2,28] = 7.58, p = .001$). Planned pairwise comparisons confirmed a simple pattern in which Time on Task was increased over baseline controls in both the Recall and Justification conditions, with no other differences. This pattern emerged whether comparisons between groups were made using the Least Significant Difference multiple range test (LSD, $p < .05$), or the highly conservative Tukey's Honestly-Significant-Difference test.

**Subjective Exchange Volume.** The directional component of the sociocognitive elaboration process is measured in Subjective Exchange Volume. Hypotheses 2 and 5 predicted that sociocognitive elaboration would be increased over baseline Control only in the Justification condition. These hypotheses were supported. While the Recall condition was
statistically equivalent to Control in Subjective Exchange Volume ($t = 0.35, 70 \text{ df}, p = .365, \text{ one tailed}$), groups in the Justification condition reported a significantly higher Subjective Exchange Volume than did Controls ($t = 2.77, 79 \text{ df}, p = .004, \text{ one tailed}$). There were no unpredicted differences between conditions in Subjective Exchange Volume. Thus, Hypotheses 2 and 5 were supported in that only Justification accountability (not Recall) increased sociocognitive elaboration relative to controls.

**Cognitive Convergence**

Hypotheses 3 and 6 predicted that cognitive convergence would occur only under the Justification requirement. In experimental logic, cognitive similarity at Time 2 should be greater in Justification condition than in either of the others. Cognitive similarity was indexed at the group level by three variables: 1) average Proximity Rating Similarity --average correlations between group members' raw proximity ratings, 2) Average PfNet Similarity --average 'C' index between group member's PfNets, and 3) the Subjective Common Ground scale. Average Proximity Rating Similarity and Average PfNet Similarity per group were highly correlated ($r$
The Subjective Common Ground measure correlated significantly, but not highly, with both the above measures ($r = .29, p = .00$ for Avg. Proximity Rating Similarity; $r = .20, p = .04$ for Avg. PfNet Similarity), indicating that it taps unique variance in the construct of cognitive convergence.

**Subjective Common Ground.** On the subjective side is the degree of common ground group members reported their groups as having after solving the problem. Groups in the Justification condition reported a greater Subjective Common Ground than did groups in either the Control or Recall conditions ($t = 3.64, 79 \text{ df}, p = .000$, one tailed, for Control; $t = 2.73, 77 \text{ df}, p = .004$, one tailed, for Recall). There were no unpredicted differences between conditions for this variable. Thus, Hypotheses 3 and 6 were supported in that only Justification accountability (not Recall) increased Subjective Common Ground relative to controls.

**Knowledge Structure Similarity.** Analyses of objective group cognitive convergence were derived by comparing the proximity ratings made by group members. Given that groups were initially equivalent across conditions in terms of
average inter-member cognitive similarity before the group decision making session, cognitive convergence was defined in terms of similarity at after the discussion. Planned comparisons between groups were made using the Least Significant Difference multiple range test (LSD), so that each condition was compared to each other (with no adjustment for groupwise error).

Comparing raw proximity ratings between group members supports the hypothesis that the Justification condition encourages cognitive convergence. At the group level, there was an overall effect for condition on the Average Proximity Rating Similarity ($F[2,113] = 14.44, p = .000$). LSD tests confirmed that groups under the Justification requirement experienced higher convergence than those in either the Control or Recall conditions ($p < .05$). There were no unpredicted differences between conditions for this variable. Thus, Hypotheses 3 and 6 were supported in that only Justification accountability (not Recall) increased the correlation between proximity rating sets relative to controls.
When cognitive convergence was analyzed in terms of latent knowledge structure similarity, the same pattern emerged. There was an overall effect for condition on Average PfNet Similarity ($F[2,113] = 3.64, p = .030$). LSD tests confirmed that groups who solved the problem under the Justification requirement experienced higher convergence than those in either the Control or Recall conditions ($p < .05$). There were no unpredicted differences between conditions in knowledge structure similarity. Thus, Hypotheses 3 and 6 were supported in that only Justification accountability (not Recall) increased cognitive convergence relative to controls. Results for cognitive similarity are graphed in Figure 1 (Please see Figure 1). The slopes of the lines joining similarity data before and after discussion indicate cognitive convergence. Note that while all three treatment conditions start at about the same similarity level, the Justification condition clearly outgains the other two in cognitive convergence.

**Ancillary Analyses**

Although this study focussed on cognitive convergence, it is instructive to examine effects on knowledge structure
coherence. Presumably, the greater cognitive elaboration in the Justification condition would result in proximity rating sets with a relatively high degree of internal consistency. In fact, the results on proximity rating coherence follow exactly the same pattern as those for rating set intercorrelations and knowledge structure similarity. There was an overall effect for condition on the Average Knowledge Structure Coherence ($F[2,113] = 3.64, p = .030$). LSD tests confirmed that groups under the Justification requirement had higher Average Knowledge Structure Coherence than those in either the Control or Recall conditions ($p < .05$). There were no other differences in group-average coherence between conditions.

One could also presume that groups in the Justification condition would produce solutions similar to that produced by the expert panel which developed the task. Surprisingly, ancillary analyses detected no effects for experimental condition on Group Decision Quality in solving the Winter Survival Exercise ($F[2,113] = 0.17, p = .843$). This result is somewhat disturbing, because it signifies a lack of evidence of the association between cognitive convergence
and group decision quality. As an examination of Table 4 indicates, Group Decision Quality had no linear association with either measure of cognitive convergence ($r = -0.08, p = 0.407$, for Average PfNet Similarity; $r = -0.05, p = 0.592$, for Average Proximity Rating Similarity). Table 4 further reveals that Group Decision quality was essentially unrelated to all variables central to the main hypotheses. There are many possible explanations for this result, and some will be touched upon in the Discussion section.

The final ancillary hypothesis is designed to rule out a potential alternative explanation for the observed effects of Justification accountability on the cognitive similarity between group members. It is possible that the increase in similarity merely reflects the fact that all participants considered the same strategic decision task. That is, perhaps cognitive similarity between group members after group discussion reflects individual-level learning based on the task stimulus, rather than group-level convergence based on sociocognitive elaboration. This concern is heightened by the fact that all individuals in a given condition were exposed to the same experimental stimuli, regardless of
which group they were assigned to. Given this common experience with experimenter, task, and procedures, some post-session cognitive similarity is likely to have developed between any given pair of individuals run in the same condition, whether the individuals are members of the same group (i.e. discussed the problem together) or not (e.g., randomly selected from the pool of participants assigned to the same condition). Therefore, bolstering the claim that similarity reflects group cognitive process, rather than mere exposure to the same experimental stimuli, requires a demonstration that intragroup cognitive similarity is greater than intergroup cognitive similarity (Brewer, personal communication, 1996).

