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# GSS Technology as a Moderator of Influence and Perceived Expertise

Kevin V. Thompson

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THESIS

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AFIT/GIR/ENV/01M-14

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# GSS TECHNOLOGY AS A MODERATOR OF INFLUENCE AND PERCEIVED EXPERTISE


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Kevin V. Thompson

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*Abstract*

Group Support System (GSS) research has found that content and process anonymity influence problem solving groups. However, previous studies report mixed results on how GSS technology changes social influence processes and recognition of expertise which affect group performance.

This thesis explored content and process anonymity's affect on influence and perceived expertise using three treatments to derive possible explanations for the mixed results found in previous GSS research. The study developed a theoretical model of influence, perceived expertise, and performance. Using structural equation modeling, the study tested the relationships between expertise and participation rates, and overall group performance. An experiment was developed to explore how content and process anonymity affect informational influence processes and recognition of expertise.

Groups participated in conditions of complete anonymity, process only anonymity, and no anonymity. The results of this study suggest that varying levels of anonymity affect the influence processes exhibited by decision-making groups. In general, it was found that in face-to-face groups, perceived expertise is based mostly on participation rates than actual expertise. In GSS-supported groups, influence and perceived expertise occur through different interaction processes and expertise is based mostly on the quality and merits of individual participants' comments.

# GSS TECHNOLOGY AS A MODERATOR OF INFLUENCE AND PERCEIVED EXPERTISE

## *Chapter I - Introduction*

The intense competition in today's rapidly paced, highly electronic business environment is forcing firms to rely heavily on computer-supported collaboration between their employees to solve business problems (Satzinger, Garfield & Nagasundaram, 1999:143). They now realize that today's global business environment is simply too dynamic, interdependent, interconnected, and unpredictable for management alone to solve the firm's problems. Innovative solutions to business problems require integrative thinking by problem-solving groups at all levels within the firm, especially at the firm's operating core (Laudon & Laudon, 1999).

Less than two decades ago, groups of people faced with a problem-solving task had to come together in face-to-face meetings where ideas were generated, discussed, and hopefully resulted in a sound solution to the problem at hand. A significant problem inherent in face-to-face meetings is that dominant or high-status individuals are often recognized as the team expert (Bales, 1953). These individual personal and contextual traits often lead to the dominant member exerting the most influence on the group thereby leading the members towards a specific, although possibly incorrect, solution. Key to overcoming these process losses is the fact that recognition of expertise is an important component of group performance (Littlepage & Silbiger, 1992).

Today, the information technology revolution is changing the way groups interact to solve problems. Advances in information technologies over the past two decades, such as networked personal computers and desktop collaboration software, have spawned the development of electronic collaboration systems in which groups can interact to solve problems. A particular subset of these emerging systems that facilitates group interaction and problem resolution, termed Group Support Systems (GSS), has left the research laboratory and college campus and entered both public and private industry conference rooms.

### *1.1 Background*

Since the early '80s, a plethora of empirical research into GSS has been conducted. By mid 1998, the results of nearly 200 empirical experiments were available in approximately 230 published articles in refereed journals and information technology conference proceedings (Fjermestad & Hiltz, 1998:1). Throughout this literature, electronic collaboration systems have taken on many different labels such as: Group Decision Support Systems, Distributed Group Support Systems, Electronic Meeting Systems, Computer-Supported Collaborative Work Systems, and Computer-Mediated Communications Systems (Fjermestad & Hiltz, 1998:7). However, for the context of this research, the term "GSS" is used to refer to suites of software and hardware tools designed to focus the deliberation and enhance the communication of teams or groups working under high cognitive loads (Briggs, Nunamaker, & Sprague, 1998:5).

GSS are a computer-based "social technology" (Turoff, Hiltz, Baghat, & Rana 1993:400), a combination of computer hardware and software, often administered and managed via human facilitation that provide users with computer, communication, and decision support tools to increase the effectiveness and efficiency of decision-making groups. The software components of a GSS are shared between all users by means of a local or distributed network connecting the hardware components, typically desktop personal computers, a system server, network protocols, and guided media.

One of the most popular applications provided by a GSS to enhance group problem-solving tasks is electronic collaboration. Groups often use GSS in both co-located and distributed environments to brainstorm possible solutions to problems, discuss the merits of each solution, and come to consensus on a chosen solution. In a co-located configuration, group members are all physically located within eyesight of one another, such as in a conference room setting. Conversely, in a distributed environment, team members are physically separated but virtually connected over some type of local or wide area network architecture.

One of the advantages of electronic collaboration using a GSS over traditional, face-to-face meetings is that each participant's comments can be captured and stored automatically by the system software. (Aiken, Krosp, Shirani, & Martin, 1994:141). The capability for automated, electronic capture of human thought processes during problem solving settings has made data collection for research purposes in this field much easier, and has subsequently led to an increase in empirical studies of how humans interact with technology to solve problems.

An abundance of empirical research exists concerning how humans interact with GSS technology and group processes that occur while using GSS technology. Past results indicate that teams using a GSS produce more and better ideas than teams that do not (Gallupe, Dennis, Cooper, Valacich, Bastianutti, & Nunamaker, 1992:350-369). Some of the independent variables considered within this research stream include the team's evaluative tone (Connoly, Jessup, & Valacich, 1990:689-703), the problem's stratification, and individuals' social comparison basis (Steuer, 1995:33-56). The overwhelming majority of these studies focused on individual and group performance outcomes as the dependent variable.

However, empirical research on the effectiveness of GSS reveals mixed results. Past studies on meeting and decision effectiveness between GSS and traditional meeting formats revealed strongly positive results of GSS use. Others found slightly positive, mixed, neutral, or even negative effects of GSS over traditional meetings. Contextual factors that differed between these numerous studies provide a rich area of research that could potentially explain these confounding findings.

The existing research also indicates that there are numerous factors which moderate performance in an electronic brainstorming environment. A recent GSS research meta-analysis (Eierman, Niederman, & Adams, 1995) revealed 122 empirically investigated relationships around eight broad GSS constructs. The majority of these studies focused on the constructs of technology, environment, and task in moderating group and individual performance and system use in a GSS setting. Eleven studies were cited with user as the primary independent construct, and four focused on implementation strategy. The remaining seven studied the impact of user behavior on individual and group performance. According to their analysis, empirical research in the field of GSS focusing on participant interaction processes has received the least attention to date.

Recent studies have tried to address these mixed effects and limitations by focusing on GSS designs that may affect the social and structural dimensions of group interaction. A study by Lea (1998) revealed that group members' perceptions and social interaction processes could be influenced by manipulating specific attributes of the meeting facilitator and the GSS design. In Lea's study, when the GSS design was structured such that the facilitator was perceived as being unbiased towards any particular group member, member attitudes toward the group and the technology and overall group performance improved.

A follow-on study evaluated the impact of facilitator alignment, co-location, and video intervention on the efficacy of a GSS when deployed in a distributed environment (Heberlie & Tolbert, 1999). Although many of the findings in this study confirmed those in Lea's study, it indicated that the meeting facilitator need not be physically separated from the group to influence perceptions of neutrality. These two previous efforts recommended further investigation into additional contextual factors that might affect GSS processes and outcomes. The goal of this line of research is to discover GSS meeting processes and designs that can consistently increase the quantity and quality of comments and ideas generated in a meeting which may increase decision quality and overall group performance in GSS-supported groups (George, Easton, Nunamaker, & Northcraft, 1990:400).

A question important to many GSS administrators and implementers has received virtually no attention—the impact of GSS technology on expert group members' ability to influence member decision-making and overall group effectiveness through electronic collaboration during GSS problem solving sessions. Expert group members are those individuals possessing the highest level of task-related knowledge in relation to a particular task. Given the conflicting research on GSS effectiveness, and the promising results of recent research on contextual factors of GSS design, this topic is worthy of further investigation.

This report of research conducted is one of four concurrent theses that continued the systematic investigation of contextual factors concerning various aspects of GSS use. Each of the four research efforts analyzed data collected from the same experiment, but each thesis examined a different area within the GSS research stream. One study evaluated the effect that varying levels of anonymity had on user participation rates between GSS and face-to-face groups. A second study investigated the influence of individual personality characteristics and anonymity on member participation in a GSS environment. A third study examined the effects of coincidental feedback through comment labeling and feedback provided by the facilitator on the quantity and quality of ideas generated in a GSS environment. The final study reported in this paper examined the effect of GSS technology on the processes of influence and perceived expertise.

### *1.2 Problem Statement and Purpose of Research*

In 1998, Briggs, Nunamaker, and Sprague cited a number of their colleagues' claim that GSS research is dead. The authors, on the other hand, argue that, "...GSS research is much more like a fresh sapling than a tough and tired forest giant" (Briggs et al, 1998:3). Tan and Wei (1999) note that one of the purported benefits of a GSS is the removal of undue influence by certain group members. This removal tends to equalize the influence exerted by the participants. Existing research shows that some influence promotes task performance while certain forms of influence detract from it. This assertion holds true if the influence is due to conversational dominance, members' high status or authority, or pressure to conform. However, since the impact of influential group members is one of the key distinctions between effective and ineffective groups (Hirokawa, 1980), it would follow that the removal of expert influence on group decisions by GSS technology should be viewed as a process loss.

Past research into face-to-face group interaction processes has shown that the level of influence exerted on a problem-solving group by its expert member(s) is moderated by members' perceived expertise of others in the group (Littlepage, Schmidt, Whisler, & Frost, 1995). During face-to-face group interaction processes, non-verbal cues such as facial expressions and hand movements, and verbal cues such as voice inflection and volume are present. These factors may positively affect members' perceived expertise of team member input. However, during a GSS group problem-solving session, these cues are non-existent since the majority of group interaction occurs as typed input via a computer keyboard, which can be viewed by all group members as output on a computer screen. Therefore, GSS problem-solving groups may be less likely to recognize other members' level of expertise thereby decreasing an expert member's ability to influence group performance.

This study investigates two questions that have yet to receive attention in existing GSS research:

1. Does GSS technology affect the ability of problem-solving groups to recognize other group members' level of task expertise?

2. If GSS-supported group work affects members' ability to recognize task expertise, does this change the expert member's ability to influence the group's decision?

This study attempts to answer these questions by examining the main and moderating effects of GSS technology on expert members' ability to positively influence group members' decision quality and group members' ability to recognize expertise within the group. The results of this effort will provide valuable information necessary for GSS facilitators and practitioners to make informed decisions concerning the use of GSS technology by weighing the advantages of purported process gains against the possible costs of process losses.

### *1.3 Research Applicability to the United States Air Force*

Throughout the 1980's and into the early 1990's, the United States Air Force experienced significant budget cuts and personnel reductions. During this period of "right-sizing," Air Force senior leaders expected Air Force personnel to be more innovative--to accomplish an increasingly complex mission with fewer resources. For instance, between 1987 and 1998 active duty Air Force manpower strength was cut by nearly 39 percent, from 609,000 to 372,000 (Washington Headquarters Services Directorate for Information, Operations, and Reports, 1999). Yet operations in the Middle East and Eastern Europe continued to tax continually shrinking operations and support forces.

In response to these significant manpower and budget cuts, privatization of many support functions began to increase. Air Force logistics and sustainment functions were faced with competitive forces requiring the acquisitions and logistics community to streamline its processes and cut its costs, or face elimination. Therefore, in the late 1980s the Air Force implemented Lean Logistics—a program designed to streamline its sustainment processes and infrastructure towards the overarching goal of "transitioning the force from a just-in-case, to a demand driven, just-in-time asset management and repair system" (Lea, 1998:3). In 1999, the Air Force renamed the Lean Logistics program to "Agile Logistics," but the program's focus remains the same.

A specific area targeted by the Agile Logistics program is Depot-Level Maintenance and Repair of Air Force weapon systems. In 1996, The Office of the Secretary of Defense issued guidance on how Department of Defense (DoD) depot maintenance is to be managed by mandating innovative maintenance concepts, improved management structures, and effective management systems. Specifically, it directed the deployment of management information systems that result in cheaper, more effective and efficient maintenance operations (OSD, 1996:22).

In late 1997, the Sustainment Logistics Branch of the Air Force Research Laboratory implemented its response to DoD's call for improved depot-level maintenance functions by launching the development of a new collaborative management information system. The program consisted of two separate but interrelated programs. The first, Readiness Assessment and Planning Tool Research was aimed at assisting organizations in business process reengineering efforts (Lea, 1998:4). The Air Force Research Lab recognized the need for collaboration among organizational stakeholders during process change efforts. Therefore, a sub-component of the Readiness Assessment and Planning Tool was developed to allow organizations to assess cultural, technological, and strategic issues within the organization during the change processes. This sub-system was termed Depot Operations Modeling Environment and functions as a collaborative GSS tool set.

The goal of this new collaboration tool was to "aid in the design and modeling of Air Force logistics processes using a collaborative environment which establishes connectivity between dispersed groups and installations" (Heberlie & Tolbert, 1999:5). The system is a combination of personal computer hardware and commercial off-the-shelf software connected and distributed via a LAN architecture. The GSS software consists of Ventana Corporation's GroupSystems® and other tools developed in-house by Air Force Research Lab engineers that support process modeling in an any time, any place environment.

In late 1998, the Depot Operations and Modeling Environment was successfully installed and demonstrated at both Warner-Robins Air Logistics Center in Georgia and the 366$^{th}$ Wing at Mountain Home AFB, Idaho. Since early 1999, the system has been used extensively by the Acquisition Support Team and the Reengineering Division at Warner-Robins to improve on-going F-15 aircraft periodic depot maintenance.

An issue of increasing importance to the depot operations at Warner-Robins surrounds decision effectiveness. Since its installation and initial familiarization training period of approximately 6 months, system resource availability has been reduced to near zero due to constant use. Warner-Robins personnel have successfully employed the GSS tool set to enhance risk workshop assessment, strategic planning, process modeling and collaborative data collection. "Our GSS system is saturated and consumes 100 percent of the availability of the RE conference room where it is housed" (Ayer, 2000).

However, engineers, logisticians, and managers are concerned that the system is not being used as efficiently as possible. "We are worried that the system is limiting some of our most knowledgeable team members' ability to influence decision makers towards the best solution" (Ayer, 2000). Program managers applaud the benefits it provides, such as increased participation during team collaboration and anonymity of member inputs in a politically sensitive environment; however, they are equally concerned that these benefits may be negatively affecting decision outcomes.

Air Force and DoD use of collaborative information technologies continues to grow. In early 2000, a Joint Staff Tiger Team was created to evaluate various collaborative planning tools for the Department of Defense. The team's primary purpose is to "enhance interoperability across DoD for collaborative services" (Joint Staff Message, 2000). As a result, US Joint Forces Command's Joint Battle Center, located at Norfolk, Virginia, has been tasked with evaluating five collaborative planning tools against user requirements (DeLapp, 2000:26). One, Ventana Corporation's GroupSystems®, is central to this research effort since it is the GSS software employed throughout the empirical experimentation and data collection process.

The developers of GroupSystems assert that the missing element in the new collaboration paradigm is the automation of knowledge producing processes within an organization. They claim these processes rely on the interactions of the stakeholders, combining their expertise with information to make decisions and solve problems (DeLapp, 2000:35-36). A subsidiary of Ventana Corporation, GroupSystems.com, operates on the belief that technology is not the only key to innovation and responsiveness through collaboration. In a letter by Scott Edelman, President and CEO of GroupSystems.com, he states that collaborative technologies are important enablers, but the people and process truly make the difference (Edelman, 2000). To summarize his main point, the overarching issue is the psychology and not just the technology. It is readily apparent that GroupSystem.com's approach to collaboration does not focus on the technological aspect, but rather on the psychological aspect of knowledge production.

The increased emphasis on collaboration technologies within the DoD requires answers regarding the impact of these technologies on the behavioral and psychological aspects of group work. The results of this research will provide the evidence needed to determine if suspected reductions in decision quality are attributable to the use of GSS technology. It will empirically test the questions surrounding perceived expertise and expert influence on group decision processes by comparing an existing, yet slightly modified, model of influence and performance between traditional face-to-face problem-solving groups and GSS-supported problem-solving groups. The outcome will provide evidence to either support or reject the assumption that group interaction via GSS and other collaboration technologies inhibits experts' ability to influence group decisions and limits members' ability to recognize member expertise. The results will allow practitioners to make informed decisions concerning the costs of possible process losses against the benefits of process gains offered by GSS tools in use.

### *1.4 Summary*

The overwhelmingly successful implementation of GSS tools at Warner-Robins has shed light on an area within GSS research that has received little attention—the ability of group members to recognize team member expertise, and experts' ability to influence group decisions. In their struggle to meet the Agile Logistics requirements levied by both DoD and AF mandates, Warner-Robins personnel are concerned that the quality of team decision processes are being hampered by GSS technology.

Past GSS research has focused on the technology, task, and collaborative environment's affect on performance and outcomes. This study breaks new ground by exploring the human processes that occur during group interaction and how they are affected by the technology. An input-process-output model of member influence and perceived expertise is developed and tested in an attempt to answer the research questions cited in this chapter.

### *1.5 Organization of this Thesis*

Chapter II presents a comprehensive review of the existing literature covering the body of GSS and small-group research that pertains to the dependent variable under study in this thesis. In Chapter III, a detailed treatment of the methodology used to conduct this research is provided. Chapter IV covers data collection, statistical analysis of the data, and the results of this research. Finally, Chapter V interprets the findings discussed in Chapter IV in relation to the research hypotheses under investigation. The findings are treated in three sub-sections: conclusions reached, limitations of the study, and recommendations for further research in the area.

## *Chapter II - Literature Review*

### *2.1 Introduction*

Today, virtually every task accomplished by humans involves intact, purpose-specific groups of people working together towards a common goal, or ad-hoc, virtual groups composed of individuals connected via advanced information technologies. Problem-solving and decision-making are two of the most common purposes for the formation of groups in our society. Organizations often build groups comprised of members from different areas so that a wider range of information and opinions can be considered (Dennis, 1996).

For the most part, organizations consist of a combination of both permanent and temporary groups. Evidence indicates that in the near future, work will be performed in task-focused teams, not in traditional departments or by relatively isolated individuals (Ancona & Nadler, 1989; Drucker, 1988). Groups bring a larger pool of information to bear upon the problem than any single individual. Therefore, intuitively one would assume groups of individuals would perform better than any single individual when faced with an intellective problem-solving task. Existing literature concerning face-to-face group interaction and problem-solving supports the preceding assumption.

Steiner (1972) states that groups often outperform individuals in problem-solving tasks since the group composite possesses greater potential for intellectively correct solutions than the individual. Numerous studies support this assertion. For example, a study on executive decision-making determined that decisions made by groups of executives were better than those made by individual executives (Bass, 1977). Similarly, judgments made by groups are generally more accurate than judgments made by a single member (Sniezek & Henry, 1990).

Teamwork, and the many advantages it brings to the organization, is not without its inherent problems. For instance, some participants may not understand the group's goals, may not be able to remain focused on the team's task, or may harbor hidden agendas. Additionally, dominant individuals may suppress participation of more reserved members and misunderstandings can result from cultural, language, or other socially-based differences (Nunamaker & Briggs, 1997:163). Regardless of these possible disadvantages, few would argue that the small group is not a vital component of our society in both business and personal endeavors.

This chapter combines theoretical research into small group interaction with GSS research theory and builds upon an existing model of expertise, influence, and group performance similar to that developed by Littlepage et al (1995), leading to a description of the research hypotheses under investigation in this study.

### *2.2 Summary of GSS Research*

The computer revolution of the 1970s and 1980s, along with the global interconnectivity of the 1990s, has brought the social sciences and technology face to face. During these three decades, a new arm of research was born. Referred to as management information systems (MIS), it combines the theoretical work of computer science, management science, and operations research with a practical orientation toward building systems and applications while also paying attention to behavioral issues raised by sociology, economics, and psychology (Laudon & Laudon, 1997:14). This area, concerned with how organizations and individuals interact with technology as a buffer and connector, is the primary focus of the present study.

Jessup & Valacich (1993:61-64) note that the GSS research stream can be considered from five distinct phases. The first was the initial technological exploration phase from the mid-1970s to around 1980 that focused on computer messaging in distributed settings. The second phase, early group process exploration from 1980 to about 1984, focused on testing GSS applications to support group work. The third phase, from around 1984 to the early 1990s, consists of empirical research comparing GSS-supported groups with non-GSS groups with the intent to explore the effects on group processes and outcomes in a controlled laboratory environment. Phase four is considered the "field studies" phase and occurred only after the migration of GSS from the laboratory to actual field settings (Jessup & Valacich, 1993:66). Finally, phase five spans from the early 1990s to the present and is characterized by its in-depth focus on the specific aspects of GSS technology or its users. It is this fifth category of research on which the present study is grounded.

"Theoretical frameworks are designed to aid in the understanding and design of empirical investigations" (Fjermestad & Hiltz, 1999:3). The aforementioned authors use this statement to introduce what is arguably the most comprehensive framework from which to analyze GSS literature. From an exhaustive review, Fjermestad and Hiltz developed the GSS research framework depicted in Table 2.1.

**Table 2.1 Theoretical Framework for Analyzing GSS (Adapted from Fjermestad & Hiltz, 1999 with emphasis added)**

| *INPUT* | *PROCESS* | | *OUTPUT* |
|---|---|---|---|
| **Contextual Factors** | **Intervening Factors** | **Adaptation Factors** | **Outcome Factors** |
| 1. Technology:<br>- Includes Task Support Tools, Process Structures (time, proximity, etc.), **Communication Mode (FtF, GSS, etc.)**, and Design (Room configuration, etc.). | 1. Methods:<br>- Includes **Experimental Design, Task Implementation**, Session Length, Number of Sessions, Training, and Rewards. | 1. Group Adaptation:<br>- Includes Process, Structuration, Social Technology, Structural Features (e.g., Consensus), **Process Variables (e.g., Participation and Influence)**, and Process Issues. | 1. Efficiency Measures:<br>- Includes Decision Time, Number of Decision Cycles, and Time to Consensus. |
| 2. Group:<br>- Group Characteristics **(e.g., adhoc/established)**, Composition, Leadership, Member Characteristics, Meeting Structure, Group Structures **(e.g., perceptions of others knowledge)**. | 2. Summary Variables:<br>- Communication Dimensions, **Group Member Perception, & Problem Solving (e.g., level and utilization of member knowledge and skill)**, Organizing Concepts, and Operating Concepts. | 2. Process Gains/Losses:<br>- Synergy, Learning Memory, Clarity, and Choice Shift<br>- Free Riding, Evaluation Apprehension, Attenuation, Flaming, Dominance. | 2. Effectiveness Measures:<br>- Communication, Number of Comments, Idea Quality, **Decision Quality**, Decision Confidence, Task Focus, etc. |
| 3. Task:<br>- **Type**, Characteristics, Equivocality, Complexity, Enjoyability, **Expertise** | | 3. Intermediate Role Outcomes:<br>- Role Assumption by Technology, Participant Roles and Values | 3. Satisfaction Measures:<br>- Participation, Cohesiveness, Conflict Management, **Influence**, Confidence, Attitude, etc. |
| 4. Context:<br>- Environmental, Organizational, Cultural. | | | 4. Consensus:<br>- Decision Agreement, Commitment. |
| | | | 5. Usability Measures:<br>- Learning Time, Willingness to Work Together Again, System Utilization, Errors, Design Preference. |

Fjermestad and Hiltz's framework categorizes four major sets of variables found in major GSS research works into three primary sets: input variables, process variables, and output variables. This conceptualization has important implications to the present study for two reasons. First, the dominant theoretical perspectives on group performance consist of input-process-output (IPO) models (Guzzo & Shea, 1992). Drawing from existing small group experimental models and research results adds relevance and a common reference from which to build and test research hypotheses. Second, this study adapts and tests an existing IPO model of expertise, influence, and performance developed by Littlepage et al (1995), except under different conditions--GSS support. In Table 2.1, the variables of concern to the present study are indicated by bold print.