In order to demonstrate that group members converged as a result of their unique own sociocognitive elaboration histories, the ten most highly-converged groups (i.e., those with the highest Average PfNet Similarity after discussion) were selected. Each of 4 members from each of the 10 groups was put into a pool of 40 individuals. PCKNOT (Interlink, 1992) was used to apply the Pathfinder scaling algorithm in generating similarity comparisons between the knowledge
network structures for every possible pair of individuals in the pool. PCKNOT also generated probability estimates (significance levels) for each resulting similarity rating. A pair was considered significantly similar if and only if the probability of the observed similarity level occurring by chance was less than five percent (p < .05).

Each pair of knowledge networks represented either members of the same actual group (n = 60 pairs coded "1"), or individuals subjected to the same experimental conditions but not from the same group (n = 720 pairs coded "0"). Table 5 details this analysis (please see Table 5). One striking result revealed in Table 5A is that similarity was much higher for pairs of actual group members (mean similarity = .63) than for pairs of individuals (mean similarity = .28). Interestingly, similarity between pairs of individuals subjected to the Justification requirement (but not from the same group) was at about the same level as similarity between group members in the baseline control condition (.31, from Table 2). Together, these facts confirm that observed similarity levels reflect group-level cognitive convergence.
A related analysis concerns whether or not statistically-significant (p < .05) similarity even exists between a given pair of participants. Pairs with significant similarity were coded "1"; others were coded "0". This division was cross-tabulated with the coding mentioned above for group-member pairs versus pairs of individuals. Table 5 shows that while only 21% of non-member pairs showed any significant degree of similarity, 82% of member pairs were significantly similar to each other. Chi square analysis indicates that in the pairs analyzed, group membership was strongly associated with the existence of similarity ($\chi^2 = 109.57$, 1 df, $p = .000$).

Clearly, the observed increase in inter-member cognitive similarity reflects group-level cognitive convergence rather than a condition-wide commonality developed through exposure to common experimental materials.
CHAPTER 6

DISCUSSION

Results Summary

To summarize results, accountability increased the effort expended by groups as they generated a common solution to the strategic problem. Both the Recall and Justification requirement resulted in increased allocations of time to the decision making session. Interestingly, only participants in the Justification condition reported experiencing a heightened sense of effort.

As predicted, only the Justification requirement resulted in an increased exchange of ideas during group discussion. When group discussion was over, groups in the Justification condition had achieved a higher degree of cognitive convergence than groups in either of the other two conditions. Not only were their latent knowledge structures more objectively similar, but they also reported a greater
subjective common ground than did groups in either the Recall or Control conditions. Knowledge structure convergence is a group phenomenon which is empirically distinguishable from the effects of exposure to common stimulus materials.

Finally, ancillary analyses indicate that these closely converged structures in the Justification condition were also more coherent than those in the other conditions. Interestingly, experimental conditions had no apparent effects on the expert quality of solutions to the strategic decision task.

**Contributions to Cognitive Convergence Theory**

This study represents a new level of coherence, formality, and specificity in cognitive convergence theory. It is the first formal specification of the micro-mediational processes by which cognitive similarity develops between members of groups and teams. The construct labeled "cognitive convergence" was developed here to represent the empirical phenomenon in which individuals cooperating in goal-oriented contexts develop similarities in their structural cognitive representations.
Cognitive convergence as a phenomenon was substantiated according to modern standards of systematic empiricism. This represents a substantial improvement over mainstream treatments of cognitive convergence. Most researchers have appeared content to draw unempirical conclusions about the role of cognitive convergence (for an exception, see Rentsch, Heffner, & Duffy, 1993), based on analyses of communicative behaviors and their relationships to concurrent performance levels.

As an example of current literature on shared cognition, Orasanu (1990) reports a study entitled "Shared Mental Models and Crew Decision Making", which observed flight crews as they coped with emergencies during simulated flight. Results indicate that high-performing crews were more alert to information, more planful and more communicative than low-performing crews. The main conclusion is that "effective team decision making and performance depend on shared mental models for the situation" (Orasanu, 1990, p. 1). This intuitively appealing conclusion represents an enormous leap from an empirical perspective. It is the same leap which continues...
to be made by the mainstream of group- and team-effectiveness research: presuming a causal role for cognitive convergence without both 1) empirically substantiating convergence using independent measurement procedures, and 2) inducing cognitive convergence through experimental manipulations.

Regarding the first point, this study measured cognitive convergence using a structural approach to cognitive representation of a specific problem domain. Cognitive similarity was assessed through comparisons of graph theoretic representations of participant's cognitive structures. Convergence was examined by comparing similarity indices both before and after a focal group development process.

Regarding the second point, this original importation of cognitive elaboration theory into the context of group development aided in specifying the processes and causal factors behind cognitive convergence. Cognitive convergence is modeled as a product of motivated group interaction. The theory of cognitive convergence specifies the energy and direction of interaction that enables the alteration of
cognitive structures at the individual level in a manner which is convergent at the group level.

The theory of cognitive convergence advances cognitive elaboration theory by further explicating the processes by which cognitive structures are altered in social interaction. Individual cognitive effort is necessary but not sufficient for building knowledge structure similarity among group members discussing a problem domain. Effort must be channeled in a direction which supports sociocognitive elaboration, a process characterized by a high exchange of ideas among group members. This study examined elaboration likelihood in real, goal-oriented groups.

The Justification condition of this experiment was designed to direct individual effort toward sociocognitive elaboration, by charging each group member with the responsibility of justifying the group's decision to a group of authorities. Accountability for justifying a group's solution interests the agent in contributing, receiving, and collaboratively testing messages from fellow group members. This condition resulted in higher cognitive effort,
sociocognitive elaboration, and cognitive convergence relative to Control.

The Recall condition was designed to mobilize cognitive effort, but to channel it toward simple recall, not sociocognitive elaboration. This condition resulted in higher cognitive effort, but no increment in either sociocognitive elaboration or cognitive convergence, relative to Control. The Recall condition in this experiment demonstrates empirically that effort is distinct from elaboration. While effort represents the energetic dimension of cognitive convergence process, sociocognitive elaboration represents the directional component. High levels of effort were observed in both the Recall and Justification conditions. In contrast, only the Justification condition was characterized by a high volume of idea exchange, with the resulting cognitive convergence.

Future directions in theory development include the need to develop process measures which predict cognitive convergence. Innami (1992, 1994) developed a system for classifying utterances made by group members as they solved a decision problem through verbal interaction. The system
predicted decision quality, but could not be empirically related to cognitive convergence, which was unmeasured.

Finally, the issue of decision quality in the present study should be addressed. Ancillary analyses indicate that there were no detectable effects by accountability condition on decision quality. Tables 1 and 2 indicate that neither practice solution quality (before manipulations), nor group solution quality, nor the quality of private individual solutions taken after the experiment was over, differed by accountability condition. There are two likely explanations for this non-significant result.

The first is a lack of domain-specific knowledge on the part of group members. An examination of verbatim transcripts reveals that participants tended to be quite naive in their approaches to solving the Winter Survival Exercise. Even groups who reasoned extensively about item functions tended to produce solutions involving naive survival priorities (e.g., setting out for a town before insulating the body from the cold; planning elaborate defenses against ferocious wildlife), impossible uses for survival items (e.g., using a 42.5% alcohol solution as
lighter fluid), and counterproductive uses (e.g., drinking whiskey to stay warm, although the liquid would actually be cold enough to destroy internal body tissues). In short, participants lacked domain-relevant knowledge. It is possible that the absence of performance effects is due to a relative absence of domain-relevant knowledge resources among group members. Effective group decision making requires not only effective group process, but also a knowledge base for the group to draw from (Klimoski & Jones, 1994). In organizational terms, groups may have suffered from very poor staffing (cf., Klimoski & Jones, 1994). The lack of performance effects here highlights that group decision making is a combining process which taps the cognitive resources of group members. The case of the present participants working on the present task may be one of "garbage in, garbage out."

A second possible explanation for lack of performance effects involves the performance measure itself. Decision quality in groups' solutions was computed in reference to an expert solution, as described in the Methods section above. As a few participants pointed out during experimental
debriefing, there is more than one clever way to rank the survival items, and agreement with the expert solution represents one of what may be dozens of viable solutions.

In questioning the validity of the decision quality measure, it is instructive to note that Group Decision Quality exhibited no significant correlation with any of the seven other group-level variables (please see Table 4). This unusual "blackout" pattern could indicate an undefined problem with what otherwise appears to be a credible performance measure. Alternatively, the blackout pattern can be traced to the nature of the accountability conditions used to highlight convergence processes. Specifically, as an examination of the experimenter scripts (please see Appendix F) reveals, none of the accountability conditions explicitly anticipates the measurement of decision quality. The Recall conditions demanded just that --that participants prepare to recall their group's decision; the Justification further demanded the ability to justify that decision once it was made, stating "...We are interested in how accurately you can recall, explain, and justify your group's [solution to the Winter Survival Exercise], because in work
organizations, teams depend on their members to champion the team's decisions..." Perhaps the explicit addition of a demand for expert decision quality would have resulted in reliable decision quality effects. (The reader will recall that the present manipulations were designed specifically to investigate the phenomenon of cognitive convergence.)

Thus, one of the limitations of this study is that cognitive convergence was not linked to performance. Future studies should ensure that substantial domain-relevant expertise is available to groups as they attack the problem. In addition, where studies are designed to investigate decision quality effects, explicit demands for decision quality should be made.

Contributions to Group Cognition Research

As discussed above, the direct measurement of cognitive structures should be incorporated into essential standards for research involving cognitive convergence. Determining the overlap between team member's mental models may be the most difficult measurement problem imposed by the cognitive convergence hypothesis (cf., Converse, Cannon-Bowers, & Salas, 1991). Fortunately, collaborative efforts to inform
the measurement of cognitive structures in groups and teams are underway (e.g., Klimoski, Mohammed, & Rentsch, in preparation). It is fair to say that this study currently represents the state of the art in cognitive convergence measurement. Further advances in measuring group cognition are likely to occur in the near future.

On another vein, the present study contributes to methodology in cognitive convergence research by introducing a measure of subjective common ground (see Methods section above). This measure indexes the phenomenological aspects of cognitive convergence. The phenomenological approach requires that group members be conscious of their shared cognitive structures (Klimoski & Mohammed, 1994). The subjective common ground scale demonstrated good internal consistency, and it correlates significantly with objective measures of latent cognitive convergence ($r = .29$, $p = .002$, with proximity ratings; $r = .20$, $p = .037$, with PfNet similarity). Thus, group members in this sample experienced their cognitive convergence in the phenomenological sense. Member awareness of group cognitive capacity is a key to its functional significance (Klimoski & Mohammed, 1994).
Further strengthening and validation of the subjective common ground measure would yield a useful measurement device for group cognition research.

More fundamentally useful is the present contribution of a basic technique for the experimental induction of cognitive convergence in groups and teams. Accountability for justifying a group or team decision energizes and directs member resources toward sociocognitive elaboration of a target domain, resulting in cognitive convergence. Experimental manipulations of cognitive similarity are critical in justifying conclusions about the causal role of shared cognition in group and team functioning. Given that a technique for the experimental induction of cognitive convergence is now available, researchers need not rely solely on indirect evidence in developing conclusions about the causal roles of shared cognition in group and team functioning.

Guidance for Groups Developing Shared Cognition

Cognitive convergence is integral to the development of group and team cognition. When cognitive convergence is modeled as group output, the motivational process losses
(Steiner, 1972) to watch for include not only intensity of effort, but also direction of effort. Where cognitive convergence is desired, group members should be encouraged to direct their efforts toward exchanging ideas. The present research demonstrates that motivated, or at least effortful, groups are still subject to deficits in cognitive convergence.

A second type of process loss mentioned by Steiner involves deficits of coordination. Perhaps newly formed groups could benefit from having a model for developing a team mental model. In other words, the convergence of knowledge structures may be enhanced by providing guidelines for identifying and resolving conflicts among the initial knowledge structures of group members.

Such guidelines already exist, although the mechanisms by which they work have not been well articulated. For example, Stein (1982) reviews evidence that groups of heterogeneous composition tend to be relatively creative when using a technique called synectics (Stein, 1975) which encourages the use of metaphors and analogies to depict problems.
Also on the process intervention vein, an interesting investigation of the effects of providing discussion guidelines is presented by Innami (1994), who reports the successful use of an intervention known as Consensual Conflict Resolution (CCR, originally by Hall & Watson, 1970). The intervention emphasizes knowledge-based, logical discussion and consensual resolution of conflicting views in order to arrive at a group decision. Innami (1992, 1994) found that CCR simultaneously increased reasoning orientation and decreased positional orientation in the verbal interactions among managers of a Japanese pharmaceutical company. This dual effect on process in turn led to increased decision quality. Innami attributes the decision quality increment to the development of a "group belief structure" based on the integration of individual members' belief structures. However, no attempt was made to measure the existence or development of such structures (Innami, 1992, 1994).

The present study clearly demonstrates that cognitive convergence can be enhanced by means other than process interventions. In this experiment, accountability
conditions were manipulated, resulting in cognitive convergence effects. Participants were not told how to behave during group discussion, or by what means to achieve agreement. Rather, they were told what they would be accountable for once a decision was made. Apparently, participants were quite capable of structuring their own group discussions in response to accountability. This fact is striking given the relative inexperience of participants (i.e., mean work experience less than two full-time-equivalent years).

It is also an important discovery from a costs/benefits perspective. Process interventions are expensive in that they require expertise and also time set aside for the process training. Accountability interventions such as the justification requirement motivate group members to use their existing skills in achieving cognitive convergence. Therefore, it may be more cost effective to use an accountability intervention similar to that used here. For maximum effect, process training could be combined with an accountability demand.
By making each group member accountable to an audience within the organization, and then to fellow group members, for being able to justify the group's decisions, managers can reduce process losses and speed cognitive convergence. As an example, a strategic decision making group which customarily presents its findings to a board might be instructed to delay the selection of a representative until shortly before the presentation, when a representative is chosen randomly from group members. As part of the accountability manipulation, the group would convene after the representative's presentation to evaluate its fidelity to the decision reached earlier. Accountability further requires that some significant outcome be linked to that evaluation. However, the social demands inherent to the situation might be sufficient in this regard.