### *2.3 GSS Research Findings Relevant to This Study*

Many of the empirical studies comparing face-to-face and GSS-supported groups indicate that the use of a GSS during idea-generating and problem-solving tasks increases member productivity (Gallupe, Bastianutti, & Cooper, 1991; Petrovic & Petrovic, 1994; Olaniran, 1994; Dennis & Hilmer, 1998), and overall group performance (Grohowski, McGoff, Vogel, Martz, & Nunamaker, 1990; Post, 1992). One cause of this apparent effectiveness enhancement is understood to be the ability for team members to communicate in parallel, which prohibits any one member from dominating the group discussion (Jessup & Valacich, 1993:69).

Another reason GSS groups produce a greater number of unique ideas and higher quality solutions is that the parallel use of an electronic communications channel provides participants with varying levels of anonymity. For instance, Jessup, Connolly, and

Galegher (1990) found anonymous groups to be more critical and probing, more likely to adopt other's ideas, and to display higher participation rates than non-anonymous groups. Therefore, varying the levels of anonymity can have either positive or negative effects on information exchange among group members.

In general, GSS field studies have indicated positive reactions in terms of participant satisfaction and perceived effectiveness/efficiency (Jessup & Valacich, 1993:68). This leads one to conclude that, in the whole, the use of GSS technology for problem-solving and decision-making tasks enhances team productivity, efficiency, and effectiveness—all of which are outcome variables under the GSS research framework. Laboratory experiments have produced similar results concerning GSS affects on output variables. However, many conflicting and inconclusive results exist in the literature concerning GSS and the group process.

Equally confounding results exist in studies of GSS and influence. Influence is "the process by which people successfully persuade others to follow their advice, suggestions, or orders" (Keys & Case, 1990). Watson, DeSanctis, and Poole (1988) studied the affect of GSS on the ability of participants to influence other team members and found influence to be more equally distributed among the group. However, two similar studies determined GSS to have no affect on influence processes (Ho, Raman, & Watson, 1989; Tan, Wei, & Raman, 1991).

One apparent weakness in all of the aforementioned studies is that each viewed influence from a single definitive standpoint when, in fact, early social psychology research identifies two separate models of influence—informational and normative (Huang, Raman, & Wei, 1997:578). Normative influence is based on the desire to conform to the expectations of other group members, and informational influence is based on the acceptance of factual information from others as evidence about reality (Deutsch & Gerard, 1955). It is clear from this somewhat cloudy picture that additional research with a focus that spans the entire input-process-output framework is needed.

### *2.4 An IPO Model of Expertise, Influence, and Group Performance*

Littlepage, Schmidt, Whisler, and Frost (1995) tested four competing models of expertise and influence in face-to-face problem-solving groups. Their model found two specific personality variables, confidence and dominance, to be positive determinants of rates of participation by group members during the problem-solving process. An additional input variable, individual expertise was found to influence group members' perceptions of participant expertise. Rates of participation were also predictive of perceived expertise in the Littlepage model, leading finally to the outcome dependent variable identified as influence.

Because the study reported here compares face-to-face problem-solving groups to GSS problem-solving groups, the Littlepage (1995) model was modified to allow consistency of input-process-output variables across the treatments. The model developed during this study is depicted in Figure 2.1. First, the personality variables (dominance and confidence) were removed as inputs to participation since existing literature shows GSS equalizes participation regardless of individual personality characteristics (Briggs, Ramesh, Romano, & Latimer, 1995).

Second, the process variable of perceived expertise was removed from the model because the experiment reported here manipulated levels of anonymity arriving at three different GSS treatments, one of which was completely anonymous. In the completely anonymous treatment, participants were unable to attribute specific comments to specific individuals within their group. Therefore, perceptions of member expertise were unable to be measured across all subjects in the experiment. However, this study views recognition of expertise to be represented by the paths between the input, process, and outcome variables described in the sections that follow.

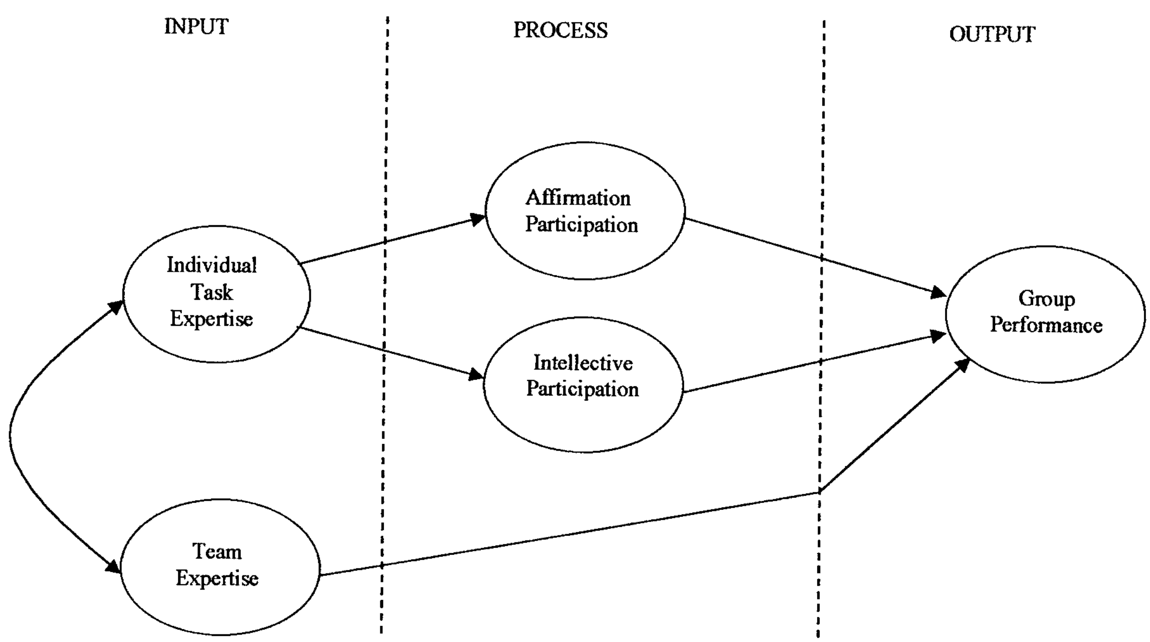



**Figure 2.1 IPO Model of Expertise, Influence, and Group Performance.**

Finally, influence was removed from the model as an observed variable because of the differences between normative and informational influence. Normative influence is prevalent in face-to-face group interaction. However, GSS tends to amplify informational influence and dampen normative influence. Therefore, this study treated the construct of influence from the standpoint of the complete paths between the input, process, and outcome variables. Influence was exerted on group members by each participant during the interaction process phase of the experiment leading to overall group performance. Of interest to this present research was the paths along which influence propagated, not individually measured levels of influence exerted by each participant.

### *2.5 Model Development – Input to Process Variables*

An individual's level of expertise relating to the knowledge needed to solve a particular task has been shown to be positively related to participation. In an observation of groups solving the National Aeronautics and Space Administration's (NASA's) moon survival problem, group members high in expertise showed higher rates of participation (Bottger, 1984). Similarly, Littlepage (1995) found expertise to be positively related to influence. Contrary to Bottger's findings however, expertise was not significantly related to participation in Littlepage's study of face-to-face problem-solving groups. It could be that the mode of communication between members dampens the affect of expertise on participation rates due to production blocking inherent in face-to-face groups, and that differences in task types between the two studies produced confounding results.

Production blocking occurs in face-to-face groups where only one person can speak at a time while others listen. Thus, participants may forget or be talked out of ideas before they get a chance to propose them (Jessup et al, 1993:273). This may lessen an expert member's ability to exert expertise and influence through participation in face-to-face groups. Since a GSS reduces production blocking by allowing participants to communicate in parallel, individual task expertise was expected to be a positive determinant of participation in GSS problem-solving groups. Additionally, because the same type of task was used across all treatments in this experiment, individual task expertise was expected to also be a positive determinant of participation in face-to-face problem solving groups. Therefore, the input to process variables in the revised IPO model are depicted in Figure 2.2.

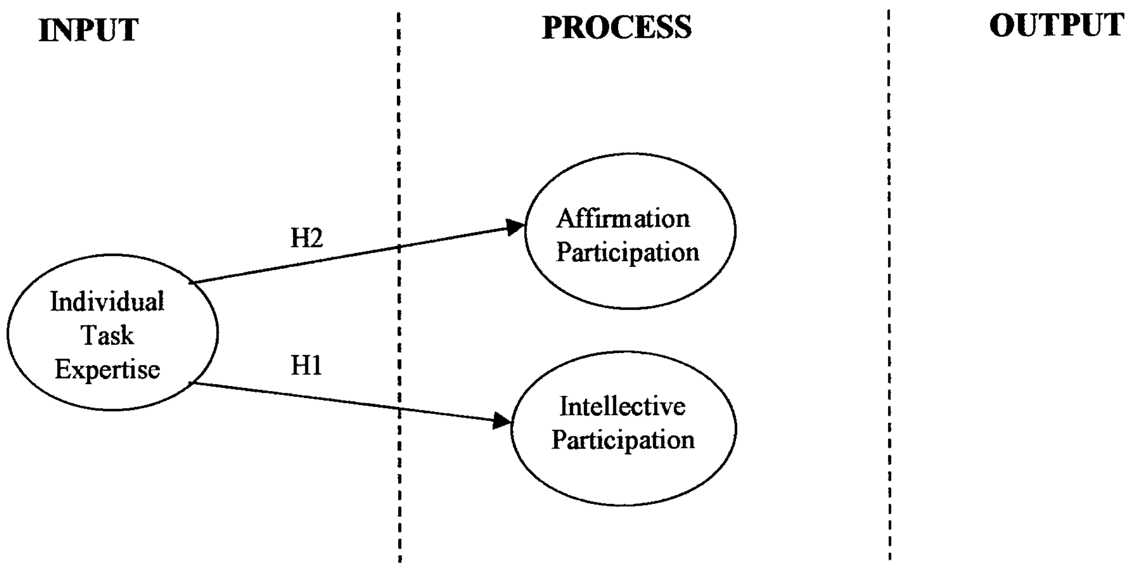



**Figure 2.2 Input to Process Model of Expertise, Influence, and Group Performance**

Studies in the group dynamics research stream have been conducted to capture the interaction processes that occur between individuals within groups (Bales & Strodtbeck, 1951; El-Shinnawy & Vinze, 1998). Each of the aforementioned researchers separated the group interaction process in varying ways depending on the purpose of the study. The present study was not concerned so much with stages of group development as identified during the interaction process, but rather the impact of different types of comments on the paths reflecting influence and recognition of expertise.

The studies by Bottger (1984) and Littlepage (1995) concerning expertise and participation rates were concerned primarily with comments that were task-specific. All utterances including task-related, process-related, and affirmative comments were grouped into a single variable. This procedure may have resulted in the loss of important relationships between influence, expertise, and group performance. For instance, individuals possessing high levels of task expertise are most likely more confident in their task knowledge, and are therefore more likely to submit a greater number of intellective comments during the group discussion. Conversely, participants exhibiting lower levels of task expertise are more likely to submit greater numbers of affirmation comments since less knowledgeable group members are more likely to agree with the more expert members of the group.

Based on the previously defined construct of influence, participation was separated into two distinct types of comments generated during the group problem-solving process—intellective or process-related comments and affirmation comments. This coding scheme was based on the theory of persuasive arguments used in three previous studies concerning group interaction (Isenberg, 1986; Vinokur & Burnstein, 1974; El-Shinnawy et al, 1998), and will be described in more detail in Chapter III.

### *2.5.1 Hypothesis 1: Individual Task Expertise is Positively Related to Intellective Participation.*

Hypothesis 1A: Individual task expertise is positively related to intellective and process-related comments in GSS groups.

Hypothesis 1B: Individual task expertise is positively related to intellective and process-related comments in face-to-face groups.

### *2.5.2 Hypothesis 2: Individual Task Expertise is Negatively Related to Affirmation Participation.*

Hypothesis 2A: Individual task expertise is negatively related to affirmation comments in GSS groups.

Hypothesis 2B: Individual task expertise is negatively related to affirmation comments in face-to-face groups.

## *2.6 Model Development – Process to Output Variables*

Early studies into the communicative dynamics of face-to-face groups indicate that individual participation rates during the group problem solving process are positively related to influence. For instance, groups generally regard the most talkative member as the person with the best ideas (Bales, 1953). Bavelas, Hastorf, Gross, and Kite (1965) manipulated the participation rates by each member and found that participation rate affected member perceptions of leadership, guidance, and idea quality. Additional research showed that when a specific group member was provided with the correct solution to an intellective task, the group was nearly twice as likely to accept the solution if it was given to the most talkative member (Riecken, 1958).

Expertise related to a specific problem-solving task is an important component which impacts overall group performance (Laughlin, 1980; McGrath, 1984). Though numerous group processes affect group performance, many studies indicate that a group's ability to recognize member expertise is important for optimum performance of problem-solving groups (Bottger, 1984; Bottger & Yetton, 1988; Libby, Trotman, & Zimmer, 1995). The study reported here posited that group members' ability to recognize expertise, thereby affecting overall group performance, was based on individual levels of intellective and affirmative participation. The process to output variables depicted in Figure 2.3 predict that intellective and affirmative member participation affects overall group performance.

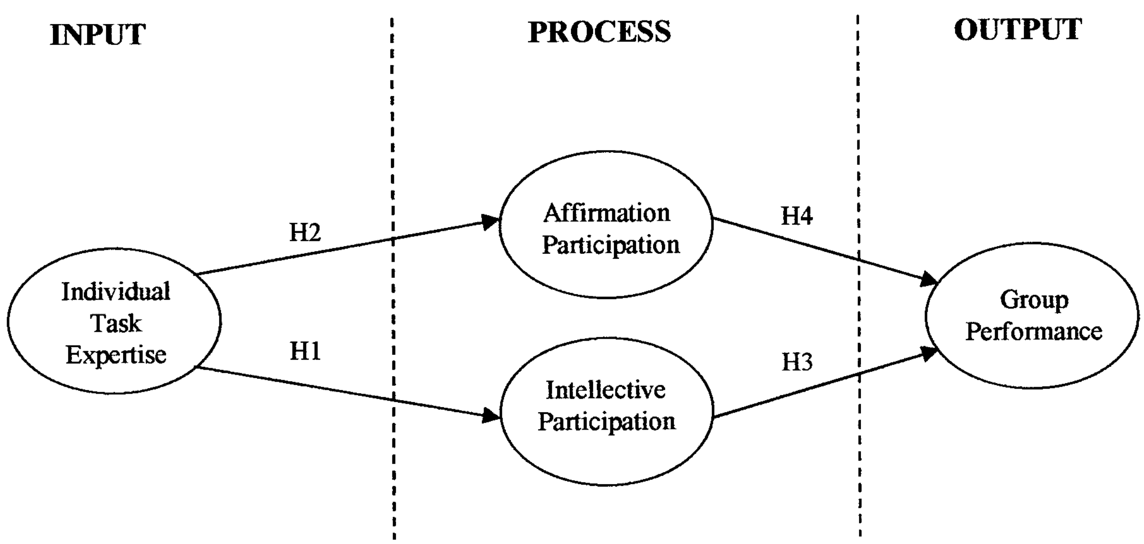



**Figure 2.3 Process to Output Model of Expertise, Influence, and Group Performance.**

Littlepage et al (1995) note that group decision-making and problem-solving literature does not view recognition of expertise as a central construct in determining group performance. Recent studies indicate that group problem-solving performance depends, to some extent, on the group's ability to recognize member expertise (Littlepage et al, 1992). However, this stream of literature focused only on face-to-face problem-solving groups.

A GSS allows for the capture and recording of participant inputs in textual form. As groups discuss the problem and possible solutions to the problem, members can review others' comments at their leisure. This ability for continuous review of member contributions allows members to weigh participants' ideas in greater detail as opposed to face-to-face groups. In face-to-face group interaction, the dominant member is often viewed as the most knowledgeable even though the most talkative member may not necessarily possess the greatest degree of task expertise. However, GSS technology tends to equalize participation thereby removing dominance as a factor leading to influence. Therefore, a GSS may moderate the influence process based on expertise exhibited through rates of intellective participation.

*2.6.1 Hypothesis 3: Intellective Participation will have Opposite Effects on Group Performance Between Face-to-face and GSS-supported Groups.*

Hypothesis 3A: Intellective participation is negatively related to overall group performance in GSS groups.

Hypothesis 3B: Intellective participation is positively related to overall group performance in face-to-face groups.

### *2.6.2 Hypothesis 4: Affirmation Participation will have Opposite Effects on Group Performance Between Face-to-face and GSS-supported Groups*

Hypothesis 4A: Affirmation participation is positively related to overall group performance in GSS groups.

Hypothesis 4B: Affirmation participation is negatively related to overall group performance in face-to-face groups.

## *2.7 Model Development – Complete Input-Process-Output Model*

Steiner (1972) states that groups often outperform individuals in problem-solving tasks since the group composite possesses greater potential for intellectively correct solutions than the individual. Numerous studies support this assertion. A study on executive decision-making determined that decisions made by groups of executives were better than those made by individual executives (Bass, 1977). Similarly, judgments made by groups are generally more accurate than judgments made by a single member (Sniezek & Henry, 1989).

Steiner (1972) also asserts that team performance is determined in part by the member resources and the group processes. Two specific studies show that member expertise is positively related to group performance. In an experiment concerning group performance as a function of the distribution of individual levels of performance, Johnson and Torcivia (1967) found that overall team performance was influenced greatly by individual performance on the same task. Similarly, a study using the NASA Moon

Survival Scenario showed that group performance was influenced by member expertise and the ability of the group to recognize that expertise (Bottger et al, 1988).

Since past literature reflects the importance of the group composite in determining overall performance on intellective problem-solving tasks, this study expected the composite input variable, termed team expertise, to significantly affect overall group performance. The complete IPO model of expertise, influence, and group performance developed for this study is depicted in Figure 2.4.

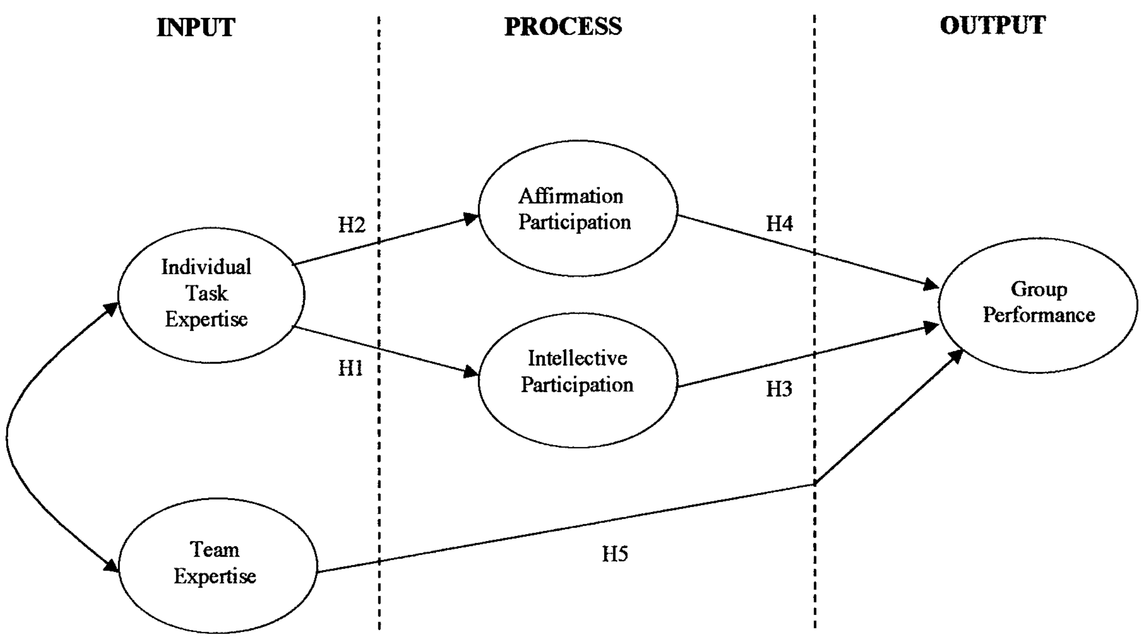



**Figure 2.4 Complete IPO Model of Expertise, Influence, and Group Performance.**

Due to the equalizing effect of GSS technology on individual levels of participation, the ability for participants to communicate in parallel, and the increased level of scrutiny concerning the groups' inputs, this study expected to find significant differences in the influence of team expertise on overall group performance between face-to-face and GSS-supported groups. Groups using the GSS were expected to make better use of the group expertise composite, while face-to-face groups were expected to rely more on the most active participants.

*Hypothesis 5: Team Expertise is Positively Related to Group Performance*

Hypothesis 5A: Team expertise is positively related to group performance in GSS groups.

Hypothesis 5B: Team expertise is positively related to group performance in face-to-face groups.

Hypothesis 5C: Team expertise will have a greater effect on overall group performance in GSS groups than in face-to-face groups.

### *2.8 GSS as a Moderator of Influence and Perceived Expertise*

As discussed previously, a GSS tends to increase informational influence and dampen normative influence. This is due in part to the removal of social cues such as voice inflection and gesturing inherent in face-to-face group interaction. Personality characteristics including dominance and extroversion are prevalent in face-to-face group interaction, yet significantly dampened in GSS-supported groups.

This study expected the process of influence to be exerted along different paths between face-to-face and GSS-supported group interaction since the only method available for participants to exert influence through the GSS was via their typewritten submissions. Yet in face-to-face interaction, dominant individuals are able to exert influence through increased participation, voice inflection, and physical gestures.

Additionally, member status often plays a role in influencing team members. Lower status individuals may be less willing to disagree with their superiors which could result in a loss of factually correct information.

*Hypothesis 6: Influence Processes will Significantly Differ Between GSS and Face-to-Face Groups*

In face-to-face groups, the most active and dominant member is often recognized as the expert simply based on the volume of participation and other social cues. Since a GSS allows for a more thorough review, analysis, and discussion of participant inputs and dampens normative influence, it was expected that GSS technology would moderate perceived expertise. GSS groups should be better able to recognize true expertise based on the quality rather than the quantity of member inputs.

*Hypothesis 7: Recognition of Expertise will Significantly Differ Between GSS and Face-to-face Groups*

### *2.9 Role of Group History and Group Typology in Group Problem-Solving*

For the most part, group composition and structure has been ignored in research dealing with GSS. *"It is as if research in this area believed that, if you've seen one group, you've seen them all"* (Jessup et al, 1993). Many researchers have observed that past GSS research has generated inconsistent or inconclusive results (George, 1989; Dennis, Easton, Easton, George, & Nunamaker, 1990, Dennis, Nunamaker, & Vogel, 1991). All of these studies point to group history and typology as one possible reason for these confounding findings, and assert that GSS research exhibits an almost universal use of ad-hoc rather than established groups in laboratory research. An ad-hoc group is one that was nonexistent prior to the laboratory study, and whose existence will terminate at the study's conclusion. Conversely, established groups are those that existed in some organizational setting with a history of working together prior to the laboratory study (Mennecke & Valacich, 1998).

Drawing from years of laboratory and field studies of group dynamics, McGrath developed a typology of groups that places groups into three primary categories—natural, concocted, and quasi. He defines natural groups as, *"...groups that exist independent of the researcher's activities and purposes"* (McGrath, 1984:41). For example, families, work crews, and friendship groups fall into this category.

Natural groups are highly distinguishable from concocted groups which are created explicitly for the purpose of being vehicles for research. Concocted groups may or may not contain members who coincidentally exist in natural groups outside the researcher's domain of interest. For instance, a researcher may draw members from a population of a large organization and randomly assign participants to groups. Within each group may exist members who have a history of working together in various organizational activities.