Conclusion

As organizations increasingly depend on groups for strategic decision making and implementation, cognitive congruity among group members becomes an important issue. The team mental model literature seeks to understand the performance of groups as a consequence of group-level
cognition (Klimoski & Mohammed, 1994). But this understanding is hampered by an unscientific treatment of the cognitive convergence process, resulting in provocative causal conclusions involving unmeasured, un-manipulated variables.

The present report articulated a formal theory of cognitive convergence, in which group members develop cognitive similarities through sociocognitive elaboration. The theory was tested in an experiment which also demonstrates how cognitive convergence can be induced for later research to observe its effects. Researchers of group cognition are strongly encouraged to use this technique as a basis for experimental studies of the role of cognitive similarity in group performance.
LIST OF REFERENCES


In J.K. Ford and Associates (Eds.), Improving training effectiveness in work organizations. Hillsdale, NJ: Lawrence Earlbaum.


Hutchins, E. (1990). The technology of team navigation. In J. Galegher, R. E. Kraut, & C. Egido (Eds.),

Interlink, Inc. (1992). KNOT: Knowledge network organizing tool for IBM PC's (Computer application). Las Cruces, New Mexico, USA.


James, G. S. (1951). The comparison of several groups of observations when the ratios of the population variances are unknown. Biometrika, 38, 324-329.


1. Of course, formal divisions of labor and procedural manuals/training could be considered as techniques for imposing shared cognitive structures minimally necessary for effective coordination. However, as the Hutchins example illustrates, these often assume error-free functioning on the part of individuals.

2. While the "group belief structure" is a key construct in Innami's (1992) writing, it is unmeasured in the study he reported.

3. For simplicity at this stage, the general integrative nature of group process is assumed. This is partly due to the dearth of theoretical development specifically describing the combining processes of group decision making. Follow-up research on group process (i.e. coding audio-recorded group interaction for the amount/degree of integration) may reveal an interaction between cognitive effort and integrative process in their effects on cognitive similarity. Alternatively, integrative group process could be treated as a mediator between cognitive effort and post-session cognitive similarity.

4. Accountability is used here as a laboratory technique for manipulating the level of cognitive effort expended by participants, and for directing their efforts in a manner hypothesized to result in cognitive convergence. This study is not intended to contribute to accountability theory, but rather asks what accountability techniques can do for cognitive convergence theory.
5. Experience in laboratory experimentation indicates that participants are sensitive to apparent status/expertise hierarchies within experimenter ranks. Specifically, participants naturally become cognizant of "who is in charge" by observing, for instance, that a young experimenter performing an assisting function repeatedly receives direction from an older one, or reports progress to that person. The present accountability manipulations capitalize on participants' savvy by having the apparently-in-charge experimenter deliver the instructions in the accountability conditions. In contrast, control instructions will be delivered by the apparently-not-in-charge research assistant.

6. No participant in pilot studies (N = 140) refused to consent to the accountability procedures. Some participants did report feeling anxious about the prospect of appearing in front of the panel. For this reason, the consent form serves not only as a prop in the instructional manipulation, but also as an ethical safeguard, by giving anxious participants the real option to decline participation in the procedures.
APPENDIX A

WINTER SURVIVAL SCENARIO

The Situation

You have just crash landed somewhere in the woods of northern Minnesota or southern Manitoba. It is 11:32 AM in mid-January. The small plane in which you were traveling was destroyed except for the frame. The pilot and copilot have been killed, but no one else is seriously injured.

You are in a wilderness area made up of thick woods broken by many lakes and rivers. The last weather report indicated that the temperature would reach minus twenty-five degrees in the daytime and minus forty at night. The men and women in your party are wearing business attire (including pants and jackets), street shoes, and overcoats.

While escaping from the plane, your group salvaged the fifteen items listed below. Your task is to rank these items according to their importance to your survival. You may assume that the number of persons who survived the crash is the same as number in your group and that you have agreed to stick together.

Flashlight with batteries
Ball of steel wool
Cigarette lighter (without fluid)
Quart of 85-proof whiskey
Sectional air map made of plastic
Extra shirt and pants for each person
Compress kit with 28 ft., 2 in.-gauze
Loaded .45 caliber pistol
Can of shortening
Compass
Newspaper (1 per person)
Two ski poles
Knife
30 feet of rope
Family-size chocolate bar (1 per person)

Use the first page of the packet to record your rankings.

NOTE: This scenario was developed by a group of winter survival experts, and has been used in previous research on decision making (e.g., Locke, 1991).

HINT: Even though your group initially escaped from the plane, a party in this situation definitely should NOT venture out searching for a town, rescuers, etc. The chances of survival are dramatically increased if you STAY WITH THE WRECKAGE.
**Solution to the Winter Survival Scenario**

Rank the following items in order of importance to your survival, starting with "1" for the most important, "2" for the second most important, and so on, proceeding to "15" for the least important. Feel free to refer back to the Scenario as often as you wish.

<table>
<thead>
<tr>
<th>Item</th>
<th>Individual Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compress kit with 28 ft., 2 in.-gauze</td>
<td></td>
</tr>
<tr>
<td>Ball of steel wool</td>
<td></td>
</tr>
<tr>
<td>Cigarette lighter (without fluid)</td>
<td></td>
</tr>
<tr>
<td>Loaded .45 caliber pistol</td>
<td></td>
</tr>
<tr>
<td>Newspaper (1 per person)</td>
<td></td>
</tr>
<tr>
<td>Compass</td>
<td></td>
</tr>
<tr>
<td>Two ski poles</td>
<td></td>
</tr>
<tr>
<td>Knife</td>
<td></td>
</tr>
<tr>
<td>Sectional air map made of plastic</td>
<td></td>
</tr>
<tr>
<td>30 feet of rope</td>
<td></td>
</tr>
<tr>
<td>Family-size chocolate bar (1 per person)</td>
<td></td>
</tr>
<tr>
<td>Flashlight with batteries</td>
<td></td>
</tr>
<tr>
<td>Quart of 85-proof whiskey</td>
<td></td>
</tr>
<tr>
<td>Extra shirt and pants for each person</td>
<td></td>
</tr>
<tr>
<td>Can of shortening</td>
<td></td>
</tr>
</tbody>
</table>
In this section, we ask you to make special ratings which, when analyzed by computer, give us an indication of your perspective on the Winter Survival Scenario. The following pages ask you to produce ratings of the relatedness between survival items.

Survival items are "related" according to their uses for survival in this situation. Each item may have one or more potential uses in the situation described in the Winter Survival Scenario. In comparing two items, consider the uses they serve. Items are "related" to the extent that their more important uses are the same or similar. If two items have no uses in common, they are "unrelated." Therefore, with the Winter Survival Scenario in mind, please base your ratings on overall relatedness in function.