Finally, McGrath describes the quasi group as a concocted group with a highly constrained and artificial pattern of activity imposed by the researcher. Quasi groups are most similar to the majority of groups used in past GSS studies which are identified as ad-hoc in much of the existing literature.

Based on the preceding discussion of group history and typology, groups can be viewed on a developmental continuum similar to that of the political spectrum. Figure 2.5 is a representation of various levels of group history/typology with examples drawn from existing literature placed along the continuum. At the far left end of the spectrum reside those groups used most often in empirical studies. At the far right exist those groups occurring naturally in society with a long history of existence and a well-established structure. The shaded box just left of center in Figure 2.5 represents a conceptual point along the continuum at which the groups used in this study are considered to reside.

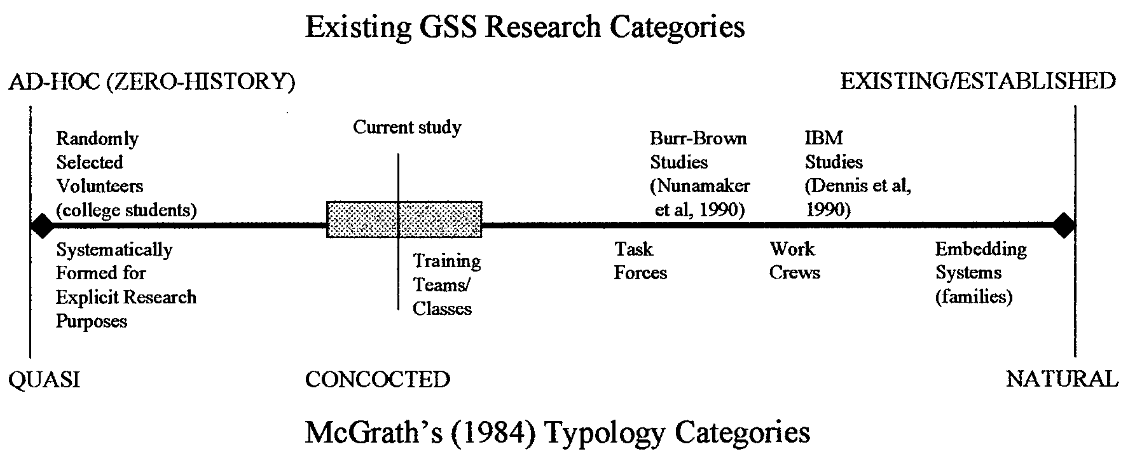



**Figure 2.5 Group History/Typology Continuum**

Central to this research was the study of the interaction processes groups undergo during intellective problem solving. Since much evidence exists indicating the impact of group history/typology on research outcomes, this study attempted to account for the confounding results caused by the overwhelming use of zero-history groups in GSS studies. As will be discussed in more detail in Chapter III, the groups used in this study were drawn primarily from naturally occurring collections of students attending formal training in established classroom settings. However, due to the limited timeframe during which the groups existed, they could not be considered truly natural, established groups under McGrath's typology. Yet they were considered existing and more established than randomly selected volunteers since each group was composed of students from formal, rigid training teams. Therefore, the groups used in this study are considered to have fallen along the shaded area depicted in Figure 2.5.

### *2.10 Role of Influence and Task Type in Group Problem-Solving*

Deutsch and Gerard (1955) assert that informational influence is based on the acceptance of factual information from others as evidence about reality and normative influence is based on the desire to conform to the expectations of other group members. A recent study that treated influence as either informational or normative found that, for intellective tasks requiring more factual information exchange, GSS amplified informational influence thereby increasing task performance, but attenuated normative influence in preference task groups (Huang et al, 1997).

In reviewing the previously mentioned findings, it is important to note the affect of task type on influence during GSS problem-solving sessions. Task type has been identified as a major moderating factor on performance outcomes (Jessup et al, 1993:74). Nunamaker, Dennis, Valacich, Vogel, and George (1991) claim task is one of four variables which fix the conditions under which group interaction takes place. It determines the type and amount of information that must be exchanged in problem-solving situations and accounts for as much as 50% of the variance in group performance

(Poole, Siebold, & McPhee, 1985). Much of the empirical GSS research to date has used two distinct types of tasks as part of their experimental structure—intellective and preference.

The aforementioned categories seemed quite limited in light of the significant impact of task type on group performance. McGrath (1984) developed a conceptually related set of task distinctions around which he built a circular task model identified as the Group Task Circumplex, Figure 2.6.

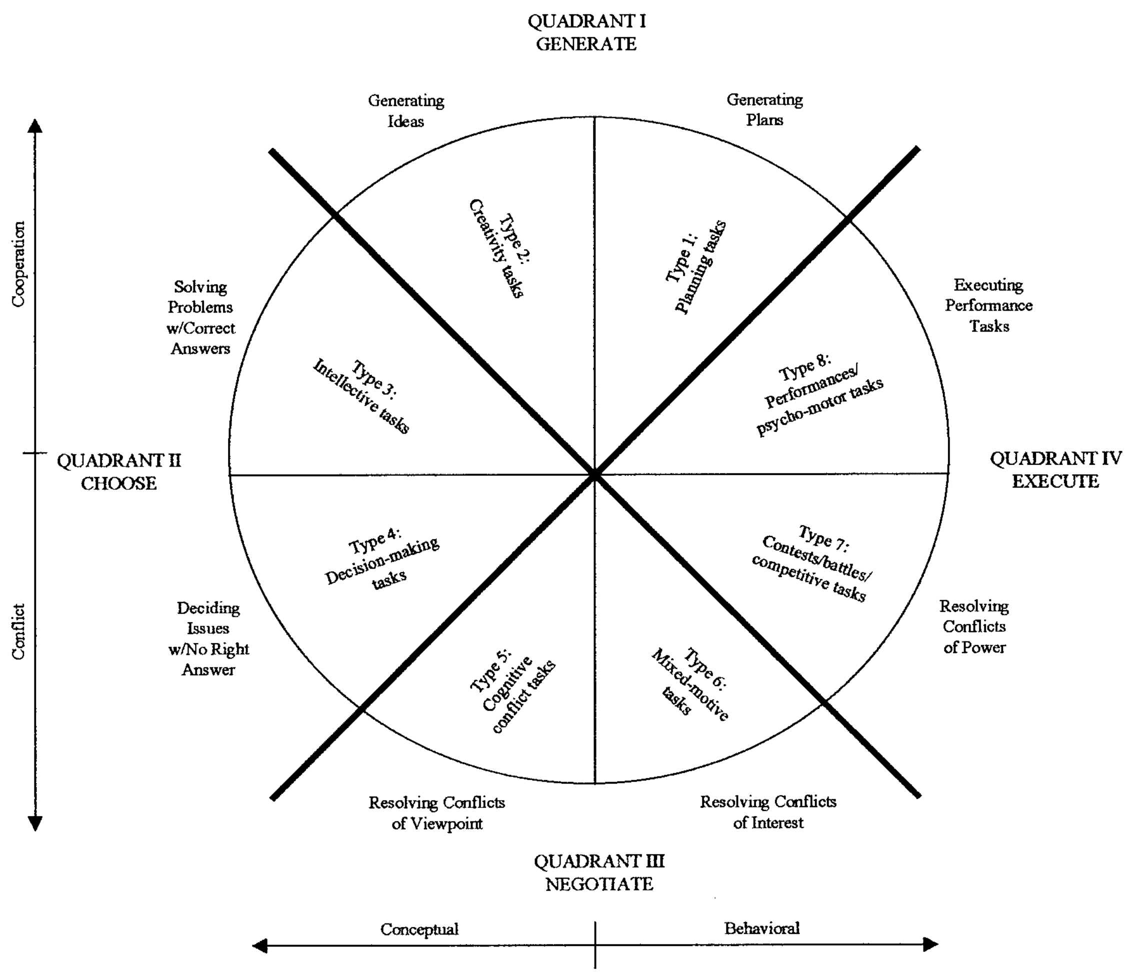



**Figure 2.6 The Group Task Circumplex (Adapted from McGrath, 1984)**

This detailed representation of task types first breaks tasks into four categories (quadrants) that indicate what the group (or individual) is required to do. Next, each quadrant is divided into two aspects related to the specific action. For instance, Quadrant II of the Group Task Circumplex (CHOOSE) asserts that groups or individuals are faced with two competing types of choice tasks: (1) intellective, and (2) decision-making.

The definition and placement of these types of tasks into the Group Task Circumplex was based on a series of studies that categorized intellective tasks as those that require the individual or group to solve problems with demonstrably correct answers (Laughlin, Kerr, Davis, Halff, & Marciniak, 1975; Laughlin, Kerr, Munch, & Haggerty, 1976; Laughlin & Sweeney, 1977; Laughlin & Adamopoulos, 1982). However, McGrath (1984:62) further defined intellective tasks as:

> ***Intellective Tasks***: Solving problems with a correct answer. E.g., Laughlin's intellective tasks, with correct and compelling answers; logic problems and other problem-solving tasks with correct but not compelling answers; tasks for which expert consensus defines answers. Key notion: Correct answer. (Emphasis in original).

The research presented here focused on Quadrant II, Type 3 tasks designated as "*... tasks for which expert consensus defines answers*," (McGrath, 1984). In contrast, preference tasks are those in which a group is given a list of choices and must reach a decision on issues without demonstrably correct answers based on group values and norms (Sia, Tan, & Wei, 1996). Therefore, informational influence would seem to be most valuable when applied to intellective problem-solving tasks. In light of Huang et al (1997) findings that GSS tend to amplify informational influence, this study focused on informational influence exerted by group members while solving an intellective problem-solving task.

### *2.11 Summary*

GSS have been touted as the cure-all to many of the problems inherent in face-to-face group interaction. The ability for group members to communicate in parallel can increase and equalize overall participation (Jessup et al, 1993). By offering anonymity to team members, GSS can elicit participation from individuals who might otherwise remain silent for fear of retaliation, value judgment by other group members, or intelligence appraisal by peers (Nunamaker, 1997).

Though much research has been conducted into the effect of GSS on overall group performance, few studies have viewed GSS group interaction across the entire input-process-output spectrum. Conflicting results concerning GSS and overall group performance indicate a possible link between the inputs, processes, and outcomes that may affect the ability of expert members to influence the group towards the correct solution to intellective problem-solving tasks. Similarly, GSS technology may be a significant moderator of recognition of expertise in intellective problem-solving groups.

Through an extensive literature review of the small group research stream and the GSS research stream, Chapter II of this report developed an IPO model of expertise, influence, and group performance, and arrived at seven hypotheses concerning the similarities and differences between traditional face-to-face and GSS-supported problem solving groups. Chapter III describes the methodology by which an empirical experiment was designed to test the hypotheses posited in Chapter II.

## *Chapter III - Methodology*

### *3.1 Introduction*

As stated in Chapter I, this study applies an input-process-output model of expertise, influence, and group performance to face-to-face and GSS-supported problem-solving groups to test the affect of GSS technology as a moderator of influence and recognition of expertise. This chapter describes how data were collected, computed, and statistically analyzed to test the hypothesized relationships between the variables in the model described in Chapter II.

### *3.2 Experimental Design*

For the purpose of this study, a commonly used group decision-making task, the NASA Moon Survival Scenario (Appendix A), was applied to small group research to investigate the relationships between expertise, participation, and group performance, and to determine if differing levels of participant labeling moderate influence and recognition of expertise. This specific task was chosen for two reasons. First, an expert solution to the problem was previously generated by experts from the Crew Equipment Research Section of the NASA Manned Spacecraft Center in Houston, Texas (Hirokawa, 1980:313-314). Second, such non-eureka type intellective tasks are often used in group decision-making and problem solving research because they tend to increase participant interaction over eureka-type tasks having a demonstrably correct solution (Bluedorn & Turban, 1999:280).

In each manipulation, four subjects interacted as a team to solve the task. A group size of four was chosen for this experiment because the average number of people attending a decision-making meeting is usually less than five (Lam, 1997:199). Four-person groups also reduce the effect of blocking due to free riding, a condition to which larger groups are susceptible in face-to-face interactions (Olaniran, 1994).

This study employed a fully randomized experimental design to investigate the relationships between the input variables representing task expertise and process variables including intellective and affirmative participation leading to an outcome variable, overall group performance. Individuals were randomly assigned to each four-person group and each group was randomly assigned to one of the following treatments:

1. Face-to-face (Some Content Anonymity)
2. GSS – Labeled with Placard (No Anonymity)
3. GSS – Labeled (Process Anonymity)
4. GSS – Unlabeled (Content and Process Anonymity)

### *3.3 Equipment and Facilities*

Experiments were conducted at each location from which participants were drawn. Two separate rooms were used to conduct the experiment: a preparation room and a task room. The preparation room was used to administer a participant consent form, various data collection questionnaires used in each of the three concurrent research efforts, and individual completion of the problem-solving task. The task room was used to conduct the group problem-solving process and to display the group's final solution to the participants. A depiction of the GSS task room is included in Appendix B.

A mobile GSS environment was used to conduct the computer-supported group problem-solving sessions at each experiment location. Care was taken to ensure GSS configuration and room layout were identical at all locations. The GSS was comprised of six Pentium-based personal computers and one Microsoft NT® Pentium-based server configured with Ventana Corporation's GroupSystems® software running under the Microsoft Windows 95® operating system. A meta-analysis of over 200 GSS studies found GroupSystems, developed by researchers at the University of Arizona, to be the most widely used group interaction software in GSS studies (Fjermestad & Hiltz, 1999). An InFocus® projector was also used to display team results to all participants in the group immediately following task completion.

### *3.4 Anonymity Manipulations*

Three anonymity manipulations were of interest to this study as indicated in Table 3.1. Though complete non-anonymity as a moderator of the model described in Chapter II was not of concern to this study, it was of specific concern to two of the four studies discussed in Chapter I that were conducted concurrently with that reported here. Non-anonymity treatment methodology is reported in this study because the collection of such data was a significant aspect of the experimental design, although the data is not reported.

Content anonymity refers to a level of anonymity whereby team members are unable to easily attribute specific comments to particular individuals, but are still able to easily determine which participants are contributing to the group discussion. Process anonymity refers to a level of anonymity whereby team members cannot readily determine which specific individuals are or are not contributing to the group discussion (Jessup et al, 1993:243).

**Table 3.1 Anonymity Manipulations and Sample Size for each of Four Treatments**

| TREATMENT | ANONYMITY LEVEL | SAMPLE SIZE |
|---|---|---|
| Face-to-face | Some Content Anonymity | N = 80 |
| GSS-Labeled/Placard | No Anonymity | N = 84 |
| GSS-Labeled Only | Process Anonymity | N = 76 |
| GSS-Unlabeled | Process and Content Anonymity | N = 60 |

Anonymity was manipulated in the three GSS treatments by varying the configuration of the system. GroupSystems can be configured to attach terminal identification labels to the end of each comment submitted by the participants. Each of the four participant machines was configured to include a terminal identifier. In this study, one of four colors (red, blue, green, or yellow) was used to identify participant terminals. The software provides the system administrator the ability to enable or disable the display of terminal labels during system configuration. Experiment manipulation checks were included in the post-task survey given to all participants. The results of the manipulation checks indicate that the anonymity manipulations discussed in the following section were successful.

*3.4.1 Anonymity Manipulation Procedures.*

Anonymity was manipulated by randomly assigning groups to one of the four treatments identified in Table 3.1. Subjects assigned to the face-to-face treatment were situated in a conference room setting, seated two across from one another. Each individual could easily identify the originator of each comment. However, participants could not necessarily remember the originator of specific comments over time. Therefore, subjects assigned to this treatment condition exhibited a degree of content anonymity over the course of the group problem-solving session.

In the GSS labeled with placard treatment, the system was configured to attach terminal labels to the end of each comment, and each terminal was physically labeled with a large colored placard corresponding to the system's label. As participants submitted comments during the problem-solving discussion, each member of the group could identify the terminal and the individual who submitted the comment. Therefore, subjects assigned to this treatment were completely non-anonymous since participants could review the inputs of each member over the course of the group problem-solving sessions.

In the GSS labeled treatment, no placard was attached to participant terminals. Members could identify the originator of a comment by their logical label, but were unable to identify the physical participant who submitted the comment. This manipulation resulted in process anonymity whereby members could not easily attribute participation to specific individuals.

Finally, process and content anonymity was achieved by removing the comment labels during system configuration. During this treatment, members could not readily determine who did and did not contribute to the group discussion. Measurement instrument reliability and manipulation check statistics for comment labeling and anonymity are presented in section 3.7.

### *3.5 Subjects*

The 300 participants in this study were predominately United States Air Force Company Grade Officers who were either graduate students at the Air Force Institute of Technology, or technical training students at the Air Force Communications Officer Training program located at Keesler AFB, MS. Approximately 20 percent of the participants were Air Force ROTC Cadets from three detachments. As discussed in Chapter II, Section 2.6 the subjects were considered to be members of somewhat established groups since each 4-person group was drawn from formal, rigorous training classes that worked together on a daily basis.

The study included both male and female subjects, though gender was not of concern to this study. Table 3.2 identifies demographics relevant to the sample population used in this study. The majority of the participants were males who represented nearly 80 percent of the sample population. A slight majority of the participants were single (55.7%). The mean age of the participants was 26.16 years, and ages ranged from a low of 17 years to a high of 55 years. The education level of the participants was measured on a scale from 1-5 as indicated in Table 3.2. A large majority of the participants held at least a Bachelor's Degree (80%). 18.7 percent of the participants had completed some college level studies, and four of the participants were high school graduates.

Participants' experience using personal computer technology was measured on a scale from 1 to 4 as indicated in Table 3.2. A large majority of the participants (81%) had been using personal computer technology for at least 6 years. Participants' frequency of personal computer use was also measured on a scale from 1 to 4. Over 85% of the participants reported using personal computers at least 11 hours per week.

**Table 3.2 Population Sample Demographics**

| DEMOGRAPHIC MEASURE | M | N | % |
|---|---|---|---|
| Gender | N/A | | |
| Males: | | 239 | 79.7 |
| Females: | | 61 | 20.3 |
| Marital Status | N/A | | |
| Married: | | 133 | 44.3 |
| Single: | | 167 | 55.7 |
| Age | 26.16 | N/A | N/A |
| Education Level: 1 – 5 | 3.09 | | |
| 1 - High School: | | 4 | 1.3 |
| 2 - Some College: | | 56 | 18.7 |
| 3 - Bachelor's Degree: | | 169 | 56.3 |
| 4 - Some Graduate Studies: | | 51 | 17.0 |
| 5 - Graduate Degree: | | 20 | 6.7 |
| Personal Computer Experience (Years) | 3.18 | | |
| 1: Less than 1 | | 0 | 0 |
| 2: One to five | | 57 | 19.0 |
| 3: Six to ten | | 131 | 43.7 |
| 4: More than 10 | | 112 | 37.3 |
| Personal Computer Use (Hours/Week) | 2.59 | | |
| 1: 0 to 10 | | 49 | 16.3 |
| 2: 11 to 20 | | 100 | 33.3 |
| 3: 21 to 30 | | 77 | 25.7 |
| 4: 31 or more | | 74 | 24.7 |

Notes: (M) Mean, (N) Number of sample, (%) Percent of sample.

### *3.6 Experiment Procedures*

As each team arrived for the study, the participants were seated in the preparatory room. Two researchers conducted each experimental session: a facilitator and an assistant. Reading from a script, the facilitator introduced himself and his assistant and welcomed the participants. The assistant distributed a manila folder to each participant that contained an experiment consent form (Appendix C), a personality questionnaire, and a paper copy of the NASA Moon Survival Scenario. The participants were asked to read and sign the informed consent form that outlined the subjects' rights during the study and stated that participation was entirely voluntary. Upon completion of the consent form, the assistant collected them and placed them in a clearly marked folder separate from all other data collection instruments. The facilitator then assured the subjects that any information provided during the experiment would not be personally associated with them.

Subjects were then asked to complete a personality questionnaire used to collect data relevant to another research effort. As the subjects completed each instrument, they were instructed to place it in their manila folder. Next, each participant individually completed the moon scenario by ranking the 15 items in order of importance (1 being most, 15 being least) for survival on the moon. Since the NASA moon survival scenario is commonly used in studies of group dynamics, leadership, and team building exercises, the participants were instructed not to inform the other members of their group if they had completed the task previously. This was done so as to prevent any one participant from biasing others' perceptions of their task knowledge during the group problem-solving session.

Once all subjects were finished with the task, the facilitator then briefly discussed group decision-making and problem solving processes in general terms. The process of idea generation through brainstorming was emphasized, and the facilitator described the process of group consensus as defined for this study. Participants were then instructed that, during the group problem-solving discussion period, they were to come to consensus on a group solution that all team members could endorse. Upon completion of the preparatory room activities, participants were led to either the face-to-face task room or the GSS task room, depending on which treatment the group was assigned to.

*3.6.1 Face-to-face Treatment Procedures.*

Groups assigned to the face-to-face treatment were seated at one of four positions around a large conference table. Members sat two across from each other in a conference room setting. The two researchers sat at one end of the conference table to facilitate the problem-solving process. Each member of the group was given a clean copy of the scenario and allowed to use scratch paper or a white board while solving the problem. Each group was given 15 minutes in which to discuss and reach consensus on a group solution. The facilitator informed the group when they had 5 and 2 minutes respectively remaining in the discussion period. At the end of the 15-minute discussion period, all notes were collected and the white board was erased. Each participant was given another clean copy of the scenario and asked to complete it according to the group's decision. Participants were not permitted to refer to their notes or the white board, not to discuss their decision further so as to ensure consistency between the face-to-face process and the process of voting in the GSS problem-solving treatments. Once each member finished voting, researchers collected each task and consolidated the votes into one team solution. The team's solution was used to compute a final team score for the task.

*3.6.2 GSS Treatment Procedures.*

Groups assigned to the GSS treatment were instructed to sit at any one of four computer terminals comprising the GSS participant stations. The GSS included a facilitator terminal and four participant stations. Participants were led through a brief training scenario that introduced them to the two GSS tools to be used during the problem-solving session—Categorizer and Vote. During the training session, the facilitator instructed the group on how to enter comments into the Categorizer tool. After each member entered a comment, the facilitator pointed out that each member of the group could see all the comments submitted by each participant. Depending on the GSS treatment, the facilitator also pointed out that each member could identify the originator of each comment. Participants were then trained on the GroupSystems Vote tool that was used to arrive at a final group solution.

Immediately following the training session, each group was allotted 15 minutes in which to discuss and solve the scenario. Participants were instructed to focus their discussion on the merits of the items in the list, and not simply on the order they should be ranked. This was done to increase intellective participation and avoid conversational lag that might occur if the team simply discussed their individual solution to the task. Members were allowed to discuss the problem only through the GSS Categorizer tool and were not allowed to discuss the task verbally. During the 15-minute discussion period, the original list of items was visible to each participant on their computer screen. The facilitator notified the group when they had 5 and 2 minutes remaining in the discussion period. At the end of the 15-minute discussion period, the group was instructed to stop their discussion and was given one minute to review all comments submitted.

Following the discussion period, the facilitator closed the Categorizer tool and opened the GroupSystems Vote tool. Each member was instructed to reorder the list according to their group's solution and to cast their ballot. Once all ballots were cast, the facilitator provided feedback on the final solution based on the consolidation of the group vote. However, no feedback was provided in terms of how well the group scored on the task since this could bias post-discussion questionnaires on perceptions of member expertise, group performance, meeting utility, and other measures taken after the group problem-solving process.

### *3.6.3 Post-task Procedures.*

At the end of the problem-solving sessions, each group was led back to the preparatory room where each member individually completed a variety of post-task measurement instruments to collect data for other studies as mentioned in Chapter I. Participants then completed instruments used to measure the labeling and anonymity manipulation checks. A final questionnaire was completed to collect data measuring member perceptions of expertise for each individual. A sample of the instrument is provided in Appendix D. Finally, each group was debriefed and released back to their respective duty sections. During the debrief, participants were reminded not to discuss the experiment with their fellow classmates to avoid biasing follow-on groups' performance.