Each survival item will be centered on the top of a list containing other items. As you go down the list, compare the centered item with each of those in the list. Indicate your judgement of relatedness of each list item to the centered item by marking in the blank next to the list item. For example, if you feel that the list item is not related at all to the centered item write "1" in the list blank. If you feel the items are highly related you would mark an "8" or a "9". Higher numbers indicate greater overall relatedness in terms of the survival scenario. If anything is unclear, just ask the experimenter. You have about 20 minutes to make 105 ratings. Begin.

| UNRELATED 1 2 3 4 5 6 7 8 9 RELATED |

Compress kit with 28 ft., 2 in.-gauze

Ball of steel wool

Cigarette lighter (without fluid)
| UNRELATED 1 2 3 4 5 6 7 8 9 RELATED |

**Ball of steel wool**

<table>
<thead>
<tr>
<th>Loaded .45 caliber pistol</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Newspaper (1 per person)</td>
<td></td>
</tr>
<tr>
<td>Compass</td>
<td></td>
</tr>
<tr>
<td>Two ski poles</td>
<td></td>
</tr>
<tr>
<td>Knife</td>
<td></td>
</tr>
<tr>
<td>Sectional air map made of plastic</td>
<td></td>
</tr>
<tr>
<td>30 feet of rope</td>
<td></td>
</tr>
<tr>
<td>Family-size chocolate bar (1 per person)</td>
<td></td>
</tr>
<tr>
<td>Flashlight with batteries</td>
<td></td>
</tr>
<tr>
<td>Quart of 85-proof whiskey</td>
<td></td>
</tr>
<tr>
<td>Extra shirt and pants for each person</td>
<td></td>
</tr>
<tr>
<td>Can of shortening</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cigarette lighter (without fluid)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Loaded .45 caliber pistol</td>
<td></td>
</tr>
<tr>
<td>Newspaper (1 per person)</td>
<td></td>
</tr>
<tr>
<td>Compass</td>
<td></td>
</tr>
<tr>
<td>Two ski poles</td>
<td></td>
</tr>
<tr>
<td>Knife</td>
<td></td>
</tr>
<tr>
<td>Sectional air map made of plastic</td>
<td></td>
</tr>
<tr>
<td>30 feet of rope</td>
<td></td>
</tr>
<tr>
<td>Family-size chocolate bar (1 per person)</td>
<td></td>
</tr>
<tr>
<td>Flashlight with batteries</td>
<td></td>
</tr>
<tr>
<td>Quart of 85-proof whiskey</td>
<td></td>
</tr>
<tr>
<td>Extra shirt and pants for each person</td>
<td></td>
</tr>
</tbody>
</table>
Can of shortening

Cigarette lighter (without fluid)

Loaded .45 caliber pistol
Newspaper (1 per person)
Compass
Two ski poles
Knife
Sectional air map made of plastic
30 feet of rope
Family-size chocolate bar (1 per person)
Flashlight with batteries
Quart of 85-proof whiskey
Extra shirt and pants for each person
Can of shortening

Loaded .45 caliber pistol

Newspaper (1 per person)
Compass
Two ski poles
Knife
Sectional air map made of plastic
30 feet of rope
Family-size chocolate bar (1 per person)
Flashlight with batteries
Quart of 85-proof whiskey
Extra shirt and pants for each person
Can of shortening

|---|---|---|---|---|---|---|---|---|---|
UNRELATED 1 2 3 4 5 6 7 8 9 RELATED

Newspaper (1 per person)

Compass
Two ski poles
Knife
Sectional air map made of plastic
30 feet of rope
Family-size chocolate bar (1 per person)
Flashlight with batteries
Quart of 85-proof whiskey
Extra shirt and pants for each person
Can of shortening

|---|---|---|---|---|---|---|---|---|---|
UNRELATED 1 2 3 4 5 6 7 8 9 RELATED

Compass

Two ski poles
Knife
Sectional air map made of plastic
30 feet of rope
Family-size chocolate bar (1 per person)
Flashlight with batteries
Quart of 85-proof whiskey
Extra shirt and pants for each person
Can of shortening

|-----------------|
UNRELATED 1 2 3 4 5 6 7 8 9 RELATED

Two ski poles

Knife
Sectional air map made of plastic
30 feet of rope
Family-size chocolate bar (1 per person)
Flashlight with batteries
Quart of 85-proof whiskey
Extra shirt and pants for each person
Can of shortening

|-----------------|
UNRELATED 1 2 3 4 5 6 7 8 9 RELATED

Knife

Sectional air map made of plastic
30 feet of rope
Family-size chocolate bar (1 per person)
Flashlight with batteries
Quart of 85-proof whiskey
Extra shirt and pants for each person
Can of shortening

131
Sectional air map made of plastic

30 feet of rope
Family-size chocolate bar (1 per person)
Flashlight with batteries
Quart of 85-proof whiskey
Extra shirt and pants for each person
Can of shortening

30 feet of rope
Family-size chocolate bar (1 per person)
Flashlight with batteries
Quart of 85-proof whiskey
Extra shirt and pants for each person
Can of shortening

Family-size chocolate bar (1 per person)
Flashlight with batteries
Quart of 85-proof whiskey
Extra shirt and pants for each person
Can of shortening
Flashlight with batteries

Quart of 85-proof whiskey
Extra shirt and pants for each person
Can of shortening

Quart of 85-proof whiskey
Extra shirt and pants for each person
Can of shortening

Extra shirt and pants for each person
Can of shortening
APPENDIX C

SUBJECTIVE COMMON GROUND SCALE

Judge each of the following statements according to what extent it is accurate in describing your group at this point in time. Indicate your judgement by writing one of the numbers from the rating scale in the blank to the left of each item. For example, a highly accurate statement gets a "5", and a highly inaccurate statement gets a "1". A zero means it is too soon to tell.

**Rating scale:**
1 = totally inaccurate  
2 = fairly inaccurate  
3 = slightly inaccurate  
4 = slightly accurate  
5 = fairly accurate  
6 = totally accurate  
0 = no way to judge this particular item yet

___ 1. Our individual ideas combine readily into a whole.
___ 2. We have a "group view" which incorporates the views of members.
___ 3. We have a shared understanding of the task.
___ 4. We have common ground.
___ 5. We look at things from the same perspective.
___ 6. We have a common stake how well the group performs.
7. We interpret things the same way.

8. We assess situations in a similar way.

9. In discussing the task, we naturally come to consensus.

10. We share definite "group beliefs."
CONFIDENTIAL RESPONSE: Your personal responses to these items are totally confidential, because it is important to us that you answer each item honestly and accurately.

Think back to the group decision making session. The following questions ask you about various aspects of the group decision making session itself. Please circle one NUMBER on the rating scale to answer each question as accurately as possible.

<table>
<thead>
<tr>
<th>Question</th>
<th>Rating Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How difficult did you find the group decision making session?</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td>very, very easy</td>
</tr>
<tr>
<td>2. What level of thought did you put into the group decision task?</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td>very very shallow thought</td>
</tr>
<tr>
<td>3. How much mental effort did you invest in the group session?</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td>very, very low mental effort</td>
</tr>
</tbody>
</table>
4. How often did your thoughts wander to other concerns?

1 2 3 4 5 6 7 8 9
not even once very, very often

5. How much attention did you pay to what was being said?

1 2 3 4 5 6 7 8 9
very little a very great amount of attention of attention

6. How difficult was it to gain an overall view of the problem?

1 2 3 4 5 6 7 8 9
very, very easy very, very difficult

7. To what degree did you concentrate on the group's task of ranking items?

1 2 3 4 5 6 7 8 9
not at all to a very great degree

8. To what degree were you focussed on coming up with the best group solution?

1 2 3 4 5 6 7 8 9
not at all extremely focussed

9. What level of effort did you put into understanding the group's decisions?

1 2 3 4 5 6 7 8 9
very low very high level of effort
10. To what extent did you carefully read the information presented in the Winter Survival Scenario?

1 2 3 4 5 6 7 8 9
not at all to a very great extent

11. To what extent do you consider the Winter Survival Scenario to be a useful task for examining a person's overall decision making skill?

1 2 3 4 5 6 7 8 9
does not indicate accurately indicates skill
APPENDIX E

SUBJECTIVE EXCHANGE VOLUME SCALE

Please circle one NUMBER to indicate how much you disagree or agree with each statement about the behavior of your group and group members during the group decision making session. All responses are confidential.

1. Everyone contributed all their knowledge on the problem.
   strongly disagree 1  2  3  4  5  6  strongly agree

2. Some spoke up only when asked.
   strongly disagree 1  2  3  4  5  6  strongly agree

3. The group heard all relevant ideas before deciding on a solution.
   strongly disagree 1  2  3  4  5  6  strongly agree

4. Everyone participated.
   strongly disagree 1  2  3  4  5  6  strongly agree

5. Each person had a chance to be heard.
   strongly disagree 1  2  3  4  5  6  strongly agree

6. Some members appeared to withhold questions.
   strongly disagree 1  2  3  4  5  6  strongly agree

7. We maintained a high exchange of ideas.
   strongly disagree 1  2  3  4  5  6  strongly agree
8. We had constructive arguments.

strongly disagree 1 2 3 4 5 6 strongly agree

9. One or two members tended to do most of the talking.

strongly disagree 1 2 3 4 5 6 strongly agree

10. Some members of the group would not disagree in order to avoid conflict.

strongly disagree 1 2 3 4 5 6 strongly agree
APPENDIX F

EXPERIMENTER SCRIPT

(SCRIPTED INSTRUCTIONS TO PARTICIPANTS PER CONDITION)

INTRODUCTION

CONTROL: Experimenter Script:

= = = = = = = = = = = pass out Scenario, and Packet I = = = = = = = = = =

Welcome to the experiment. The principle investigator is Robert Billings, a professor in the Psychology Department at OSU. The head experimenter is Timothy Crespin, a graduate research associate in industrial/organizational psychology at OSU. Your participation involves completing a complex decision task, and reporting to researchers about the experience. Participation is voluntary and you may withdraw at any time.

We're using a task which has been developed specially for research on decision making. It's called the Winter Survival Scenario. Free feel to write on this sheet.

In solving this problem, it is not necessary to make believe that you are actually in this survival situation. Simply assume the perspective of a survivor in this situation, and make what you feel are the best decisions.
Take the first 15 minutes of the experiment to solve the scenario by filling out the first page of your packet. You solve the scenario by ranking the survival items according to how important they are to your survival. You'll assign the most important item a rank of "1", the second most gets a "2", and so on, with the least important getting a "15." Read the instructions, and if you have any questions, ask.

--- allow up to 15 min., giving 2 minute warning ---

Now turn the page and begin the remainder of this packet. Read the instructions carefully before beginning. If you have any questions about making relatedness ratings, feel free to ask. As soon as everyone's finished, I'll describe how the main part of the experiment will be conducted.
RECALL ACCOUNTABILITY CONDITION

AND ALSO

JUSTIFICATION ACCOUNTABILITY CONDITION (IDENTICAL)

Experimenter Script:

============= pass out Scenario, and Packet I
============= =

Welcome to the experiment. The first half will be conducted here, and the second half will be conducted in another room.

We're using a task which has been developed specially for research on decision making. It's called the Winter Survival Scenario.

In solving this problem, it is not necessary to make believe that you are actually in this survival situation. Simply assume the perspective of a survivor in this situation, and make what you feel are the best decisions.

Take the first 15 minutes of the experiment to solve the scenario by filling out the first page of your packet. You solve the scenario by ranking the survival items according to how important they are to your survival. You'll assign the most important item a rank of "1", the second most gets a "2", and so on, with the least important getting a "15." Read the instructions, and if you have any questions, ask.
As soon as everyone's finished, I'll describe how the remainder of the experiment will be conducted.

== =========== allow up to 15 min., giving 2 minute warning =========== =

Now turn the page and begin the remainder of this packet. Read the instructions carefully before beginning. If you have any questions about making relatedness ratings, feel free to ask. As soon as everyone's finished, I'll describe how the main part of the experiment will be conducted.
ACCOUNTABILITY MANIPULATION:

CONTROL CONDITION

You have completed the practice phase of the experiment, in which we gave you a chance to become familiar with solving the Winter Survival Scenario, and also making relatedness comparisons.

In this next phase, you will solve the Winter Survival Scenario as a group. That is, the group will decide on the best way to rank the survival items.

When you and your group have decided on the best set of priority rankings, we will move on to something else.

We will not document anything here your name, and all your responses will totally anonymous. No part of the rest of the experiment will be associated with you personally in any way.

Before you begin the rest of the experiment, let me thank you for participating.
RECALL ACCOUNTABILITY

You have completed the practice phase of the experiment, in which we gave you a chance to become familiar with solving the Winter Survival Scenario, and also making relatedness comparisons.

In this next phase, you will solve the Winter Survival Scenario as a group. That is, the group will decide on the best way to rank the survival items.

Before you begin, it is important that you understand that each of you is individually accountable for being able to recall the solution your group generates.

When you and your group have decided on the best set of priority rankings, I'll guide each of you individually to an observation room where I will ask you to recall those numerical rankings accurately in front of me and two graduate students.

We are interested in how accurately you can reproduce your group's numerical rankings, because in work organizations, teams depend on their members to remember the team's decisions, regardless of how that plan or decision came to be.

Our observation panel will assess how much effort you have put toward being able to recall the priority rankings decided upon by you and your group. We will need to document the assessment in your name for use by us and other faculty and researchers in the psychology department, in case they wish to contact you. Now, the only thing that we will document in your name is how closely your reproduction matches the numerical priority rankings recorded by the group. Nothing else here will be associated with you in any way.

[point out features of form]
Sign the form to show your formal consent to allow us to document and release your recall of the priority rankings. Fill in the date, your age and gender, and find the blank further down to write in your name.
JUSTIFICATION ACCOUNTABILITY

I'll read these instructions to you, because they're important:

You have completed the practice phase of the experiment, in which we gave you a chance to become familiar with solving the Winter Survival Scenario, and also making relatedness comparisons.