### *3.7 Reliability Analysis and Experimental Manipulation Checks*

In order to determine the effectiveness of the experimental manipulations, participants were asked to complete two 3-item surveys. Survey data was first analyzed to ensure inter-item reliability. Scale reliability was estimated by calculating the internal consistency of each multi-item scale as indexed by Cronbach's coefficient alpha ($\alpha$) (Hair, Anderson, Tatham, & Black, 1998). Next, experimental manipulation checks were conducted across treatment groups using an ANOVA test to assess the significance of the difference between means of each treatment group.

#### *3.7.1 Reliability Analysis – Comment Labeling*

Table 3.3 presents the results of the inter-item reliability analysis for the labeling manipulation check. Inter-item reliability as indexed by Cronbach's coefficient alpha was assessed at .89, well above the suggested acceptable cutoff of .70 (Hair et al, 1998), indicating an acceptable internal consistency level for the 3-item scale designed to assess the success of the information labeling manipulation.

#### *3.7.2 Reliability Analysis – Anonymity*

Table 3.4 presents the results of the inter-item reliability analysis for the anonymity manipulation check. Inter-item reliability as indexed by Cronbach's coefficient alpha was assessed at .86 indicating an acceptable internal consistency level for the 3-item scale.

**Table 3.3 Reliability Analysis – Comment Labeling**

| COMMENT LABELING ITEMS | M | SD | α |
|---|---|---|---|
| Combined | 4.6410 | 1.5009 | .8928 |
| I could tell if someone was sharing more information than other members of the group. | 4.6369 | 1.6464 | |
| I could tell if someone participated less than other members of the group. | 4.47024 | 1.6994 | |
| Other group members could judge the extent that I participated in the group. | 4.7262 | 1.6151 | |

Notes: M (Mean), SD (Standard Deviation), (α) Coefficient Alpha.

**Table 3.4 Reliability Analysis – Anonymity Manipulation Check**

| ANONYMITY ITEMS | M | SD | α |
|---|---|---|---|
| Combined | 4.9087 | 1.4935 | .8662 |
| I could recognize the originator of most comments. | 4.8036 | 1.8377 | |
| Other group members could connect me to the comments I made. | 4.9345 | 1.6224 | |
| Other group members knew when I made a contribution to the group. | 5.0655 | 1.5727 | |

Notes: M (Mean), SD (Standard Deviation), (α) Coefficient Alpha.

*3.7.3. Manipulation Check – Comment Labeling*

Table 3.5 presents the summary results for the labeling manipulation check between the face-to-face and GSS Labeled treatments. The results indicate that the face-to-face treatment participants did not exhibit content anonymity. There was no statistically significant difference in means between the face-to-face treatment (5.60, s =

1.098) and the GSS labeled treatment (5.17, s = 1.107). This unexpected result was possibly a result of task duration. The problem-solving task was relatively short; approximately 20 minutes. Therefore, participants were able to remember who said what during the exercise. During the manipulation check, it is likely that participants felt like they knew who said what which resulted in higher scores on the manipulation check instrument. Thus, the data suggest that the face-to-face treatment participants operated in a non-anonymous condition.

Table 3.6 presents the summary results for the labeling manipulation check between the two GSS treatments. The results indicate that the manipulation was successful between groups exhibiting process anonymity alone and groups exhibiting process and content anonymity. GSS labeled participants registered a mean of 5.17 (s = 1.11) compared to GSS unlabeled participants who registered a mean of 3.41 (s = 1.38). The difference in means was statistically significant at $p < .05$ with a strong effect as indexed by $eta^2 = .33$ (Jaccard & Becker, 1997).

**Table 3.5 Labeling Manipulation Check – Content Only to Process Only**

| ***FACE-TO-FACE*** | | ***GSS Labeled*** | |
|---|---|---|---|
| **M** | **SD** | **M** | **SD** |
| 5.60 | 1.098 | 5.17 | 1.107 |

Notes: p<.05

**Table 3.6 Labeling Manipulation Check – Process Only to Process and Content**

| ***GSS Labeled*** | | ***GSS Unlabeled*** | |
|---|---|---|---|
| **M** | **SD** | **M** | **SD** |
| 5.17 | 1.107 | 3.41 | 1.382 |

Notes: p<.05

### *3.7.4. Manipulation Check – Anonymity*

Table 3.7 presents the summary results for the anonymity manipulation check between the face-to-face and GSS treatments. Once again, no statistically significant difference in means between the face-to-face and GSS labeled treatments was found. The results provide further evidence that the participants in the face-to-face treatment operated under a non-anonymous condition, probably due to the short duration of the task. Participants were easily able to tie specific comments to physical individuals within their respective groups, and were able to remember which participants submitted particular comments.

Table 3.8 presents the summary results for the anonymity manipulation check between the two GSS treatments. The results indicate that the manipulation was successful between groups exhibiting process anonymity alone and groups exhibiting process and content anonymity. GSS labeled participants registered a mean of 5.13 (s = 1.302) compared to GSS unlabeled participants who registered a mean of 3.77 (s = 1.301). The difference in means was statistically significant at $p < .05$ with a strong effect as indexed by $eta^2 = .22$. This difference was expected since participants in the GSS labeled treatment were able to identify the originator of specific comments via the logical label attached to the end of the submission.

**Table 3.7 Anonymity Manipulation Check – Content Only to Process Only**

| ***FACE-TO-FACE*** | | ***GSS Labeled*** | |
|---|---|---|---|
| **M** | **SD** | **M** | **SD** |
| 5.70 | .7687 | 5.13 | 1.3010 |

Notes: p<.05

**Table 3.8 Anonymity Manipulation Check – Process Only to Process and Content**

| *GSS Labeled* | | *GSS Unlabeled* | |
|---|---|---|---|
| **M** | **SD** | **M** | **SD** |
| 5.13 | 1.3019 | 3.77 | 1.3010 |

Notes: $p<.05$

*3.8 Hypothesis Outcome Measures*

As discussed earlier, this study applies an input-process-output model of expertise, participation, and group performance to face-to-face and GSS-supported problem-solving groups to explore the effect of GSS technology on influence and recognition of expertise. It is based upon the supposition that the manipulation of information labeling and group processes provided by GSS technology will affect participants' ability to influence team members and to recognize expertise within the group. The constructs under scrutiny in this study are defined in Table 3.9.

Individual task expertise represents the level of task knowledge possessed by each individual in the group. Individual expertise was operationalized as the individual's solution to the task in relation to the previously derived NASA experts' solution. It was computed using equation 3.1:

$$IE = 112 - \sum_{i=1}^{15} | IR - ER | \qquad (3.1)$$

where IE is individual task expertise, IR is the individual's rating of the item in the list, and ER is the NASA experts' rating of the item in the list. Because discrepancies between individual and expert ratings represented errors, the sum of the discrepancies was subtracted from a constant yielding an index of individual expertise in which higher scores reflected greater expertise.

**Table 3.9 Root Constructs, Definitions, and Operationalizations**

| CONSTRUCT | DEFINITION | OPERATIONALIZATION |
|---|---|---|
| Individual Expertise (Littlepage et al, 1995) | The level of individual knowledge exhibited by the participant relevant to the task. | The difference between the individual participant's score and the NASA expert's solution to the task, subtracted from a constant to yield a positive index of expertise. |
| Intellective Participation | The relative level of participation exhibited by the participant relating directly to the task or the group process. | The number of intellective comments submitted by the individual during the group problem-solving process measured in whole numbers. |
| Affirmation Participation | The relative level of participation exhibited by the participant that directly confirmed or refuted other members' intellective comments. | The number of affirmative/refutive comments submitted by the individual during the group problem-solving process measured in whole numbers. |
| Group Performance | The relative level of performance exhibited by the group concerning the intellective problem-solving task. | The difference between the group's score and the NASA expert's solution to the task, subtracted from a constant to yield a positive index of group performance. |
| Team Expertise | The composite level of knowledge exhibited by the group relevant to the intellective problem-solving task. | The mean of the individual expertise measures between the four members of the group. |

Intellective participation measured each individual's rate of participation during the group problem-solving task. For the purposes of this study, intellective comments were defined as comments specifically related to the intellective problem-solving task, or the process by which the group attempted to solve the task. During the face-to-face treatment, two coders counted the number of intellective comments submitted by each individual in the group. One researcher counted comments submitted by participants one and two, and the other researcher counted comments submitted by participants three and four. Comments were counted on a tally sheet with tick marks and summed at the end of the 15-minute discussion period.

In the three GSS treatments, an electronic log file for each participant was kept on each GSS terminal. At the end of the 15-minute discussion period, each log file was reviewed and comments were coded based on unique, independent thoughts submitted by the participant. That is, intellective participation was coded according to individual thought processes within each entry. For instance, if a participant typed a paragraph of thoughts prior to striking the <Enter> key, each separate thought was coded as an intellective comment, rather than the entire entry counted as a single input.

Affirmation participation measured each participant's level of participation in terms of the number of affirmative comments submitted. Comments that simply indicated agreement with other members' intellective comments, affirmed previously submitted intellective comments, or refuted previously submitted intellective comments were coded as affirmation comments. Affirmation participation was coded in the same manner as intellective participation in both the face-to-face and GSS treatments.

Inter-rater reliability was assessed for intellective and affirmation participation coding in both face-to-face and GSS treatments. During pilot studies conducted in preparation for empirical data collection, two coders counted the intellective and affirmation comments submitted by the same two face-to-face participants in 20 percent of the pilot study sessions. Inter-rater reliability was assessed using Cronbach's coefficient alpha at .86. In the GSS treatments, an AFIT faculty member coded 15 percent of the log files for comparison against the researcher's coding results. Inter-rater reliability was assessed at .93. An sample group transcript is provided in Appendix E.

Group performance measured the overall level of performance exhibited by the group on the intellective problem-solving task. Once each group reached agreement on a final solution, a team score was computed in the same manner individual scores were computed using equation 3.2:

$$GP = 112 - \sum_{i=1}^{15} |TR - ER| \qquad (3.2)$$

where GP is group performance, TR is the team's rating of the item in the list, and ER is the NASA experts' rating of the item in the list.

Finally, team task expertise represented the overall level of expertise existing within the group, and was measured as the mean of the group's individual expertise scores on the task. This construct represents an overall average measure of the level of task expertise that existed across the group as a whole. It is a composite representation of the potential expertise available within the group.

*3.9 Statistical Analysis*

The hypotheses identified in Chapter II were proposed to test the basic premise that the input variable identified as individual task expertise would be deterministic of process variables, namely individual participation levels during group problem-solving of intellective, non-eureka type tasks. Additionally, the process variables identified as intellective and affirmation participation, as well as the input variable identified as team expertise, were expected to be deterministic of overall group performance. Each of these hypotheses required a statistical test of the differences between the IPO variables identified in the model across all treatments.

The statistical technique employed to test for these relationships was structural equation modeling. Structural equation modeling (SEM) encompasses an entire family of statistical analysis techniques distinguished by two characteristics: (1) estimation of multiple and interrelated dependence relationships, and (2) the ability to represent unobserved concepts in these relationships and account for measurement error in the estimation process (Hair et al, 1998). This second characteristic is of primary concern to this study since the constructs identified as influence and perceived expertise were not directly nor indirectly observed variables, but were concepts expected to be represented by the relationships between the observed variables in the model.

The SEM program LISREL® v8.14 was used to test the relationships identified in Chapter II. LISREL provides more than 15 different goodness-of-fit indices that reflect the consistency between a model and the covariance data under analysis. In SEM analysis, overall model fit must be tested and deemed acceptable before attempting to interpret hypothetical relationships. Once model fit is deemed acceptable according to predetermined thresholds, the researcher can then begin interpreting the relationships indicated by the path coefficients.

The hypotheses presented in Chapter II were tested in two phases. First, overall fit of the data from each treatment group to the theoretical model was tested using the likelihood ratio chi-square ($\chi^2$) statistic. The $\chi^2$ test is a test of perfect model fit in which the null hypothesis is that the model fits the population data perfectly. A statistically significant $\chi^2$ causes rejection of the null hypothesis which may suggest an imperfect model fit and therefore possible rejection of the model. A statistically non-significant $\chi^2$ is consistent with a good model fit and suggests that the model can be retained as viable (Jaccard & Wan, 1996).

Since $\chi^2$ can be affected by numerous data characteristics including sample size, multivariate normality, and others, experts suggest using a variety of goodness of fit indices to confirm overall model fit. Therefore, four other LISREL fit indices were used in assessing data fit to the hypothetical model. These fit indices fall into three basic categories which are identified and described in Table 3.10.

For the purposes of this research, the model was deemed acceptable if all five of the fit indices fell within the thresholds of acceptability identified in column 3, Table 3.10. If the data within each treatment group provided acceptable fit to the hypothetical model, the hypothesized bivariate relationships were then analyzed by inspecting the resulting path coefficients and their associated levels of significance to determine if the data supported or rejected the hypothesized relationships. LISREL provided a statistical test for each path coefficient using a z-score. The critical value of z for a one-tailed test is 1.65 equating to a .05 level of significance. A one-tailed test was used because the relationships between the variables were hypothesized to be either positive or negative.

**Table 3.10 Fit Index Categories, Descriptions, and Levels of Acceptability**

| GFI CATEGORY | GFI MEASURE AND DESCRIPTION | TEST OF ACCEPTABILITY |
|---|---|---|
| Absolute Fit - Measures only overall model fit with no adjustment for the degree of "overfitting" that might occur (Hair et al, 1998:611). | $\chi^2$ – Test of perfect model fit in which the null hypothesis is that the model fits the population data perfectly (Jaccard & Wan, 1996). | Degress of Freedom >= 0<br>p > .05 |
| Absolute Fit | Standardized Root Mean Square Residual – The average absolute discrepancy between the predicted and observed covariance matrices (Thurston, 2000). | Std RMR < .05 |
| Absolute Fit | Goodness of Fit Index (GFI) – Measures the correspondence of the actual or observed covariance matrix with that predicted from the proposed model (Hair et al, 1998:610-611). | GFI > .90 |
| Parsimonious Fit – Adjusts measures of fit providing a comparison between models with differing numbers of estimated coefficients to determine the amount of fit achieved by each estimated coefficient (Hair et al, 1998:611). | Root Mean Square Error of Approximation (RMSEA) – The average difference per degree of freedom expected to occur in the population rather than the sample (Hair et al, 1998:660). Associated p-value tests the null hypothesis that RMSEA < .05 (Thurston, 2000). | RMSEA < .08<br>p > .05 |
| Incremental Fit – Compares the proposed model to another model specified by the researcher (Hair et al, 1998) | Comparative Fit Index (CFI) – Considers the relative fit of the model to the null model rather than testing for perfect fit (Thurston, 2000). | CFI > .90 |

The second phase of analysis tested the hypothesized differences between the treatment groups. LISREL provides a multi-group strategy that allows comparison of suspected interaction effects involving moderator variables, qualitative or quantitative, with few values. This second phase of analysis was accomplished in three steps.

First, a multi-group solution, including parameter estimates and goodness of fit measures, for the hypothesized model was derived by simultaneously comparing the covariance matrices across all treatment groups. LISREL bases the goodness of fit on a pooling of the fit measures from each group separately. A statistically non-significant pooled $\chi^2$ is consistent with a model that fits well across treatments. The pooled group solution does not formally evaluate the interaction effect, but provides perspectives on how well the model fits the data when coefficients are estimated separately without constraints across groups (Jaccard et al, 1996). Prior to proceeding to step 2, the model must fit well across all groups. In this study, acceptable fit for the multi-group solution was based on the same fit indices used in the independent group solutions described in Table 3.10.

Step 2 involved placing equality constraints on the path or paths in the model where hypothesized interaction effects were expected. This procedure entailed fixing one or more paths equal to one another, and re-running the model using the step 1 multi-group input covariance matrices. If no interaction effect existed, meaning the two path coefficients were equal across the sample populations, then the equality constraint would not adversely affect model fit relative to the step 1 analysis. However, if a statistically significant interaction effect did indeed exist, then the equality constraint would adversely affect model fit. This adverse affect on model fit was tested in step 3.

Finally, the resulting $\chi^2$ statistics from step 1 and step 2 were compared using a $\chi^2$ difference test which is simply a comparison of the differences between the constrained multi-group solution and the unconstrained multi-group solution. The degrees of freedom and $\chi^2$ from step 1 were subtracted from the degrees of freedom and $\chi^2$ from step 2. This difference between the two test statistics is also distributed as a $\chi^2$ statistic that is either statistically significant or statistically non-significant (Jaccard et al, 1996). A statistically significant difference between the step 1 and step 2 $\chi^2$ test statistics indicates the presence of an interaction effect on the constrained path(s).

### *3.10 Summary*

The purpose of this chapter was to describe the randomized experimental design used to analyze the impact of varying levels of participant labeling through the use of GSS technology on influence, recognition of expertise, and performance between face-to-face and GSS-supported problem-solving groups. Chapter III described the equipment and facilities used, the subjects used in the study, the task, and the experimental procedures. The chapter then defined and explained the constructs of interest to this study. Finally, the statistical methods used to analyze and test the hypotheses presented in Chapter II were described.

Chapter IV will present the results of the statistical analysis in narrative and graphical form to explain the results of this study. Based on these results, recommendations for future research will be presented in Chapter V.

## *Chapter IV - Analysis of Data*

### *4.1 Introduction*

This chapter presents the results of the statistical analyses performed on the data collected during the empirical experiment. Structural equation modeling assumptions are addressed first, followed by the results of the structural equation modeling analysis presented in the sequence described in Chapter III. The findings presented in this chapter, as they relate to the hypotheses presented in Chapter II, will be discussed in greater detail in Chapter V.

### *4.2 Test for Multivariate Normality*

Structural equation modeling is very sensitive to violations of certain multivariate statistical assumptions. Departures from the assumption of multivariate normality resulting in strong skewness or kurtosis in the data are of particular concern. Extreme positive kurtosis can sometimes cause a reduction in standard errors which leads to an increased chance of committing a Type I error (Jaccard et al, 1996).

Skewness and kurtosis values outside the range +1 to –1 indicate a substantially skewed or kurtotic distribution, respectively (Hair et al, 1998:47-48). Three instances of excessive skewness and kurtosis were found across two of the three treatments. Affirmation participation within the face-to-face treatment group had a skewness value of 1.131, and a kurtosis value of 1.481. In the GSS labeled treatment affirmation participation had a skewness of 1.152 and a kurtosis of 1.621, and group performance was skewed at –1.390 with a kurtosis value of 1.557.

To determine the degree to which these data departed from normality, visual examinations of the relative frequency distributions and normal probability plots of all data were conducted (Appendix F-H). In addition to the visual inspection for non-normality, two statistical tests were conducted to assess departures from normality according to recommendations by Hair et al (1998).

First, a test for the statistical significance of the skewness values was conducted using equation 4.1:

$$z_{skewness} = \frac{skewness}{\sqrt{\frac{6}{N}}} \quad (4.1)$$

where $z_{skewness}$ is a z-statistic, *skewness* is the skewness value, 6 is a constant, and $N$ is the sample size. Second, statistical significance of the kurtosis values was assessed using equation 4.2:

$$z_{kurtosis} = \frac{kurtosis}{\sqrt{\frac{24}{N}}} \quad (4.2)$$

where $z_{kurtosis}$ is a z-statistic, kurtosis is the kurtosis value, 24 is a constant, and N is the sample size.

Each equation returned a z-statistic based on a two-tailed test of significance. Table 4.1 contains the results of the statistical tests for departure from normality. The results indicate that the assumption of normality for the three variables in Table 4.4 can be rejected.

**Table 4.1 Significance Test Results for Skewness and Kurtosis**

| TREATMENT AND VARIABLE | SKEWNESS VALUE | p | KURTOSIS VALUE | p |
|---|---|---|---|---|
| Face-to-face | | | | |
| (AP) | 1.131 | *** | 1.481 | ** |
| GSS Labeled | | | | |
| (AP) | 1.152 | *** | 1.621 | ** |
| (GP) | -1.390 | *** | 1.557 | ** |

Notes. $^{**}p<.01$; $^{***}p<.001$

*4.3 Handling Non-normality in Data*

The initial strategy to account for problems with non-normality in structural equation modeling is to remove any outliers (Jaccard et al, 1996). Thurston (2000) describes an outlier as any score on a variable that is extreme when compared to all of the other scores on the same variable. To handle the apparent departure from normality of the variables noted in Table 4.1, a review of the relative frequency distributions of the data was conducted. All observations with scores on the respective variables that fell above or below three standard deviations away from the mean were removed. Once removed, skewness and kurtosis values for all variables fell within the –1 to +1 range. Statistical tests for the significance of the new skewness and kurtosis scores were non-significant. However, the removal of the observations identified as outliers resulted in a reduction in sample size for two of the three treatments. In the face-to-face treatment, N dropped from 80 to 78, and N was reduced from 76 to 64 in the GSS labeled treatment

Once the initial goodness of fit, path coefficients, and standard errors were calculated using the smaller samples, the original data with existing outliers was contrasted against the smaller sample to determine if non-normality changed the results. A comparison of the standard errors between the small and large samples resulted in significant differences. The removal of outliers changed the path coefficients, goodness of fit indices, and standard errors between the two samples. Therefore, the results reported here are based on sample data with outliers removed.

### *4.4 Within-group Descriptives, Correlations, and Covariances*

Structural equation modeling focuses on the pattern and strength of the relationships across respondents in estimating the path coefficients between variables in the model. It uses as its input either a correlation or covariance matrix between the observed variables representing the constructs in the model. Tables 4.2 through 4.4 contain descriptive statistics, correlations, and covariances for each observed variable across all treatment groups. Correlation matrices were generated to test the linear, bivariate relationships (positive or negative) that existed between the independent and dependent variables in the model. Covariance matrices are provided since SEM was initially formulated for use with the variance-covariance matrix, and has the advantage of providing valid comparisons between different populations or samples—a feature not possible in model estimation with correlations (Hair et al, 1998). The SEM analysis reported here used the variance-covariance matrices as inputs to the model.

**Table 4.2 Variable Descriptives, Correlations, and Covariances -- Face-to-Face Treatment**

| | M | S | K | INDIVIDUAL EXPERTISE (IE) | TEAM EXPERTISE (TE) | AFFIRMATION PARTICIPATION (AP) | INTELLECTIVE PARTICIPATION (IP) | GROUP PERF (GP) |
|---|---|---|---|---|---|---|---|---|
| **IE** | 70.84 | -.291 | -.391 | | 0.482** | -0.215* | 0.125 | 0.118 |
| **TE** | 70.84 | .261 | -.898 | 35.291 | | -0.150 | -0.037 | 0.248* |
| **AP** | 10.16 | .727 | .229 | -14.212 | -4.788 | | 0.173* | 0.106 |
| **IP** | 50.28 | .307 | .430 | 28.594 | -4.077 | 17.208 | | 0.353** |
| **GP** | 85.25 | -.544 | -.865 | 12.332 | 14.602 | 4.830 | 55.737 | |

Notes. (M) mean, (S) skewness, (K) kurtosis. Covariances are shown below the diagonal, and standard Pearson correlations above the diagonal.
*p<.05, **p<.01. N = 80.

**Table 4.3 Variable Descriptives, Correlations, and Covariances -- GSS Labeled Treatment Group**

| | M | S | K | INDIVIDUAL EXPERTISE (IE) | TEAM EXPERTISE (TE) | AFFIRMATION PARTICIPATION (AP) | INTELLECTIVE PARTICIPATION (IP) | GROUP PERF (GP) |
|---|---|---|---|---|---|---|---|---|
| **IE** | 70.76 | -.302 | -.328 | | 0.468** | -0.190 | -0.030 | 0.214** |
| **TE** | 70.76 | -.956 | .829 | 25.726 | | -0.103 | -0.089 | 0.452** |
| **AP** | 4.24 | .489 | .383 | -.097 | -1.290 | | 0.374** | 0.150 |
| **IP** | 21.93 | .739 | .424 | -3.036 | -4.250 | 8.714 | | -0.134 |
| **GP** | 83.11 | -.004 | -.910 | 10.540 | 10.372 | -1.680 | -5.970 | |

Notes. (M) mean, (S) skewness, (K) kurtosis. Covariances are shown below the diagonal, and standard Pearson correlations above the diagonal.
*$p<.05$, **$p<.01$. N = 76.