In this next phase, you will solve the Winter Survival Scenario as a group. That is, the group will decide on the best way to rank the survival items.

Before you begin, it is important that you understand that each of you is individually accountable for being able to justify the solution your group generates.

When you and your group have decided on the best set of priority rankings, I'll guide each of you individually to an observation room where I will ask you to recall, explain and justify those numerical rankings accurately in front of me and two graduate students.

We are interested in how accurately you can recall, explain, and justify your group's rankings, because in work organizations, teams depend on their members to champion the team's decisions.

In particular, our panel will want to know:

-what information was used in making each ranking decision
-the reasons why one item was ranked above or below another
-which items go together and which don't

The observation panel will assess how much effort you have put toward understanding the reasons behind the priority rankings decided upon by you and your group. We will need to document the assessment in your name for use by us and other faculty and researchers in the psychology department, in case they wish to contact you.
Sign the form to show your formal consent to allow us to document and release your recall of the priority rankings. Fill in the date, your age and gender, and find the blank further down to write in your name.
APPENDIX G

CONSENT FORMS PER CONDITION

(CONT TO BE PRINTED ON UNIVERSITY LETTERHEAD)

CONTROL CONDITION

I consent to being audio recorded in group discussion.

_____________________________  ___________________________
signature                           date

age: ____________  gender: Male Female

principle investigator Dr. Robert S. Billings __________________
RECALL ACCOUNTABILITY

ACCOUNTABILITY FOR RECALLING GROUP'S SOLUTION

ID#___________  T=2

I consent to being audio recorded in group discussion.

CONSENT TO PERSONAL ACCOUNTABILITY: I consent to personal responsibility for remembering my group's solution. I authorize a psychology panel to document how well I RECALL the group's priority rankings for each item, knowing that this information will be made available to other members of the psychology department.

_________________________  ______________________________
signature                  date

age: __________  gender: Male  Female

principle investigator Dr. Robert S. Billings ________________
JUSTIFICATION ACCOUNTABILITY

ACCOUNTABILITY FOR JUSTIFYING GROUP'S SOLUTION

I consent to being audio recorded in group discussion.

CONSENT TO PERSONAL ACCOUNTABILITY: I consent to personal responsibility for remembering my group's solution and being able to justify it. I authorize a psychology panel to document how well I RECALL, EXPLAIN AND JUSTIFY my group's solution, knowing that this information will be made available to other members of the psychology department.

________________________    __________________________
signature                     date

age: __________    gender: Male Female

principle investigator Dr. Robert S. Billings _________________
APPENDIX H

MANIPULATION CHECK

Instructions Check

Before beginning the group discussion, please answer these questions to give us an indication of how clear the instructions are to you. Circle one answer for each of the four questions.

Looking back on the experimenter's instructions...

1. Are you being held responsible for justifying and explaining your group's solution?
   no      yes      don't know

2. Are you being held responsible for recalling your group's solution?
   no      yes      don't know

After your group records its solution...

3. Will you be required to recall your group's solution?
   no      yes      don't know

4. Will you be required to justify your group's solution?
   no      yes      don't know

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Regarding the remainder of the experiment...

5. Will your responses be kept secret?
   no     yes     don't know

6. Will your performance be associated with your name?
   no     yes     don't know
APPENDIX I

TABLES AND FIGURES
<table>
<thead>
<tr>
<th>Individual-level Variables</th>
<th>Overall</th>
<th>Control condition</th>
<th>Recall condition</th>
<th>Justification condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (in years)</td>
<td>19.03 (2.13)</td>
<td>19.07 (2.26)</td>
<td>19.09 (1.83)</td>
<td>18.94 (2.26)</td>
</tr>
<tr>
<td>Work experience&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17.21 (25.64)</td>
<td>18.51 (33.86)</td>
<td>14.91 (19.06)</td>
<td>17.91 (21.86)</td>
</tr>
<tr>
<td>Practice decision quality&lt;sup&gt;b&lt;/sup&gt;</td>
<td>72.71 (16.47)</td>
<td>72.73 (22.52)</td>
<td>73.24 (13.34)</td>
<td>72.26 (12.14)</td>
</tr>
<tr>
<td>Previous acquaintance&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.31 (22.21)</td>
<td>6.50 (29.94)</td>
<td>3.44 (25.77)</td>
<td>0.57 (2.89)</td>
</tr>
<tr>
<td>Final decision quality&lt;sup&gt;b&lt;/sup&gt;</td>
<td>63.67 (30.78)</td>
<td>61.01 (13.80)</td>
<td>63.07 (12.32)</td>
<td>66.40 (47.11)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Total full-time-equivalent months of work experience.

<sup>b</sup> Discrepancy with expert solution. Lower scores indicate expertise.

<sup>c</sup> Each individual reported how long, in months, they had personally known each of the others. "Previous acquaintance" is the sum across these reports by one individual.

Table 1: Means (Standard Deviations) of the Sample of Individuals
<table>
<thead>
<tr>
<th>Group-level Variables</th>
<th>Overall</th>
<th>Control condition</th>
<th>Recall condition</th>
<th>Justification condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. Practice Decision Quality*</td>
<td>72.54(8.52)</td>
<td>72.73(11.70)</td>
<td>73.00(6.92)</td>
<td>72.04(6.21)</td>
</tr>
<tr>
<td>Military hour of session startb</td>
<td>12.82(2.13)</td>
<td>12.70(2.28)</td>
<td>13.23(2.10)</td>
<td>12.59(2.02)</td>
</tr>
<tr>
<td>Avg. Knowledge Structure Coherence, before discussion</td>
<td>.2859(.1477)</td>
<td>.2961(.1350)</td>
<td>.2927(.1593)</td>
<td>.2720(.1503)</td>
</tr>
<tr>
<td>Avg. Knowledge Structure Coherence, after discussion</td>
<td>.4593(.1485)</td>
<td>.4515(.1438)</td>
<td>.3978(.1555)</td>
<td>.5167(.1260)</td>
</tr>
<tr>
<td>Avg. Proximity Rating Similarity, before discussion</td>
<td>.2291(.0865)</td>
<td>.2316(.0800)</td>
<td>.2259(.0978)</td>
<td>.2296(.0837)</td>
</tr>
<tr>
<td>Avg. Proximity Rating Similarity, before discussion</td>
<td>.4817(.1711)</td>
<td>.4139(.1400)</td>
<td>.4229(.1416)</td>
<td>.5867(.1840)</td>
</tr>
<tr>
<td>Avg. PfNet Similarity, before discussion</td>
<td>.2140(.0592)</td>
<td>.2054(.0535)</td>
<td>.2291(.0764)</td>
<td>.2085(.0447)</td>
</tr>
<tr>
<td>Avg. PfNet Similarity, after discussion</td>
<td>.3474(.1479)</td>
<td>.3117(.1015)</td>
<td>.3258(.1613)</td>
<td>.3949(.1589)</td>
</tr>
<tr>
<td>Avg. Member Effort</td>
<td>6.78(0.59)</td>
<td>6.60(0.60)</td>
<td>6.69(0.65)</td>
<td>7.02(0.44)</td>
</tr>
<tr>
<td>Subjective Exchange Volume</td>
<td>4.60(0.59)</td>
<td>4.46(0.54)</td>
<td>4.50(0.62)</td>
<td>4.80(0.56)</td>
</tr>
<tr>
<td>Subjective Common Ground</td>
<td>4.22(0.53)</td>
<td>4.06(0.53)</td>
<td>4.11(0.56)</td>
<td>4.45(0.43)</td>
</tr>
<tr>
<td>Group Decision Quality*</td>
<td>61.74(11.10)</td>
<td>61.00(11.47)</td>
<td>61.63(12.10)</td>
<td>62.45(09.90)</td>
</tr>
</tbody>
</table>

* Discrepancy with expert solution. Lower scores indicate expertise. "Group resource" is the average member practice score where all member's scores were available for a given group.

b Decimals indicate hundredths of an hour.