**Table 4.4 Variable Descriptives, Correlations, and Covariances -- GSS Unlabeled Treatment**

| | M | S | K | INDIVIDUAL EXPERTISE (IE) | TEAM EXPERTISE (TE) | AFFIRMATION PARTICIPATION (AP) | INTELLECTIVE PARTICIPATION (IP) | GROUP PERF (GP) |
|---|---|---|---|---|---|---|---|---|
| **IE** | 71.35 | -.426 | -.174 | | 0.482** | 0.095 | 0.233 | 0.303* |
| **TE** | 71.35 | -.604 | .641 | 29.541 | | 0.206 | 0.199 | 0.628** |
| **AP** | 4.10 | .795 | .227 | 2.829 | 2.973 | | 0.129 | 0.154 |
| **IP** | 19.33 | .915 | .472 | 23.644 | 9.729 | 3.085 | | 0.057 |
| **GP** | 81.67 | -.709 | .105 | 19.712 | 19.712 | 2.356 | 2.944 | |

Notes. (M) mean, (S) skewness, (K) kurtosis. Covariances are shown below the diagonal, and standard Pearson correlations above the diagonal. *p<.05, **p<.01. N = 60.

### *4.5 Structural Equation Modeling Analysis*

LISREL v8.14 was used to assess model fit and to analyze the hypothesized relationships between the variables across the three treatment groups. LISREL was chosen in lieu of other SEM analysis software because of its ability to test bilinear interaction effects of qualitative moderator variables and to represent constructs that are not represented by directly observed variables. The analysis reported here is based on the multi-group strategy recommended by Jaccard and Wan (1996) and follows the 2-stage approach described in Chapter III.

#### *4.5.1 Structural Equation Modeling (Stage 1) – Overall Model Fit*

As discussed in Chapter III, the first step in structural equation modeling analysis is to assess overall goodness-of-fit of the data to the hypothesized model. The output resulting from the initial phase was examined to assess overall goodness-of-fit of the data to the theoretical model presented in Chapter II. Table 4.5 presents the results of the goodness-of-fit test.

**Table 4.5 Overall Model Goodness-of-fit – Simultaneous Multi-group Solution**

| $\chi^2$ | df | P | RMSEA | Std. RMR | GFI | CFI |
|---|---|---|---|---|---|---|
| 5.72 | 12 | .93 | 0, p = 1 | .056 | .98 | 1.0 |

The overall $\chi^2$ statistic from the analysis was 5.72 with 12 degrees of freedom, which was statistically non-significant ($p = .93$). The $\chi^2$ statistic is consistent with good model fit across the three treatment groups. The analysis returned an RMSEA of 0 with a non-significant p value (1). The RMSEA was well below the acceptable threshold of .08 indicating the differences expected between the population and sample covariance matrices, per degree of freedom, were insignificant. Standardized RMR was computed at .056 resulting in a statistically significant average absolute difference between the predicted and observed covariance matrices. Absolute model fit, as indexed by GFI = .98, was well above the acceptable threshold of .90. Finally, incremental model fit represented by CFI = 1.0 indicates excellent relative fit of the hypothesized model to the null model.

Although the standardized RMR was slightly above the acceptable threshold of .05, the four remaining fit indices were well within the predetermined values described in Table 3.6. Therefore, the model was determined to exhibit acceptable overall goodness-of-fit and deemed viable for further analysis of the relationships between constructs.

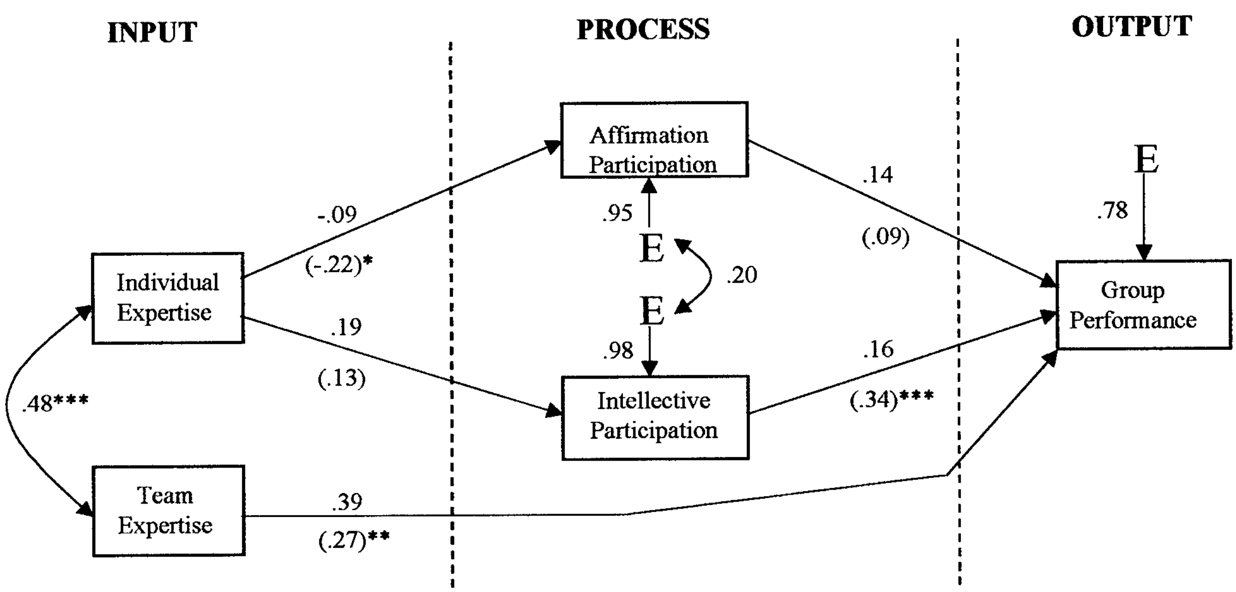
#### *4.5.2 Structural Equation Modeling (Stage 2) – Within-group Parameter Estimates*

To test the bivariate hypotheses presented in Chapter II, the parameter estimates resulting from the Stage 1 analysis were examined. Figures 4.1 through 4.3 present the parameter estimates and endogenous error terms for the face-to-face, GSS labeled, and GSS unlabeled treatments, respectively.

Within the face-to-face treatment group, hypotheses 2, 3, and 5 were supported. Individual expertise was negatively related to affirmation participation supporting hypothesis 2 at $p<.05$. As expected, intellective participation was highly and significantly predictive of group performance at $p<.001$, supporting hypothesis 3.

Finally, team expertise was shown to have a positive and significant relationship to group performance at p<.01, which supports hypothesis 5.

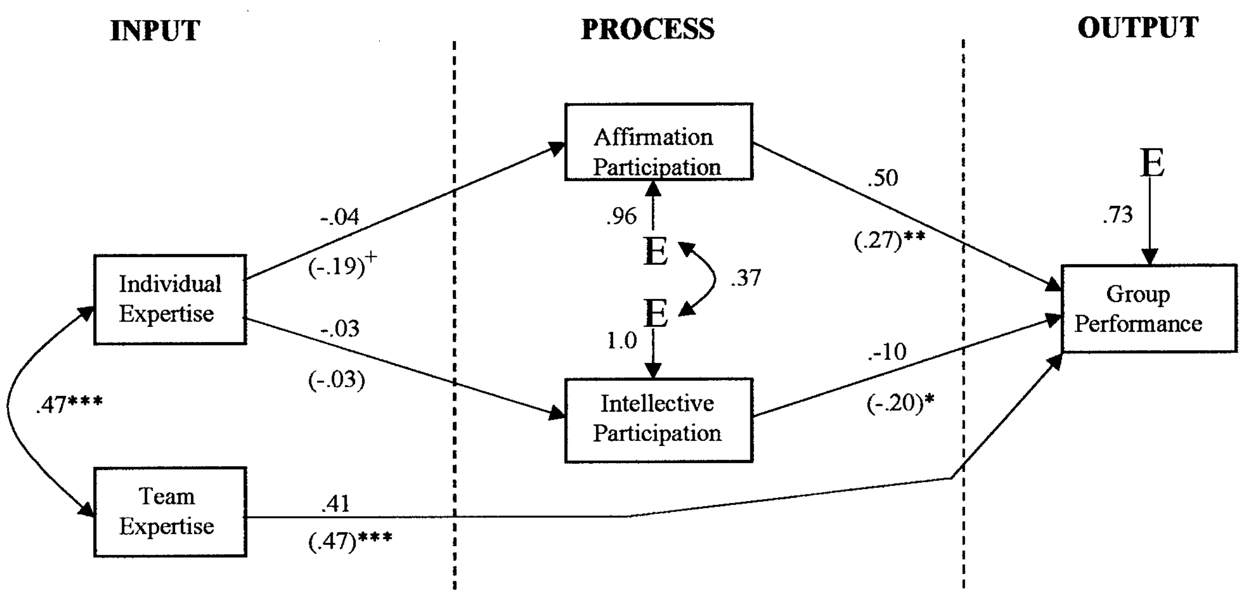
Hypothesis 1 expected individual expertise to be positively predictive of intellective participation. However, in face-to-face problem-solving groups individual expertise failed to be a statistically reliable cause of intellective participation thereby rejecting hypothesis 1. Hypothesis 4 was also not supported. Affirmation participation exhibited a positive yet non-significant relationship with group performance.




Notes: Completely standardized paths appear in parentheses. Asterisks indicate statistically reliable path coefficients. *p<.05, **p<.01, ***p<.001. N = 78.

**Figure 4.1 Unstandardized and Completely Standardized Path Coefficients and Endogenous Error Terms – FtF Treatment**

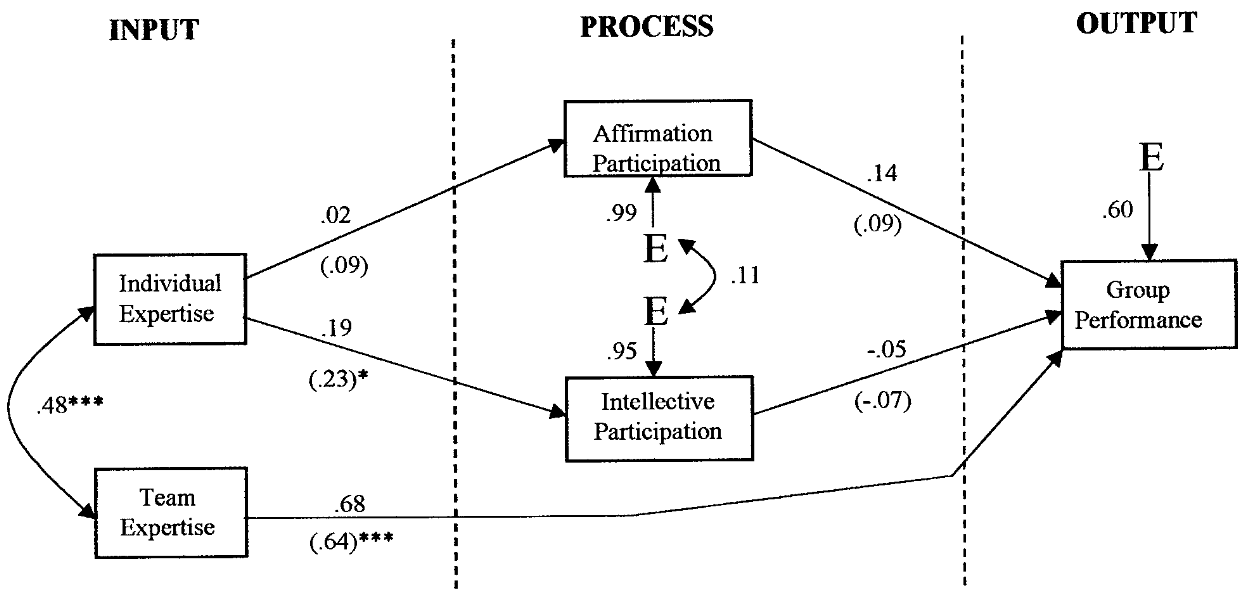
Within the GSS labeled treatment groups, hypotheses 2 through 5 were supported as indicated in Figure 4.2. Individual expertise was negatively related to affirmation participation, although barely significant at p<.10. As expected, intellective participation levels were negatively related to overall group performance at $p<.05$. Additionally, affirmation participation was a statistically reliable cause of group performance at $p<.01$. Team expertise, as expected, was also a statistically reliable predictor of group performance at $p<.001$. The data fail to support hypothesis 1 which expected individual expertise to be a statistically reliable cause of intellective participation.




Notes: Completely standardized paths appear in parentheses. Asterisks indicate statistically reliable path coefficients. +p<.10, *p<.05, **p<.01, ***p<.001. N = 66.

**Figure 4.2 Unstandardized and Completely Standardized Path Coefficients and Endogenous Error Terms – GSS Labeled Treatment**

Figure 4.3 presents the path coefficients and endogenous error terms for the GSS unlabeled treatment. Hypotheses 1 and 5 were supported. Individual expertise was a statistically reliable cause of intellective participation at $p<.05$, and team expertise was highly predictive of group performance at $p<.001$. As expected, affirmation participation was positively related to group performance, and intellective participation was negatively related to group performance although both were non-significant. Contrary to expectations, individual expertise was positively related to affirmation participation yet also non-significant.




Notes: Completely standardized paths appear in parentheses. Asterisks indicate statistically reliable path coefficients. *p<.05, ***p<.001. N = 60.

**Figure 4.3 Unstandardized and Completely Standardized Path Coefficients and Endogenous Error Terms – GSS Unlabeled Treatment**

Table 4.6 contains a review of the findings in relation to the bivariate hypotheses outlined in Chapter II.

**Table 4.6 Review of Bivariate Hypotheses**

| | | *TREATMENT* | | | |
|---|---|---|---|---|---|
| ***HYPOTHESIS*** | ***PATH*** | **FTF** | **GSS-L** | **GSS-NL** | ***SUPPORTED*** |
| H1 | IE→IP | * | + | * | Yes |
| H2 | IE→AP | ns | ns | ns | No |
| H3 | IP→GP | *** | * | ns | Yes |
| H4 | AP→GP | ns | ** | ns | Yes |
| H5 | TE→GP | ** | *** | *** | Yes |

Notes: +p<.10, *p<.05, **p<.01, ***p<.001

Although overall model goodness-of-fit across treatments was acceptable, the model explained little of the variance within the endogenous variables. A review of the y-variable error terms showed that, within the face-to-face treatment, only 5 percent of the variance in affirmation participation was explained. Furthermore, on 2 percent of the variance in intellective participation was explained. Finally, intellective participation, affirmation participation, and team expertise explained only 22 percent of the variance in group performance.

In the GSS labeled treatment, individual expertise explained only 4 percent of the variance in affirmation participation, and none of the variance in intellective participation. Furthermore, affirmation participation, intellective participation, and team expertise explained only 27 percent of the total variance in group performance.

The GSS unlabeled treatment provided the highest level of explanatory value. Affirmation participation, intellective participation, and team expertise explained 40 percent of the overall variance in group performance. However, individual expertise explained only 1 percent of the variance in affirmation participation, and only 5 percent of the variance in intellective participation. All three treatments indicated relatively low correlation between error terms. The face-to-face treatment revealed a correlation of .20. The GSS labeled treatment returned a correlation of .37, and the GSS unlabeled treatment showed a correlation between error terms of .11.

*4.5.3 Structural Equation Modeling (Stage 2) – Interaction Effects*

The final phase consisted of testing for moderating effects of content and process anonymity provided by the GSS technology. This phase entailed setting the paths of interest equal between each treatment group to determine if a statistically significant difference existed in overall model fit, indicating a possible moderating effect of anonymity on influence, perceived expertise, or both. Three independent comparisons were conducted: (1) Face-to-face to GSS labeled, (2) Face-to-face to GSS unlabeled, and (3) GSS labeled to GSS unlabeled. These three across-group comparisons tested hypotheses 6 and 7. Hypothesis 6 expected significant differences to exist between the relationships leading to influence across the three treatment groups. Hypothesis 7 posited that statistically significant differences in the recognition of expertise would be found across the three treatments. Within each across-group comparison, each of the five relationships was set equal to one another independently. This procedure resulted in five delta $\chi^2$ test statistics for each of the three across-group comparisons.

Table 4.7 presents the results of the across-group comparison between the face-to-face and GSS labeled groups, and Table 4.8 contains the results of the across-group comparison between the face-to-face and GSS unlabeled treatments. The data indicate a significant difference in the relationship between intellective participation and group performance across the face-to-face and GSS labeled treatments ($p<.001$), and across the face-to-face and GSS unlabeled treatment ($p<.01$). Therefore, a statistically reliable moderating effect of anonymity on the relationship of intellective participation and group performance was apparent across the face-to-face and GSS treatments. These results indicate support for hypothesis 6 by revealing a statistically significant difference between the influence processes occurring within face-to-face groups as compared to GSS-supported groups.

**Table 4.7 Across Group Delta $\chi^2$ Test for Moderating Effect of Anonymity (Face-to-Face to GSS-L)**

| ***ACROSS GROUP COMPARISON – FTF TO GSS LABELED (CONTENT ANONYMITY TO PROCESS ANONYMITY)*** | | | | |
|---|---|---|---|---|
| **EQUAL PATH CONSTRAINT** | $\chi^2$ | $\chi^2_{diff}$ **(df = 1)** | **Sig.** | **SUPPORTED** |
| IE → AP | 6.86 | 1.14 | ns | NO |
| IE → IP | 7.19 | 1.47 | ns | NO |
| AP → GP | 8.02 | 2.30 | ns | NO |
| IP → GP | 19.11 | 13.39 | *** | YES |
| TE → GP | 6.01 | 0.29 | ns | NO |

Notes: ***p<.001

**Table 4.8 Across Group Delta $\chi^2$ Test for Moderating Effect of Anonymity (Face-to-Face to GSS-NL)**

| *ACROSS GROUP COMPARISON – FTF TO GSS UNLABELED (CONTENT ANONYMITY TO PROCESS AND CONTENT ANONYMITY)* | | | | |
|---|---|---|---|---|
| **EQUAL PATH CONSTRAINT** | $\chi^2$ | $\chi^2_{diff}$ (df = 1) | **Sig.** | **SUPPORTED** |
| IE → AP | 10.11 | 4.39 | * | YES |
| IE → IP | 6.00 | 0.28 | ns | NO |
| AP → GP | 6.05 | 0.33 | ns | NO |
| IP → GP | 12.35 | 6.63 | ** | YES |
| TE → GP | 8.35 | 2.63 | ns | NO |

Notes: *p<.05, **p<.01

Additionally, a significant difference (p<.05) was found in the relationship between individual expertise and affirmation participation across the face-to-face and GSS unlabeled treatments (Table 4.8). This result indicates a statistically reliable moderating effect of anonymity on the relationship between individual levels of expertise and rates of affirmation participation between the face-to-face and GSS unlabeled treatments, lending further support to hypothesis 6.

Table 4.9 presents the results of the across-group comparisons between the two GSS treatments. No statistically reliable differences were found across the influence processes between the two GSS treatments. However, the data indicated a significant difference (p<.10) in the relationship between team expertise and group performance, indicating a possible moderating effect of process anonymity on recognition of expertise between the two GSS treatments. These findings provide limited support to hypothesis 7. Finally, no statistically reliable difference existed in the relationship between team expertise and group performance across the face-to-face and GSS treatments.

**Table 4.9 Across Group Delta $\chi^2$ Test: Moderating Effect of Anonymity (GSS-L to GSS-NL)**

| *ACROSS GROUP COMPARISON – GSS LABELED TO GSS UNLABELED (PROCESS ANONYMITY TO PROCESS AND CONTENT ANONYMITY)* | | | | |
|---|---|---|---|---|
| **EQUAL PATH CONSTRAINT** | $\chi^2$ | $\chi^2_{diff}$ (df = 1) | **Sig.** | **SUPPORTED** |
| IE → AP | 8.65 | 2.93 | ns | NO |
| IE → IP | 8.19 | 2.47 | ns | NO |
| AP → GP | 8.07 | 2.35 | ns | NO |
| IP → GP | 6.34 | 0.62 | ns | NO |
| TE → GP | 9.33 | 3.61 | + | YES |

Notes: $^{+}p<.10$

*4.5.4 Additional Analyses*

Additional analysis was performed to determine if recognition of expertise truly differed across the face-to-face and GSS labeled treatments. Data derived from the perceived expertise questionnaire discussed in Chapter III were analyzed to determine if perceived expertise was based on participation rates or actual expertise.

In the face-to-face treatment, 72.5 percent of the participants identified either the most talkative member or the participant with the highest individual score (true expert) as the expert member. Of that 72.5 percent, 40 percent identified the most talkative member as the expert, and 32.5 percent viewed the true expert as the expert member. 27.5 percent of the participants perceived the expert as one of the other group members.

In the GSS labeled treatment, 63 percent of the participants identified either the member with the highest participation rate or the true expert as the expert member. 50 percent of the participants identified the true expert as the expert member, and 25 percent viewed the most active participant as the expert member. 25 percent of the participants voted for another member of the group. These finding provide additional support for hypothesis 7 which states that GSS technology moderates recognition of expertise between face-to-face and GSS-supported groups. Table 4.10 presents a review of the findings from the across-group analysis in relation to the moderation hypotheses identified in Chapter II.

**Table 4.10 Review of Moderation Hypotheses**

| | | ***TREATMENT*** | | | |
|---|---|---|---|---|---|
| ***HYPOTHESIS*** | ***PATH*** | **FTF to GSS-L** | **FTF to GSS-NL** | **GSS-L to GSS-NL** | ***SUPPORTED*** |
| H6 - Influence | IE→IP | ns | ns | ns | No |
| | IE→AP | ns | * | ns | Yes |
| | IP→GP | *** | ** | ns | Yes |
| | AP→GP | ns | ns | ns | No |
| H7 – Perceived Expertise | TE→GP | ns | ns | + | Yes |

Notes: +p<.10, *p<.05, **p<.01, ***p<.001

*4.6 Summary*

This chapter presented the results of the statistical analysis performed to test the hypotheses described in Chapter II. Supporting evidence for the hypotheses was discussed in general terms. Appendix I contains a copy of the LISREL source code used to conduct the analyses described in this chapter. Chapter V presents a more detailed interpretation of the statistical results as they relate to the hypotheses in Chapter II, and concludes with a discussion of the limitations of this study and recommendations for future research.

*Chapter V – Conclusions and Recommendations*

*5.1 Introduction*

The results of this study provide moderate support for the theoretical model of influence, perceived expertise, and performance presented in Chapter II. This study developed a theoretical input-process-output model to test hypothesized differences in informational influence processes leading to recognition of expertise and overall group performance between traditional, face-to-face groups and GSS-supported groups. It also compared three levels of participant anonymity and information labeling to test a hypothesized moderating effect of GSS technology on the group problem-solving process. This chapter first presents the results of the research findings in relation to the bivariate hypotheses, then addresses the overall conclusions related to the hypothetical moderating effect of GSS technology discussed in Chapter II. It concludes by describing important limitations applicable to this study and recommendations for future research.

*5.2 Hypothesis 1: Individual Task Expertise is Positively Related to Intellective Participation*

Hypothesis 1 proposed that an individual's level of task expertise would have a positive effect on the amount of intellective participation exhibited during the group problem-solving process. This study was interested in comparing the strength of the hypothesized relationships between the variables in the IPO model across traditional, face-to-face groups and GSS-supported groups. Therefore, hypothesis 1 is divided into two sub-hypotheses.