Table 2: Means (Standard Deviations) of the Sample of Groups
### Table 3: Scale Reliabilities*

<table>
<thead>
<tr>
<th>Scale Name</th>
<th>J</th>
<th>A</th>
<th>alpha</th>
<th>mean $r_w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. Member Effort</td>
<td>8</td>
<td>9</td>
<td>.82</td>
<td>.94</td>
</tr>
<tr>
<td>Subjective Exchange Volume</td>
<td>10</td>
<td>6</td>
<td>.82</td>
<td>.87</td>
</tr>
<tr>
<td>Subjective Common Ground</td>
<td>10</td>
<td>6</td>
<td>.89</td>
<td>.69</td>
</tr>
</tbody>
</table>

*J = number of items in scale;  
A = number of response options;  
alpha = Cronbach's (1951) measure of internal consistency;  
$r_w = \left\{ \frac{J - (s_{ij}^2/\text{var}_{EU})}{J[1 - (s_{ij}^2/\text{var}_{EU})]} \right\} + (s_{ij}^2/\text{var}_{EU})$, where $r_w$ is the within-group interrater reliability for judges' mean scores based on $J$ essentially parallel items, $s_{ij}^2$ is the mean of the observed interrater variances per each of the $J$ items, and $\text{var}_{EU}$ is the expected variance based on a rectangular (random response) distribution.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Intercorrelations (Probabilities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Avg. Member Effort</td>
<td></td>
</tr>
<tr>
<td>2. Time on Task</td>
<td>.21 (0.08)</td>
</tr>
<tr>
<td>3. Subjective Exchange Volume</td>
<td>.63 (0.00) .21 (0.08)</td>
</tr>
<tr>
<td>4. Subjective Common Ground</td>
<td>.50 (0.00) .26 (0.03) .47 (0.00)</td>
</tr>
<tr>
<td>5. Avg. Proximity Rating</td>
<td>.28 (0.00) .24 (0.04) .33 (0.00) .29 (0.00)</td>
</tr>
<tr>
<td>6. Avg. PfNet Similarity</td>
<td>.09 (0.37) .13 (0.28) .19 (0.04) .20 (0.04) .69 (0.00)</td>
</tr>
<tr>
<td>7. Knowledge Structure Coherence</td>
<td>.21 (0.03) .14 (0.25) .13 (0.19) .11 (0.27) .62 (0.00) .44 (0.00)</td>
</tr>
<tr>
<td>8. Group Decision Quality</td>
<td>-.11 (0.23) -.07 (0.56) -.05 (0.60) -.05 (0.62) -.05 (0.59) -.08 (0.41) -.11 (0.24)</td>
</tr>
</tbody>
</table>

Table 4: Overall Correlations', With Associated Probabilities, Between Group Variables

1 Pearson product-moment correlations, accompanied by the 2-tailed probability of observed magnitude occurring by chance.
Table 5, section A: Analysis of similarity level by group membership.

<table>
<thead>
<tr>
<th>Group</th>
<th>Count</th>
<th>Standard Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>95 Pct Conf Int for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonmembers</td>
<td>720</td>
<td>.2619</td>
<td>.1380</td>
<td>.0051</td>
<td>.2718 TO .2920</td>
</tr>
<tr>
<td>Members</td>
<td>60</td>
<td>.6265</td>
<td>.2604</td>
<td>.0336</td>
<td>.5592 TO .6937</td>
</tr>
<tr>
<td>Overall</td>
<td>780</td>
<td>.3084</td>
<td>.1765</td>
<td>.0063</td>
<td>.2960 TO .3209</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonmembers</td>
<td>.0500</td>
<td>.8380</td>
</tr>
<tr>
<td>Members</td>
<td>.2040</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Table 5, section B: Analysis of the existence of statistically-significant similarity by group membership.

<table>
<thead>
<tr>
<th>Element</th>
<th>Count</th>
<th>Exp Val</th>
<th>ROW Pct</th>
<th>SIGNIFICANTLY SIMILAR?</th>
<th>Col Pct</th>
<th>ROW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Members</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OF SAME GROUP?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>572</td>
<td>148</td>
<td>720</td>
<td></td>
<td>181.8</td>
<td>92.3%</td>
</tr>
<tr>
<td></td>
<td>538.2</td>
<td>181.8</td>
<td>92.3%</td>
<td></td>
<td>79.4%</td>
<td>20.6%</td>
</tr>
<tr>
<td></td>
<td>98.1%</td>
<td>75.1%</td>
<td>73.4%</td>
<td></td>
<td>73.4%</td>
<td>19.0%</td>
</tr>
<tr>
<td>YES</td>
<td>11</td>
<td>49</td>
<td>60</td>
<td></td>
<td>44.8</td>
<td>7.7%</td>
</tr>
<tr>
<td></td>
<td>44.8</td>
<td>15.2</td>
<td>7.7%</td>
<td></td>
<td>18.5%</td>
<td>81.7%</td>
</tr>
<tr>
<td></td>
<td>1.9%</td>
<td>24.9%</td>
<td>1.9%</td>
<td></td>
<td>1.9%</td>
<td>6.3%</td>
</tr>
<tr>
<td>Column</td>
<td>583</td>
<td>197</td>
<td>780</td>
<td></td>
<td>74.7%</td>
<td>25.3%</td>
</tr>
<tr>
<td>Total</td>
<td>74.7%</td>
<td>25.3%</td>
<td>100.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chi-Square Value</th>
<th>DF</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson</td>
<td>109.56805</td>
<td>1</td>
</tr>
<tr>
<td>Continuity Corr</td>
<td>106.35472</td>
<td>1</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>92.90882</td>
<td>1</td>
</tr>
<tr>
<td>Mantel-Haenszel</td>
<td>109.42758</td>
<td>1</td>
</tr>
</tbody>
</table>

linear association

Minimum Expected Frequency - 15.154
Number of Missing Observations: 0

Table 5: Cross-tabular Analysis of Similarity as a Function of Group Membership

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Figure 1: Analysis of Cognitive Similarity Before and After Discussion