### *5.2.1 Hypothesis 1a*

Hypothesis 1a expected the participant's level of task expertise to have a positive relationship to the amount of intellective participation exhibited by participants in GSS-supported groups. As discussed in Chapter III, intellective participation consisted of intellective and process-related comments submitted by the participants during the group problem-solving process. Data analysis from Chapter IV of this study partially supports hypothesis 1a.

An examination of the path coefficients between individual expertise and intellective participation for the two GSS treatment groups indicates that expertise had a positive and significant effect on intellective participation rates in GSS groups assigned to the process and content anonymity (GSS unlabeled) treatment. However, individual expertise had no effect in GSS groups assigned to the process only anonymity treatment (GSS labeled). These results suggest an interaction effect provided by the combination of process and content anonymity on the relationship between expertise and intellective participation.

### *5.2.2 Hypothesis 1b*

Hypothesis 1b expected individuals' level of task expertise to have a positive relationship to the amount of intellective participation exhibited by participants in face-to-face problem-solving groups. Data analysis from Chapter IV of this study revealed no evidence to support hypothesis 1b.

An examination of the path coefficient between individual expertise and intellective participation for the face-to-face treatment group indicates that expertise had a positive yet non-significant effect on intellective participation rates in face-to-face groups assigned to the no anonymity treatment. These results support the findings discussed in the previous section indicating an interaction effect provided by the combination of process and content anonymity on the relationship between expertise and intellective participation.

### *5.2.3 Hypothesis 1 -- Discussion*

The data indicate partial overall support for hypothesis 1. Individual expertise appears to be a positive determinant of intellective participation in GSS-supported groups operating under a completely anonymous condition. However, the model provides ill fit to groups operating under content or process only anonymity. These findings refute previous research conclusions that anonymity is less important among equal-status groups with little or no difference in power and status (Jessup et al, 1993:76).

Although the participants in this study were equal in status and power, complete anonymity appears to have had a moderating effect on the relationship between task expertise and participation rates. Under complete anonymity, expert members were more willing to participate in the group discussion. Individuals exhibiting higher levels of task expertise submitted more intellective comments than experts in the GSS labeled condition. Therefore, complete anonymity was a valuable process factor causing increased levels of intellective participation from expert group members.

*5.3 Hypothesis 2: Individual Task Expertise is Negatively Related to Affirmation Participation*

Hypothesis 2 expected that an individual's level of task expertise would have a negative effect on the amount of affirmation participation exhibited during the group problem-solving process. Again, of interest to this study was the strength of the hypothesized relationship between the input and process variables across traditional, face-to-face groups and GSS-supported groups, and the possible moderating affect of anonymity and information labeling. Hypothesis 2 is divided into two sub-hypotheses.

*5.3.1 Hypothesis 2a*

Hypothesis 2a expected individuals' level of task expertise to have a negative relationship to the amount of affirmation participation exhibited by participants in GSS-supported groups. As discussed in Chapter III, affirmation participation consisted of comments submitted by the participants that either affirmed or refuted previously submitted intellective comments. Data analysis from Chapter IV of this study partially supports hypothesis 2a.

An examination of the path coefficients between individual expertise and affirmation participation for the two GSS treatment groups indicates that expertise had a negative and slightly significant ($p<.10$) effect on affirmation participation rates in GSS groups assigned to the process only anonymity (GSS labeled) treatment. However, individual expertise had no effect in GSS groups assigned to the process and content anonymity treatment (GSS unlabeled). These results suggest an interaction effect provided by the combination of process and content anonymity on the relationship between expertise and affirmation participation.

*5.3.2 Hypothesis 2b*

Hypothesis 2b expected individuals' level of task expertise to have a negative relationship to the amount of affirmation participation exhibited by participants in face-to-face problem-solving groups. Data analysis from Chapter IV of this study revealed reliable statistical evidence in support of hypothesis 2b.

An examination of the path coefficient between individual expertise and affirmation participation within the face-to-face treatment group indicates that expertise had a negative and significant effect on affirmation participation rates in face-to-face groups assigned to the no anonymity treatment. These results support the findings discussed under hypothesis 1 indicating an interaction effect provided by the combination of process and content anonymity on the relationship between expertise and participation.

*5.3.3 Hypothesis 2 -- Discussion*

The data indicate partial overall support for hypothesis 2. Individual expertise appears to be negatively related to the amount of affirmation participation in GSS-supported groups operating under a process only anonymous condition and face-to-face groups operating under a non-anonymous condition. However, the model provides no statistically reliable evidence between variables in the GSS-supported groups operating under process and content anonymity. Again, these findings refute previous research conclusions that anonymity has little affect on group processes among equal-status groups. Although the participants in this study were equal in status and power, complete anonymity appears to have had a moderating effect on the relationship between task expertise and participation rates.

Across groups operating under the process only or no anonymity conditions, higher levels of task expertise resulted in fewer affirmation comments. Yet within groups operating under a completely anonymous condition, task expertise had no effect on affirmation participation. These results suggest that, across the two GSS treatments, information labeling had a moderating effect on affirmation participation rates. It could be that comment labeling causes patterns of information to appear during the discussion process which in turn causes participants with lower levels of task expertise to agree with other participants' comments, and expert members to submit less affirmation comments.

Face-to-face treatment participants exhibited similar participation processes. However, participants that were completely anonymous were unable to focus on informational patterns since they could not tie specific comments to individuals or labels. Therefore, the communication process appears to have been more haphazard since expertise was significantly related to intellective participation, but had no affect on affirmation participation.

### *5.4 Hypothesis 3: Intellective Participation will have Opposite Effects on Group Performance Between Face-to-face and GSS-supported Groups*

Hypothesis 3 posited that individual rates of intellective participation would exhibit opposite relationships to overall group performance between face-to-face and GSS-supported groups. This hypothesis was based on previous findings indicating participation rates in face-to-face groups to be positively deterministic of group performance (Bales, 1953; Bavelas et al, 1965; Riecken, 1958). Since research into GSS indicates an equalizing effect on participation rates (Briggs et al, 1995), an opposite relationship was expected to emerge.

### *5.4.1 Hypothesis 3a*

Hypothesis 3a stated that intellective participation would be negatively related to overall group performance in GSS-supported groups. Data analysis from Chapter IV of this study revealed reliable statistical evidence to partially support hypothesis 3a.

An examination of the path coefficients between intellective participation and group performance for the two GSS treatment groups indicates that intellective participation rates had a negative and significant ($p<.05$) effect on group performance in GSS groups assigned to the process only anonymity (GSS labeled) treatment. Although negatively related to group performance, the relationship between intellective participation and group performance in GSS groups assigned to the completely anonymous treatment (GSS unlabeled) was non-significant.

### *5.4.2 Hypothesis 3b*

Hypothesis 3b expected intellective participation rates to be positively deterministic of group performance in face-to-face treatment groups. Analyses of the data presented in Chapter IV reveal high statistical reliability in support of hypothesis 3b.

An examination of the path coefficients between intellective participation and group performance for the face-to-face treatment indicates that intellective participation rates had a positive and highly significant ($p<.001$) effect on group performance. This finding is consistent with much of the research concerning face-to-face problem-solving groups where group performance was found to be closely tied to the dominant, most talkative member. This study suggests group performance was based more to the quantity rather than quality of participant contributions.

#### *5.4.3 Hypothesis 3 -- Discussion*

The results of this study support past findings indicating that GSS tend to equalize participation among group members since individual participation rates had no or negative affects on group performance. Additionally, intellective participation rates within the completely anonymous treatment were not statistically significant predictors of group performance, yet were negatively related to group performance in the process only anonymity treatment. This suggests that comment labeling enabled participants to identify factually correct information provided by specific participants based on the quality of the inputs rather than the quantity of the inputs.

### *5.5 Hypothesis 4: Affirmation Participation will have Opposite Effects on Group Performance Between Face-to-face and GSS-supported Groups*

Hypothesis 4 expected that individual rates of affirmation participation would exhibit opposite relationships to overall group performance between face-to-face and GSS-supported groups. Face-to-face participants tend to affirm or refute submissions by the dominant member whether the information submitted is factually correct or not. GSS-supported groups are better able to review and weigh participant contributions on their merits rather than sheer quantity. Therefore, affirmation participation was expected to have a negative relationship with group performance in face-to-face groups whereas GSS-supported groups were expected to exhibit a positive relationship between affirmation participation and group performance.

### *5.5.1 Hypothesis 4a*

Hypothesis 4a stated that affirmation participation would be positively related to overall group performance in GSS-supported groups. Data analysis from Chapter IV of this study revealed reliable statistical evidence to partially support hypothesis 4a.

An examination of the path coefficients between affirmation participation and group performance for the two GSS treatment groups indicates that affirmation participation rates had a positive and significant ($p<.01$) effect on group performance in GSS groups assigned to the process only anonymity (GSS labeled) treatment. Although positively related to group performance, the relationship between affirmation participation and group performance in GSS groups assigned to the completely anonymous treatment (GSS unlabeled) was non-significant.

### *5.5.2 Hypothesis 4b*

Hypothesis 4b expected affirmation participation rates to be negatively related to group performance in the face-to-face treatment. The data reveal no evidence to support this hypothesis. The path coefficient between affirmation participation and group performance for the face-to-face treatment was positive and non-significant. Affirmation participation had no effect on overall group performance within the face-to-face treatment.

### *5.5.3 Hypothesis 4 – Discussion*

Once again, the presence of information labeling exhibited a strong positive and statistically reliable effect on overall group performance. The statistical evidence suggests that the ability of participants to recognize a discernable pattern of information submitted by group members is an important factor affecting the effectiveness of the group. Affirmation participation rates had no effect on overall group performance in the no anonymity treatment and the process and content anonymity treatment. Yet with content anonymity removed through comment labeling, participants were able to affirm or refute information submitted by specific participants. The presence of process anonymity caused the affirmation process to be based more on the merits of the information rather than preconceived perceptions about who submitted the information. This suggests that the affirmation process was based more on the quality of the information rather individual personality factors such as dominance and social cues.

## *5.6 Hypothesis 5: Team Expertise is Positively Related to Group Performance*

Hypothesis 5 expected that the overall level of team task expertise would have a positive relationship to group performance. Again, of interest to this study was the strength of the hypothesized relationship between the input, process, and outcome variables across traditional, face-to-face groups and GSS-supported groups, and the possible moderating affect of anonymity and information labeling. Hypothesis 5 is divided into two sub-hypotheses.

*5.6.1 Hypothesis 5a:*

Hypothesis 5a expected team expertise to have a positive relationship to the overall level of group performance exhibited by participants in GSS-supported groups. As discussed in Chapter III, team expertise represents the combined level of task expertise of the four members in the group. Data analysis from Chapter IV of this study revealed statistically reliable evidence in support of hypothesis 5a.

An examination of the path coefficients between team expertise and group performance for the two GSS treatment groups indicates that team expertise had a strong and significant positive effect on group performance in both GSS treatment groups. These results suggest that participants across both GSS treatments were able to recognize members' expertise, and successfully apply that expertise to the problem-solving task.

*5.6.2 Hypothesis 5b:*

Hypothesis 5b expected team expertise to have a positive relationship to the overall level of group performance exhibited by participants in the face-to-face treatment. Data analysis from Chapter IV of this study also revealed statistically reliable evidence in support of hypothesis 5b.

An examination of the path coefficients between team expertise and group performance within the face-to-face treatment indicates that team expertise had a strong and significant positive effect on group performance. These results suggest that participants in the face-to-face treatment were also able to recognize members' expertise, and successfully apply that expertise to the problem-solving task.

### *5.6.3 Hypothesis 5 – Discussion*

The results of the data analysis suggest that team expertise is a statistically reliable cause of overall group performance across all three process manipulations. These findings are consistent with existing literature which shows groups tend to perform at a level equal to or better than their average member, yet rarely reach a level of performance equal to their best member (Laughlin, 1980; McGrath, 1984).

Across all levels of anonymity, the composite level of team knowledge appeared to have a significant affect on overall group performance. However, based on the previous discussion concerning the moderating effects of process and content anonymity, it is likely that the process by which members recognized and applied the team's knowledge was different across the three treatments.

## *5.7 Moderating Effects of Comment Labeling and Participant Anonymity*

As discussed in Chapter III, GSS technology provides the means by which to manipulate levels of participant anonymity by assigning comment labels to participants. The data analysis presented in Chapter IV indicate statistically reliable evidence exists to support the assumption that GSS technology has a moderating effect on the processes leading to influence and the recognition of expertise.

Stage 2 of the data analysis consisted of placing constraints on the paths between the input, process, and output variables in the theoretical model to test for significant differences across the three treatment groups. The results show a statistically reliable ($p<.05$) difference in the relationship of individual expertise to affirmation participation between groups operating under no anonymity and groups operating under the completely anonymous condition.

Data analysis also shows a statistically reliable moderating effect of anonymity on the relationship between intellective participation and group performance across all three treatments. The difference between no anonymity and process anonymity was statistically reliable at $p < .001$, and process only anonymity to process and content anonymity was significant at $p < .05$. These results indicate a statistically reliable moderating effect on the relationship between participant's intellective participation rates and overall group performance across all three treatments.

The nature of this moderating effect lends support to hypothesis 6 which expected significant differences in the influence processes between face-to-face and GSS-supported groups. In the face-to-face treatment, higher rates of intellective participation had a significant positive effect on overall group performance. But in the GSS treatments, rates of intellective participation were not significantly related to group performance, although affirmation participation was. This moderating effect of GSS technology suggests that face-to-face groups are influenced by the dominant, most talkative member whereas GSS participants are influenced more by the quality and merits of the information that is shared during the group discussion.

Finally, a slightly significant difference ($p<.10$) was found in the relationship between team expertise and group performance across the process only anonymity treatment and the process and content anonymity treatment. The conclusions drawn from these findings are addressed in the section that follows.

### *5.8 Conclusions*

Overall conclusions of this study suggest that the tools provided by GSS technology that enable the manipulation of participant anonymity through information labeling had strong moderating effects on the processes leading to informational influence and recognition of expertise. In the face-to-face treatment operating under no anonymity, participants exhibiting higher levels of participation appear to have exerted more influence on the group as a whole. The dominant, most talkative members had the strongest effect on overall group performance. This conclusion is consistent with the conclusions of past research (e.g., Bales, 1953; Bavelas et al, 1965; Riecken, 1958). In face-to-face problem-solving groups, participation rates appear to be highly predictive of overall group performance.

However, individual participation rates of members in both GSS treatments had opposite effects on group performance. The results indicate that the existence of process anonymity significantly changes the influence process. Expertise appears to be based more on the merits of the information rather than high participation rates of the team members. Additionally, comment labeling appears to be an important component affecting overall group performance leading to the conclusion that identifiable patterns of information during the problem-solving process assists in the recognition of expertise, and provides a means for more knowledgeable members to exert informational influence upon the group.

This conclusion is further supported by the significant differences between the two GSS treatments. The lack of comment labeling in the completely anonymous treatment caused influence to be exerted more equally across all participants. Rates of participation had no effect on overall group performance, yet average team expertise had a significant impact on group outcomes. When information labels were provided, participants submitted a higher number of affirmative or refutive comments which had a strong and significant effect on overall group performance. The existence of process anonymity combined with a lack of content anonymity appears to have caused participants to focus more on the content of the information submitted. Process anonymity removed personal characteristics and social cues from the group interaction process which causing the relationship between participation and group performance to change.

This study demonstrated the GSS technology produced significant differences on the processes of informational influence and recognition of expertise through information labeling and the manipulation of participant anonymity. The processes and relationships between the variables in the theoretical model were significantly different across the three treatments. However, overall performance levels across the three treatments were not significantly different. This apparent limitation will be addressed in the forthcoming section.

### *5.9 Limitations and Recommendations for Future Research*

One limitation inherent in this study was the limited amount of time provided to participants in which to solve the task. Although overall performance of most groups was satisfactory, significant performance increases might have occurred had the groups been given 25-30 minutes verses the 15-minute period allotted for this study. Due to the imposed time limitations, groups tended to exhibit a high level of process focus. In other words, teams seemed to concentrate on reaching consensus on a final solution within the allotted time period rather than reaching the correct solution. This is evident in the electronic log files by the high number of process-related comments which were considered intellective comments for the purposes of this study.

A second limitation was the simplicity of the task. The NASA Moon Survival Scenario, although used in many group problem-solving studies, is a relatively simple task. This limitation is possibly the cause of such low variance in overall group performance across the treatment groups. As discussed in Chapter II, task type is an essential component to be considered when interpreting the results of group decision processes. The results of this study must be viewed with the understanding that they can only be generalized to simple, intellective, non-eureka type tasks.

Additionally, the members of the groups used in this study had little stake in the outcome of their solution. There was no motivation provided by the researchers that would cause the participants to strive for the best solution. This lack of motivation and buy-in to the group solution may be another cause of such low variance in overall group performance across treatments.

Group typology is another factor that limits the generalizability of this study's results. As McGrath (1984) noted, the history and make-up of group members used in empirical research extends through an expansive spectrum from zero-history, quasi groups to well established, naturally occurring groups. Group typology can have a profound impact on the interaction processes occurring within the group, especially when viewed in relation to task type. The participants in this study fell within McGrath's concocted category in that they were all members of somewhat established training teams with a history of working together on a daily basis. The typology of the group's used in this study most likely had an effect on the conclusions reached.

Finally, the theoretical model developed and tested in this study explained very little variance in the three endogenous constructs. Although overall model fit was excellent, the model exhibit little explanatory value as indicated by the relatively high residuals. Individual task expertise explained no more than 5 percent of the variance in the process variables. Furthermore, team expertise and member participation rates explained at most 60 percent of the variance in group performance. These results indicate that there exist much more accurate exogenous variables that affect participation in small group problem solving interaction.

The aforementioned limitations leave open many avenues for additional GSS research into models of influence, expertise, and performance. For example, do individual personality characteristics such as dominance or extroversion provide better explanatory value in predicting member participation rates? What other input variables lead to participation in GSS-supported group work? The theoretical model developed during the course of this research offers many opportunities for refinement. For instance, the constructs of influence and recognition of expertise were unmeasured and unobserved in this study. Follow-on research concerning these processes should pursue valid measurement instruments to operationalize these latent, unrepresented constructs.

GSS technology, by providing the ability to capture the entire communications process, enables detailed exploration into the communicative dynamics of groups performing problem-solving tasks. The coding scheme used in this study was extremely simplistic. Future studies could examine participant input more closely by applying Bales' (1950) Interaction Process Analysis technique to compare group development over time using GSS tools to face-to-face group development.

Finally, does the model developed here hold across varying levels of task complexity and group typology. This study could be replicated across differing levels of task complexity and group establishment to determine if the processes of influence and recognition of expertise change.

### *5.10 Summary*

The results of this study suggest that GSS technology, while moderating the influence and recognition of expertise processes within groups, does not adversely affect group outcomes. Regardless of treatment, the groups all performed at relatively the same level indicating that participants' ability to influence the group towards the correct solution was not hindered by the GSS. However, the influence processes by which members recognized and applied team expertise to the solution of the task changed across the treatments.

The Air Force DOME system and similar collaboration tools under consideration by contingency planners include GSS tools designed to improve group work, especially over distributed network architectures. This research concludes that such tools do not adversely affect expert members ability to lead and influence participants toward the correct solution to intellective problems. Additionally, DOME is always used in a completely anonymous configuration to assist groups in the design and modeling of logistics processes between dispersed groups and installations. The results reported here indicated that process anonymity may increase the value of the system in reaching the organization's goals by providing a means to tie information together in organized streams.

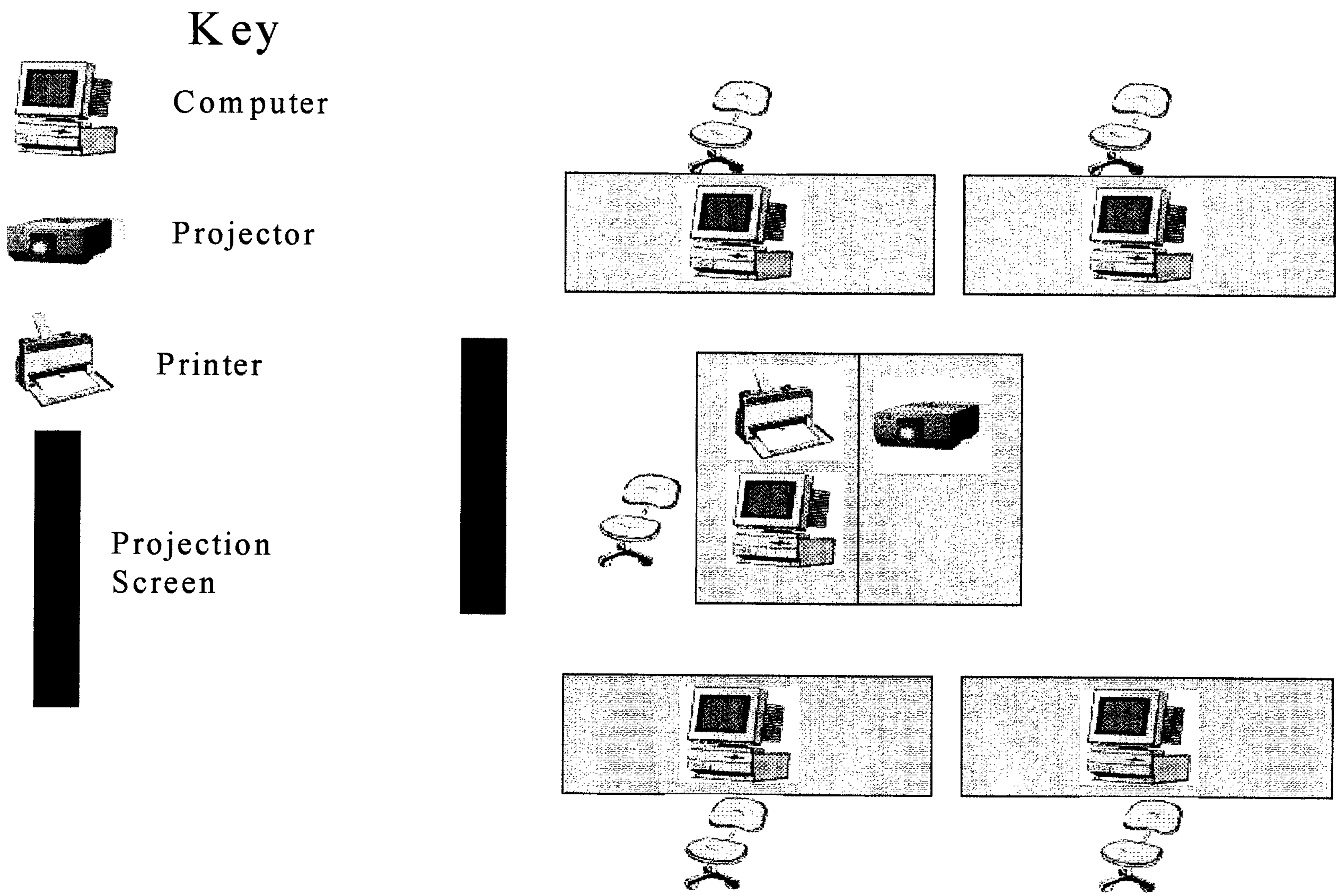
*Appendix A: Moon Survival Scenario*

You are a member of a space crew originally scheduled to rendezvous with a mother ship on the lighted surface of the moon. Due to mechanical difficulties, howiever, your ship was forced to land at a spot some 200 miles from the rendezvous point. During re-entry and landing, much of the equipment aboard was damaged and, since survival depends on reaching the mother ship, the most critical items available must be chosen for the 200-mile trip.

The 15 items left intact and undamaged after landing are listed below. Your task is to rank them in terms of their necessity to your crew in reaching the rendezvous point. Place the number 1 by the most crucial item, the number 2 by the second most crucial, and so on through number 15, the least important.

_____ Box of matches
_____ First-aid kit containing injection needles
_____ Five gallons of water
_____ Food concentrate
_____ Life raft
_____ Magnetic compass
_____ One case dehydrated milk
_____ Parachute silk
_____ Portable heating unit
_____ Signal flares
_____ Solar-powered FM receiver/transmitter
_____ Stellar map (of the moon's constellations)
_____ Two .45-caliber pistols
_____ Two 100-pound tanks of oxygen
_____ 50 ft. of nylon rope

*Appendix B – GSS Task Room Configuration*



*Appendix C: Consent Form*

Study Overview

Welcome to the experiment. The following is a general description of the study and a reminder of your rights as a potential subject. As in any study, your participation is completely voluntary. If now, or at any point during the study, you decide that you do not want to continue participating, please let the experimenter know and you will be dismissed without penalty. Also, please remember that your name will not be associated with any of the information that you provide during the study. All of the information you provide is absolutely anonymous and confidential.

In this study, you will be working as part of a group to complete two group tasks. You will also be asked to complete two questionnaires during the study. You will first be given a questionnaire to complete, then you will complete the first task as a group, after a short break you will be given the second task to complete as a group, and finally, you will be given a second questionnaire to complete. The experimenter will give you more specific instructions later in the study. If you have any questions or concerns at this time, please inform the experimenter.

For further information

The Air Force Institute of Technology faculty members responsible for conducting this research are Maj. Michael Morris and Maj. Paul Thurston. They would be happy to address any of your questions or concerns regarding this study. Maj. Morris can be reached at 255-3636 ext 4578 and Maj. Thurston can be reached at 255-6565 ext 4315.

If you would like to participate in this study, please sign in the space provided. Your signature indicates that you are aware of each of the following: 1) the general procedure to be used in this study, 2) your right to discontinue participation at any time, and 3) you and your name will not be associated with any of the information you provide.

Printed Name: ______________________

Signature:___________________________ Date:_________________

*Appendix D: Perceived Expertise Questionnaire*

Use the scale below to complete the survey for each of the two tasks you performed.

1 – Not at all
2 – Minimally
3 – Somewhat
4 – Average
5 – Above average
6 – Very
7 – Extremely

**Moon Scenario**

Rate each of the other members of your team on how knowledgeable you feel they were concerning the Moon Scenario you just completed (do not rate yourself):

Member:_____ Level of Task Knowledge:_____
Member:_____ Level of Task Knowledge:_____
Member:_____ Level of Task Knowledge:_____

Rate your entire team on its overall knowledge level concerning the Moon Scenario you just completed:_____

Please indicate the one team member you feel was most knowledgeable concerning the Moon Scenario your team just completed (red, blue, green or yellow):_________________

**Desert Scenario**

Rate each of the other members of your team on how knowledgeable you feel they were concerning the Desert Scenario you just completed (do not rate yourself):

Member:_____ Level of Task Knowledge:_____
Member:_____ Level of Task Knowledge:_____
Member:_____ Level of Task Knowledge:_____

Rate your entire team on its overall knowledge level concerning the Desert Scenario you just completed:_____

Please indicate the one team member you feel was most knowledgeable concerning the Desert Scenario your team just completed (red, blue, green or yellow):___________________

*Appendix E: Sample Group Transcript*

**Red**

11/15/00, 11:08 AM: Test

11/15/00, 11:10 AM: In my humble opinion, the guns, transmitter, and magnetic compass are useless and should be at the bottom of the list

11/15/00, 11:10 AM: Life raft could be used as a carrying case with the rope

11/15/00, 11:11 AM: Good, I forgot to mention the matches

11/15/00, 11:11 AM: Can we agree that oxygen, water, and food concentrate should among the top on the list

11/15/00, 11:14 AM: Agreed. I think the 02, H20, food concentrate, and portable heater should be at the top. Milk, stellar map, raft and rope should come next.

11/15/00, 11:15 AM: How exactly is the gun going to fire in space--besides, we have two guns and four people...

11/15/00, 11:16 AM: Remember we are on the dark side of the moon without the sun currently and traveling "towards the light"

11/15/00, 11:17 AM: No, because how were you planning on carrying the two 100pound tanks? I think the life raft would be helpful and increase the speed of the group

11/15/00, 11:19 AM: So are we going to tie every item to the rope and drap it then (02 tanks, water, heater, etc)

11/15/00, 11:19 AM: What about the guns--we never determined their location?

11/15/00, 11:20 AM: Its all theoretical so we might as well go with it.

11/15/00, 11:21 AM: 4. Portable heater
5. Rope
6. Dehydrated milk
7. First Aid kit
8 Signal flares
9 Two guns
10. Transmitter

11/15/00, 11:23 AM: O2

Water
Food
Heater
Rope
Milk
First Aid
Stellar Map
Guns
Transmitter
Silk
Raft
Signal Flares
Compass
Matches

11/15/00, 11:24 AM: Why would the heater be below the transmitter- we can't use it til the suns up and then we are toast

11/15/00, 11:25 AM: Rope needs to be high on the list as well to transport the items

11/15/00, 11:27 AM: Try number two

02
Water
Food
Heater rope
first aid
milk
map
Transmitter
Guns
Signal Flares
Life raft
Silks
Compass Matches

**Blue**

11/15/00, 11:10 AM: Matches won't work in space. Need oxygen to burn

11/15/00, 11:10 AM: Flares too.

11/15/00, 11:12 AM: The deydrated milk could be useful

11/15/00, 11:14 AM: Let's not neglect the map. It may help us get where we are going.

11/15/00, 11:17 AM: include the compass at the bottom

11/15/00, 11:17 AM: 100 lbs is meaningless in space

11/15/00, 11:19 AM: that's fine

11/15/00, 11:20 AM: let's get the transmitters at the bottom. If the sun comes out, we're toast anyway

11/15/00, 11:21 AM: okay, what's the complete list?

**Green**

11/15/00, 11:12 AM: I have this as number one.

11/15/00, 11:13 AM: these will never light - no oxygen in space. --#15

11/15/00, 11:14 AM: these are #2 – they can project you through space when fired in the opposite direction that you want to travel.

11/15/00, 11:16 AM: I think the pistols are #2 - they can be fired in the opposite direction that you want to travel, and project you through space, especially .45's.

11/15/00, 11:17 AM: Portable heater is needed when sun goes away. moon is very cold and we will freeze without it. #2 or #3?

11/15/00, 11:19 AM: I was thinking that the O2 needed for the bullet to fire would already captured within the cartridge.

11/15/00, 11:19 AM: yes. with the flares at the bottom as well

11/15/00, 11:20 AM: remember, there is very little weight in space. the tanks could float behind us as we pulled them with the rope.

11/15/00, 11:21 AM: how about the receiver/transmitter?

11/15/00, 11:22 AM: sounds good. any qualms?

11/15/00, 11:26 AM: let's go with the first aid kit before the milk. And the guns before the signal flares (at least we can through them if we need some propulsion, and they weigh more than flares)

11/15/00, 11:26 AM: note green's comments above

**Yelllow**

11/15/00, 11:10 AM: the life raft,pistols, and parachute silk are all unimportant

11/15/00, 11:12 AM: Okay lets put the pistols at 15 and matches at 14.

11/15/00, 11:13 AM: Obviously oxygen will be the most important, water as 2, and food as 3

11/15/00, 11:17 AM: Does everyone agree on
oxygen 1
water 2
food 3
and at the bottom
matches 15
life raft 14
parachute silk 13

11/15/00, 11:18 AM: okay we will go with flares as 12 and compass as 11

11/15/00, 11:18 AM: That's why I put the raft at the bottom

11/15/00, 11:20 AM: I f we agree with 1-3 and 11-15 let somebody take the initiative and list 4-10.

11/15/00, 11:24 AM: Okay.
1 oxygen
2 water
3 food
4 milk
5transmitter
6 map
7transmitter
8 heater
9 rope
10pistols
11compass
12flares
13rope
14life raft
15parachute silk

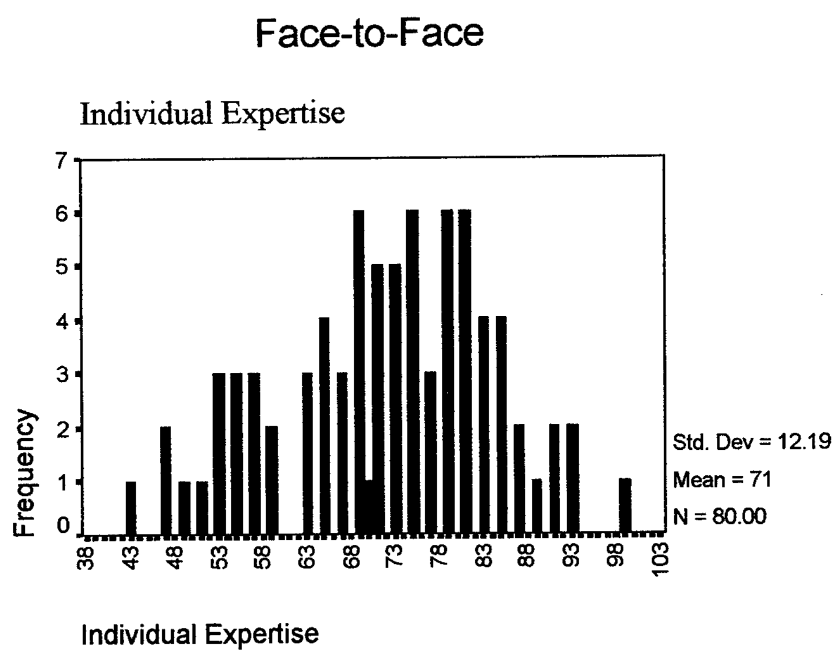
11/15/00, 11:25 AM: I like greens list better than mine so memorize the first inclusive list

11/15/00, 11:26 AM: Don't worry about toast and little green aliens, we will get lost in the weeds so concentrate on the first all inclusive list

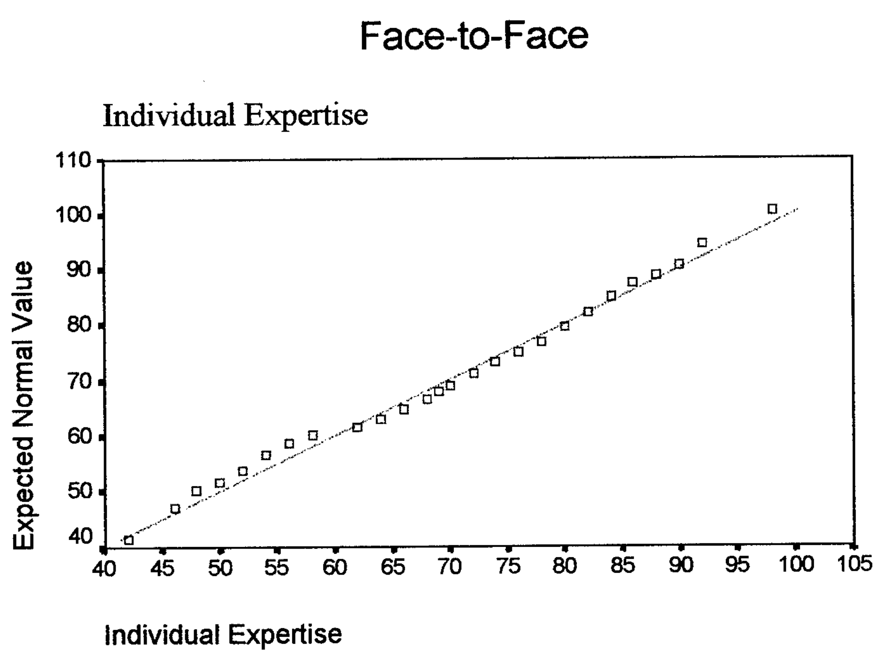
Note: This is a sample transcript from a GSS unlabeled session. GSS labeled sessions would contain a "tag" of the participants color label at the end of the comment.

*Appendix F – Data Normality (Face-to-face)*

Relative Frequency Histogram



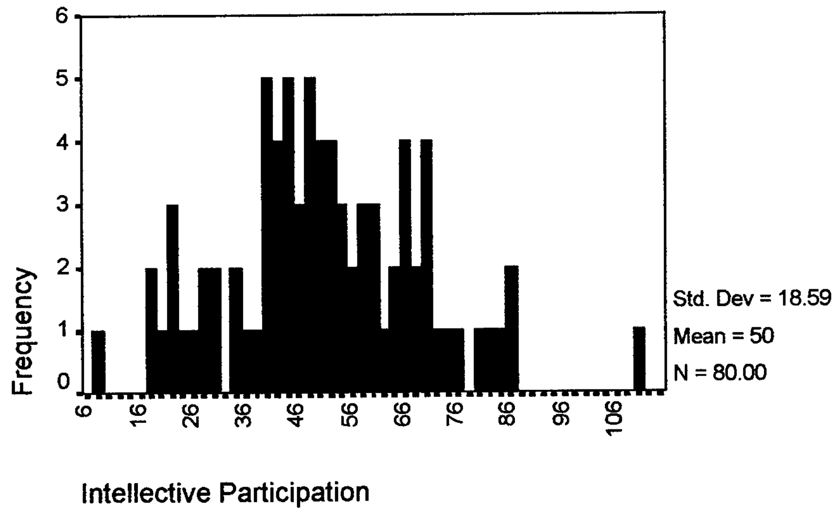

Normal Q-Q Plot



Relative Frequency Histogram

## Face-to-Face

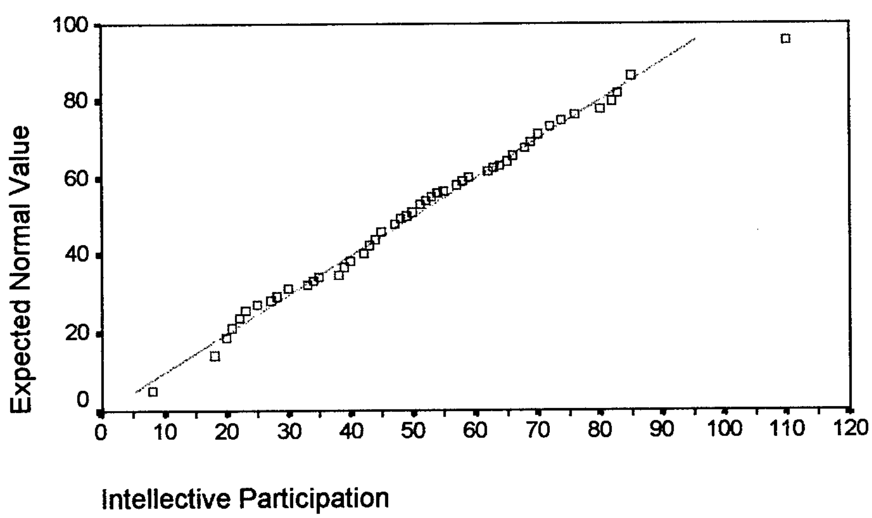
Intellective Participation




Normal Q-Q Plot

## Face-to-Face

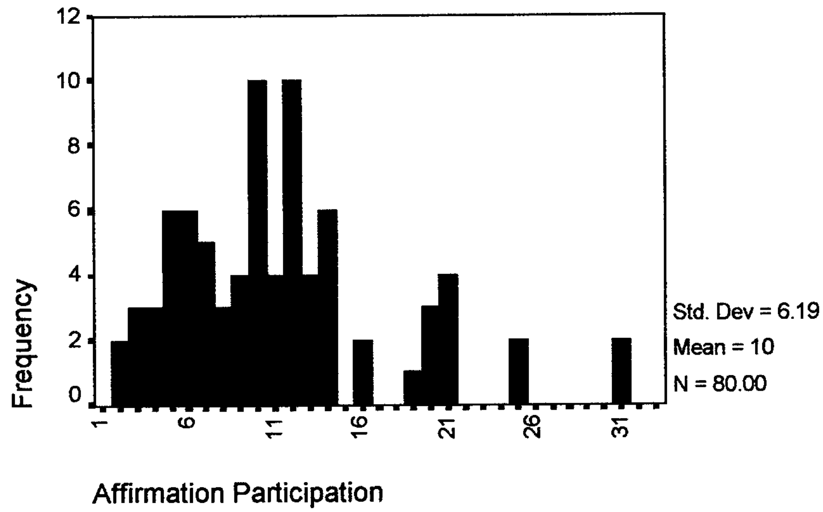
Intellective Participation



Relative Frequency Histogram

## Face-to-Face

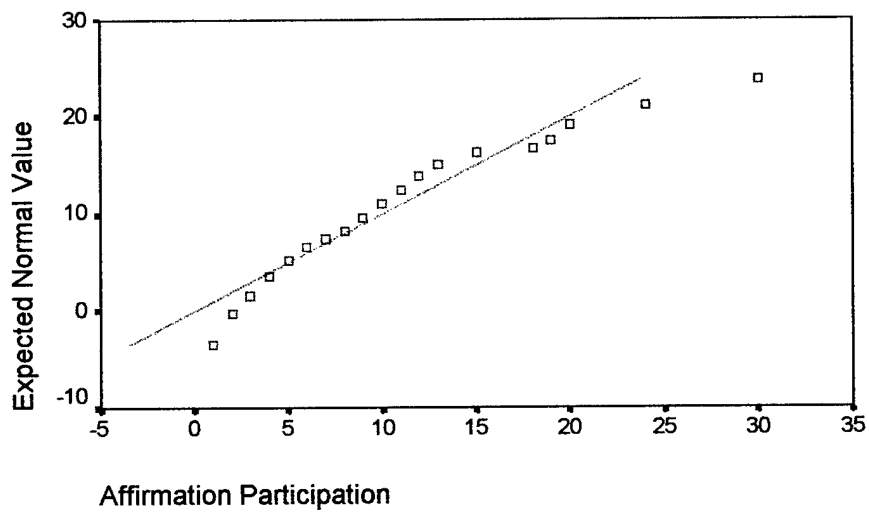
Affirmation Participation




Normal Q-Q Plot

## Face-to-Face

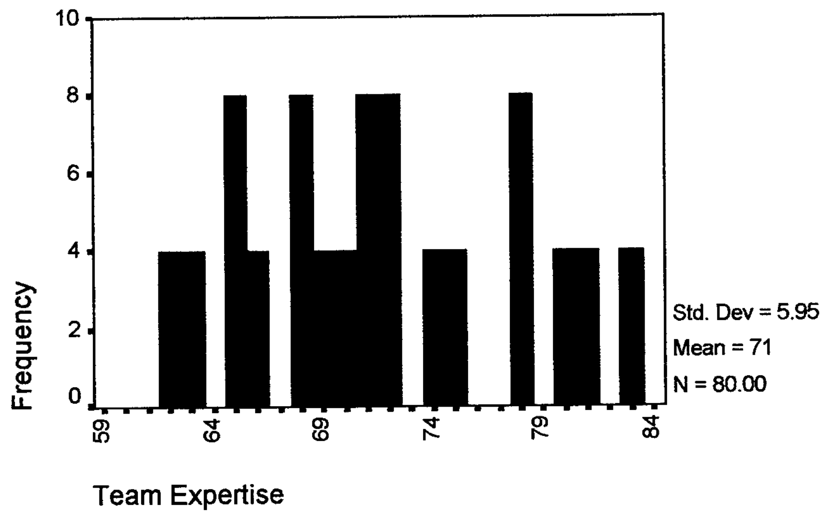
Affirmation Participation



Relative Frequency Histogram

## Face-to-Face

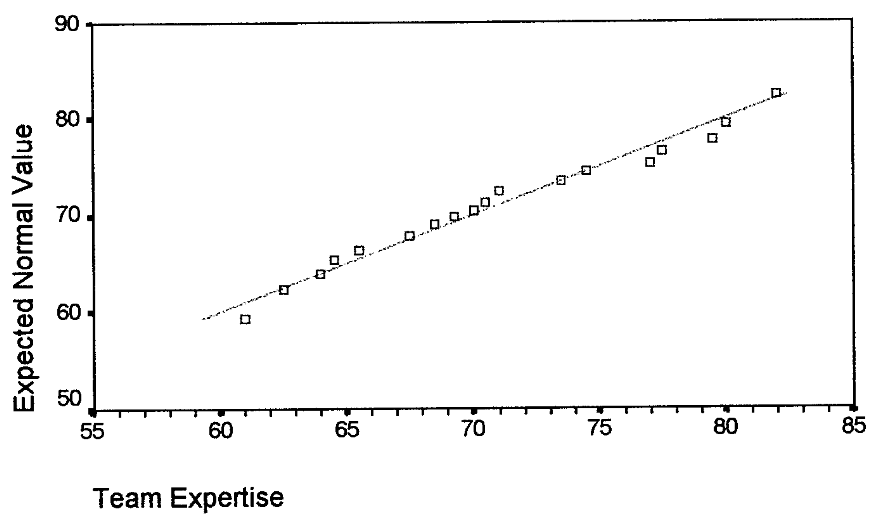
Team Expertise




Normal Q-Q Plot

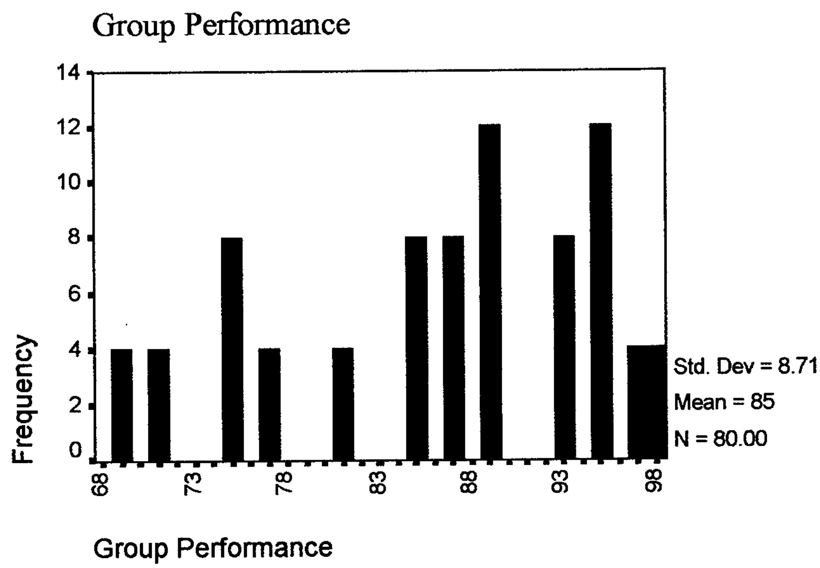
## Face-to-Face

Team Expertise



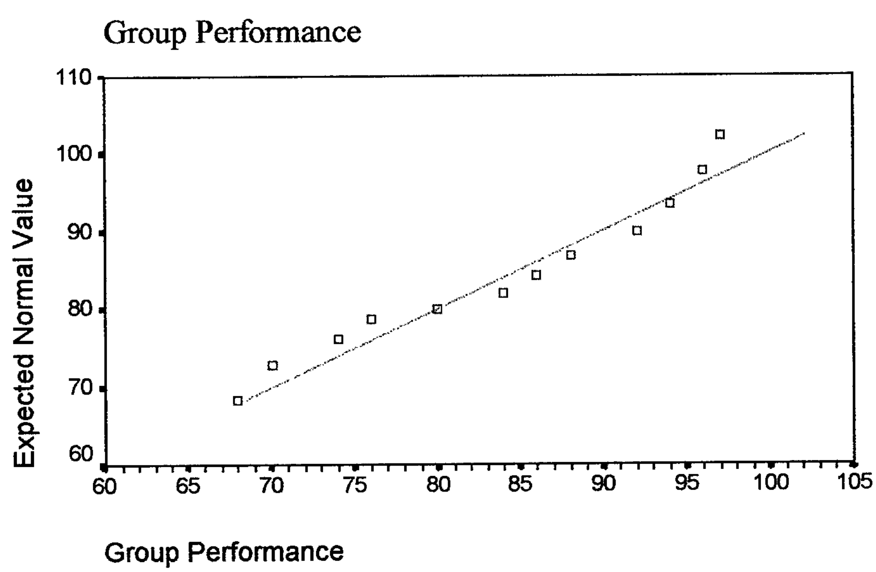
Relative Frequency Histogram

## Face-to-Face



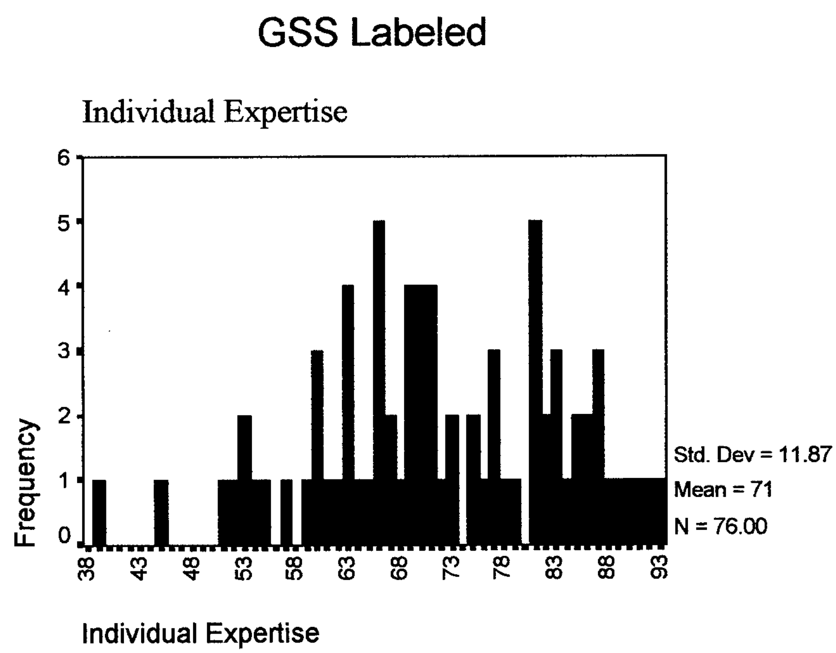

Normal Q-Q Plot

## Face-to-Face

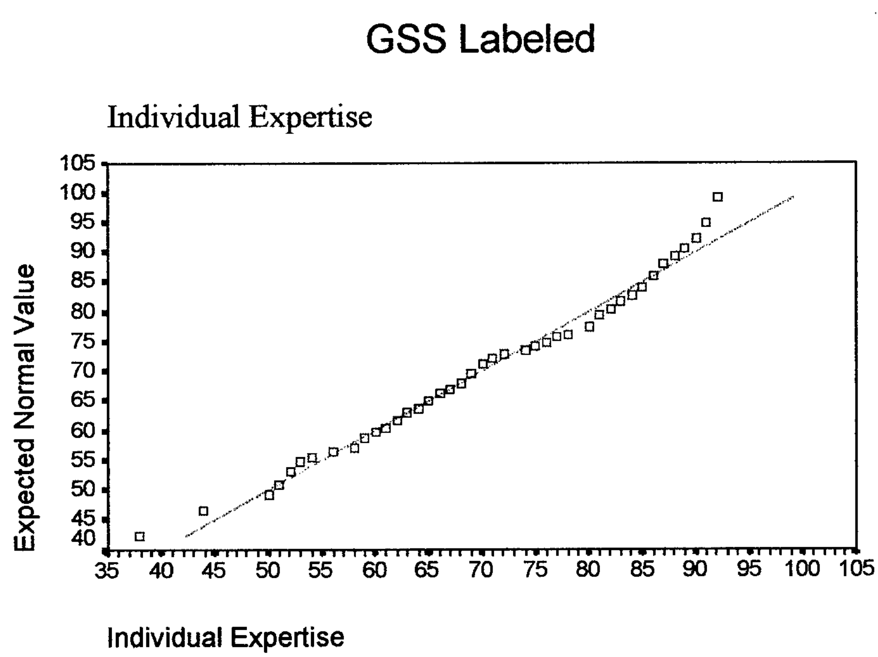


*Appendix G – Data Normality (GSS Labeled)*

Relative Frequency Histogram



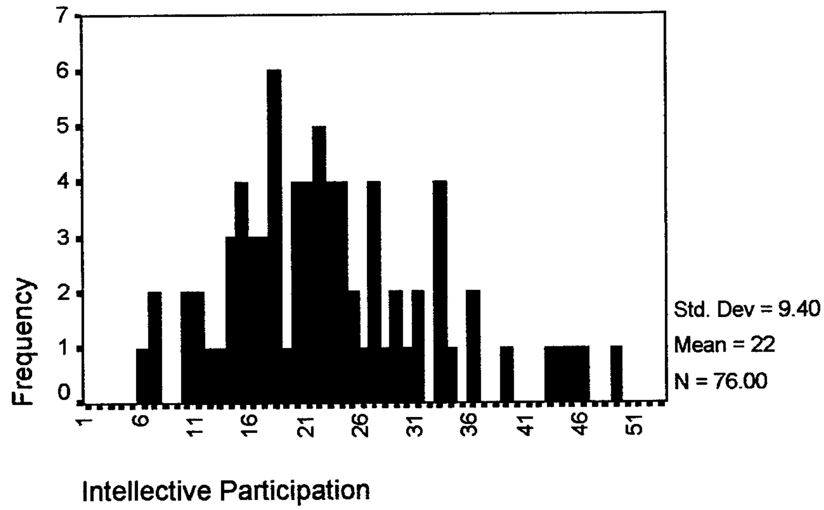

Normal Q-Q Plot



Relative Frequency Histogram

## GSS Labeled

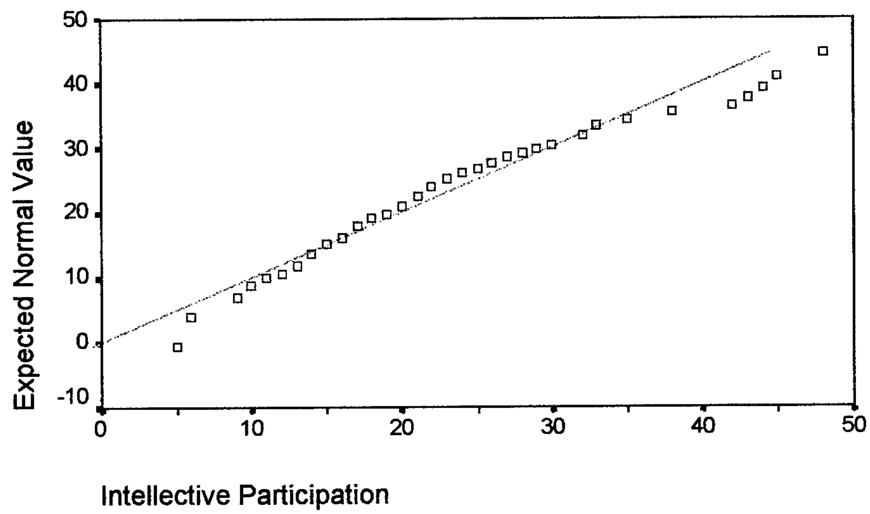
Intellective Participation




Normal Q-Q Plot

## GSS Labeled

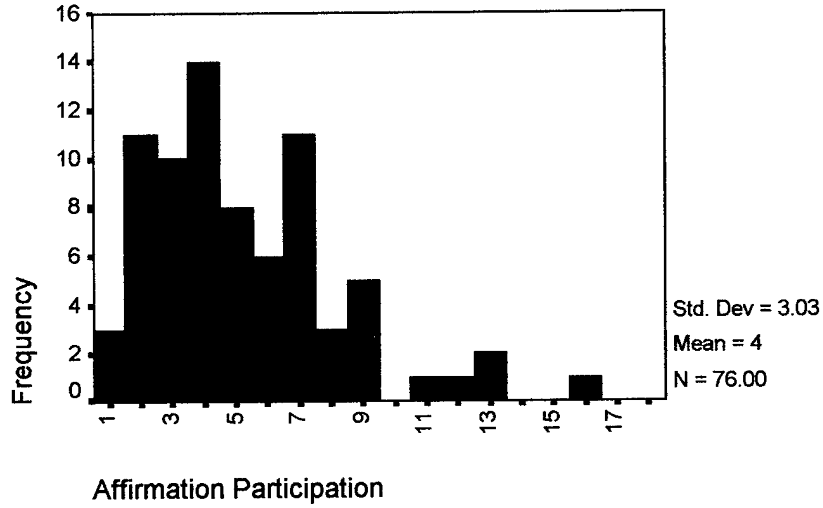
Intellective Participation



Relative Frequency Histogram

## GSS Labeled

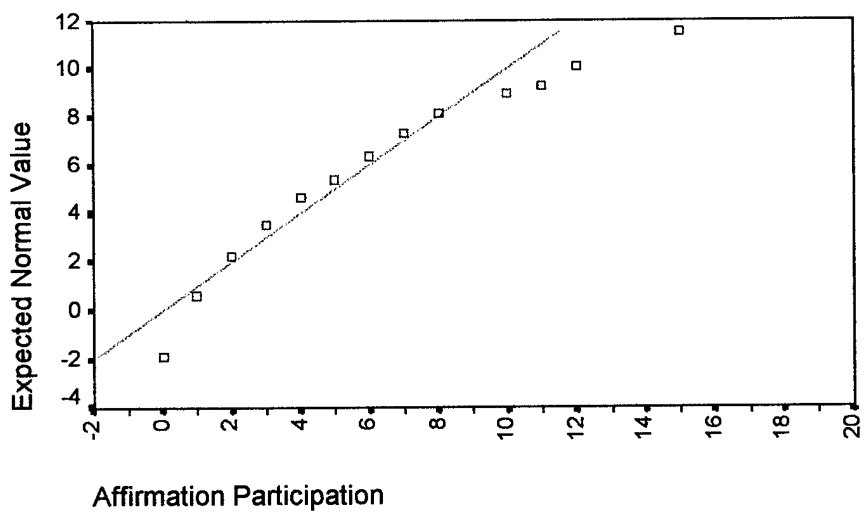
Affirmation Participation



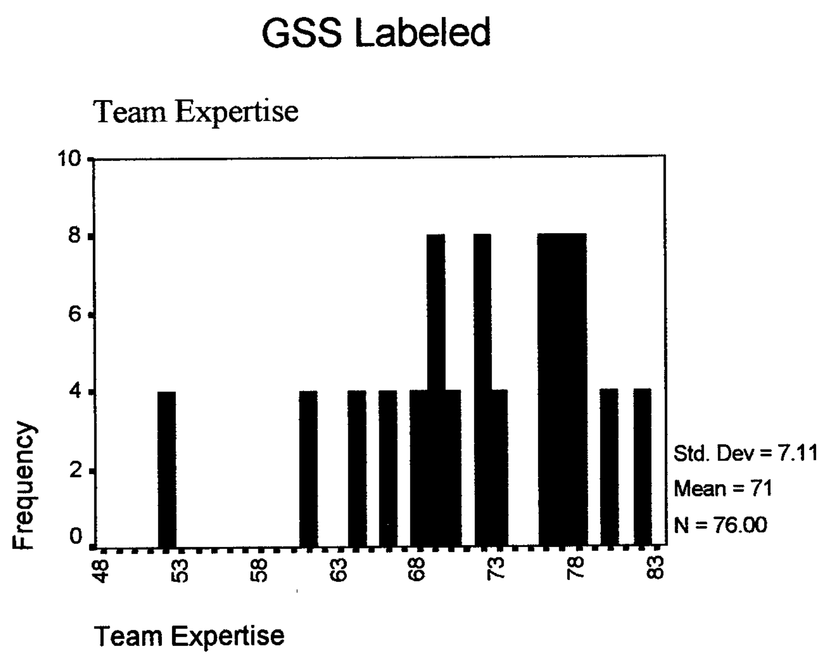

Normal Q-Q Plot

## GSS Labeled

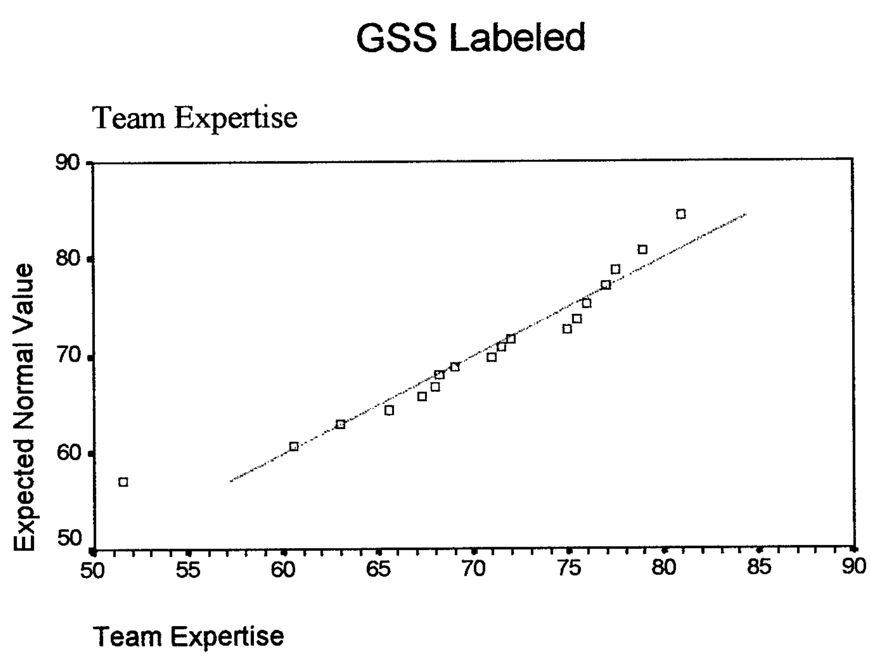
Affirmation Participation



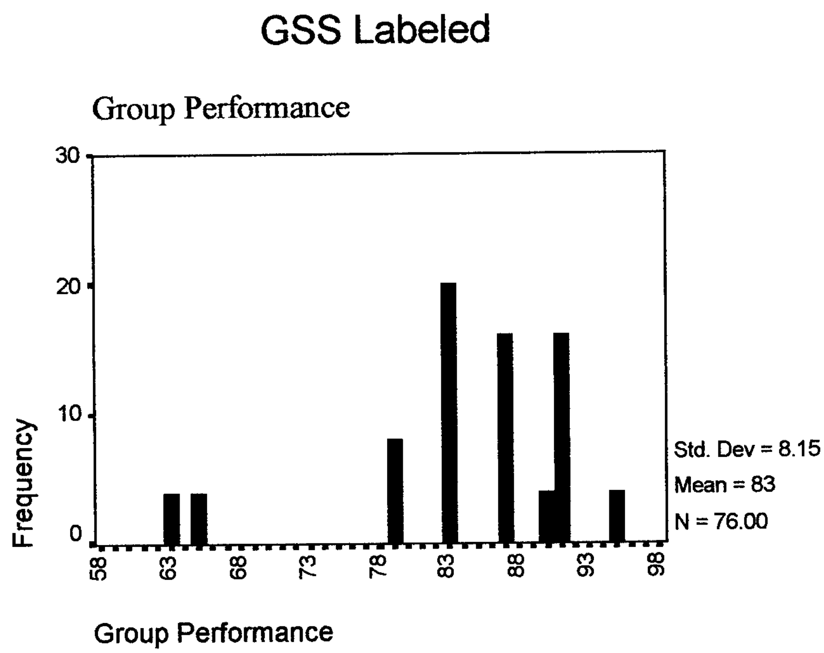
Relative Frequency Histogram



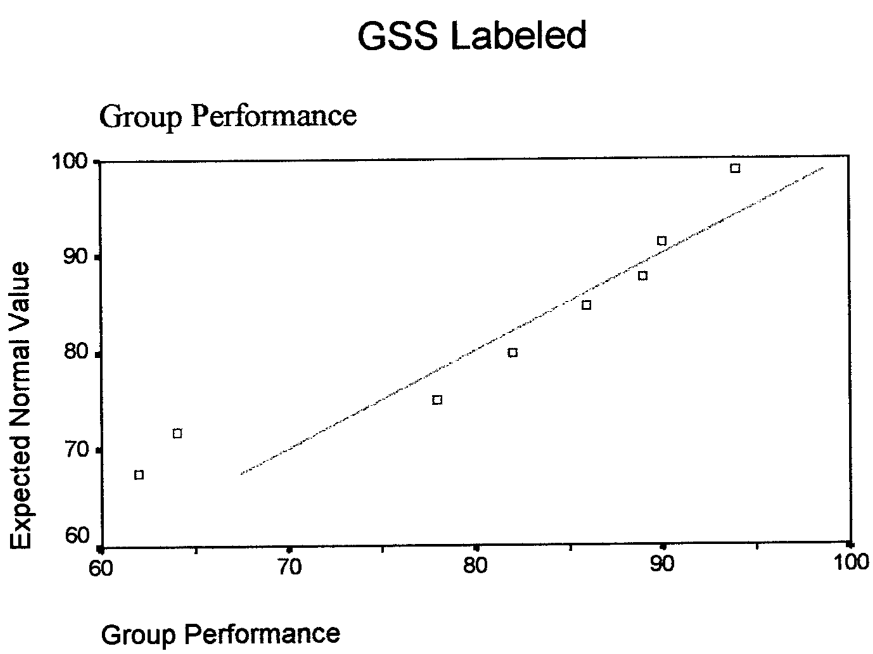

Normal Q-Q Plot



Relative Frequency Histogram

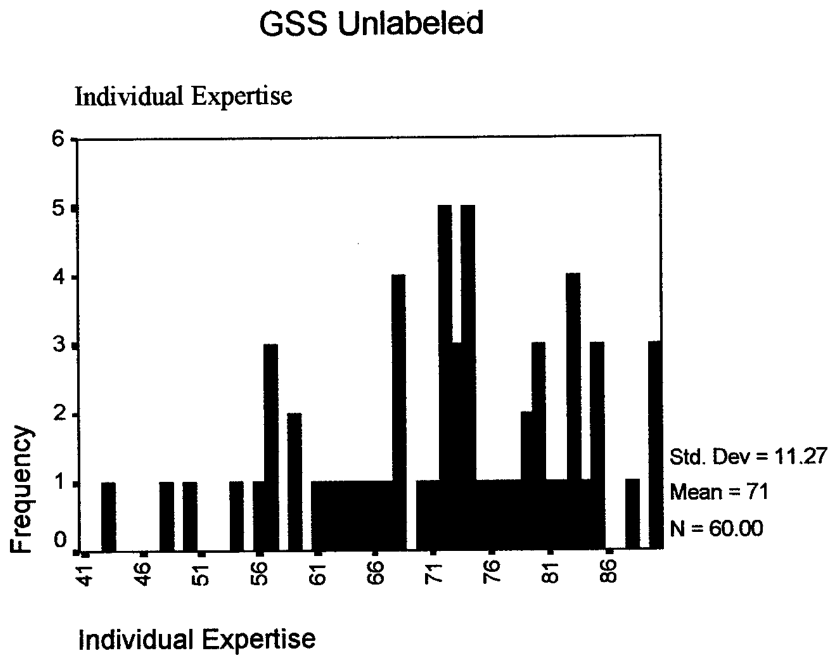



Normal Q-Q Plot

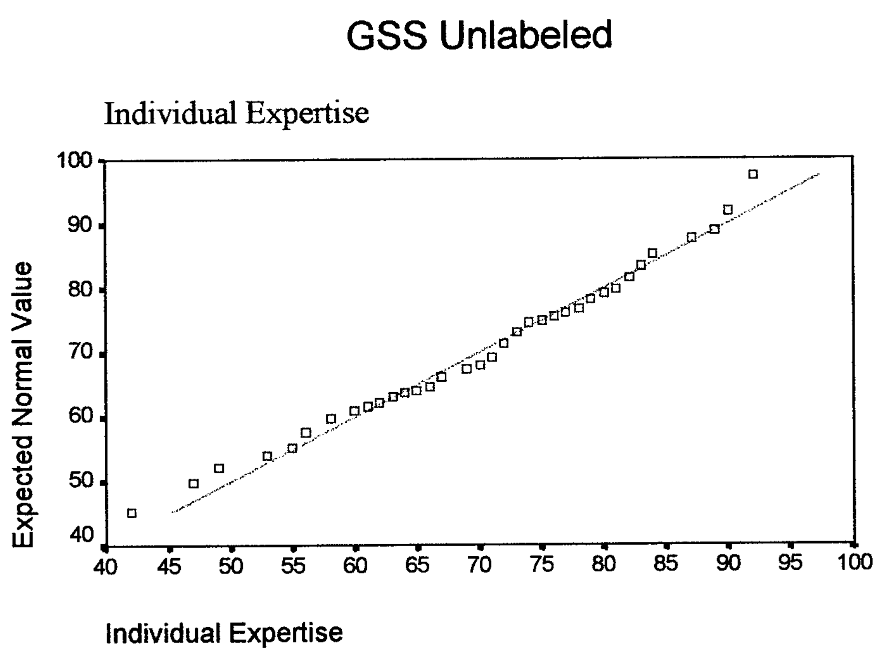


*Appendix H – Data Normality (GSS Unlabeled)*

Relative Frequency Histogram



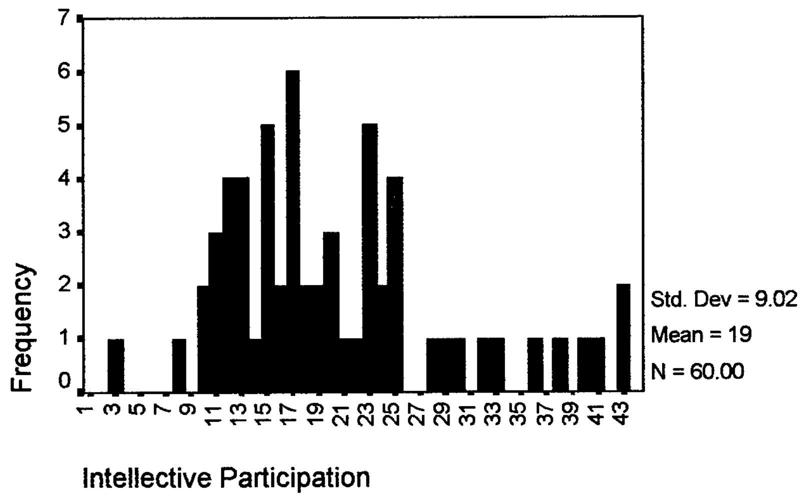

Normal Probability Plot



Relative Frequency Histogram

## GSS Unlabeled

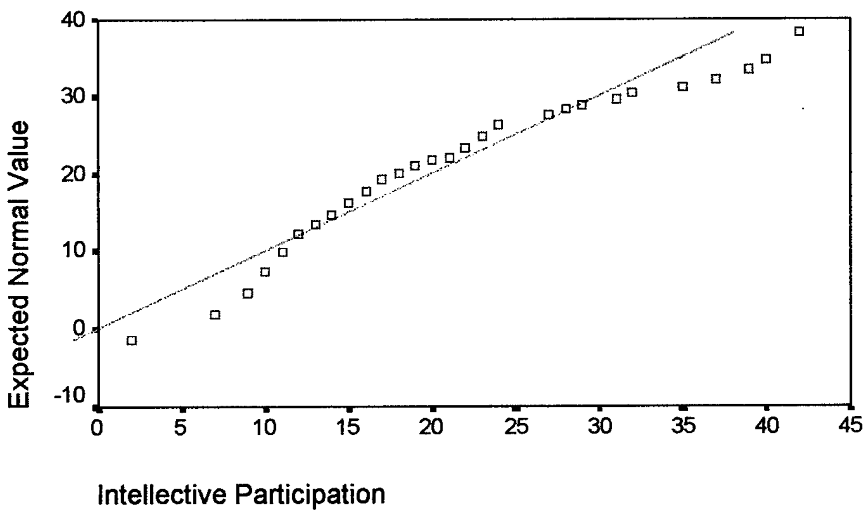
Intellective Participation



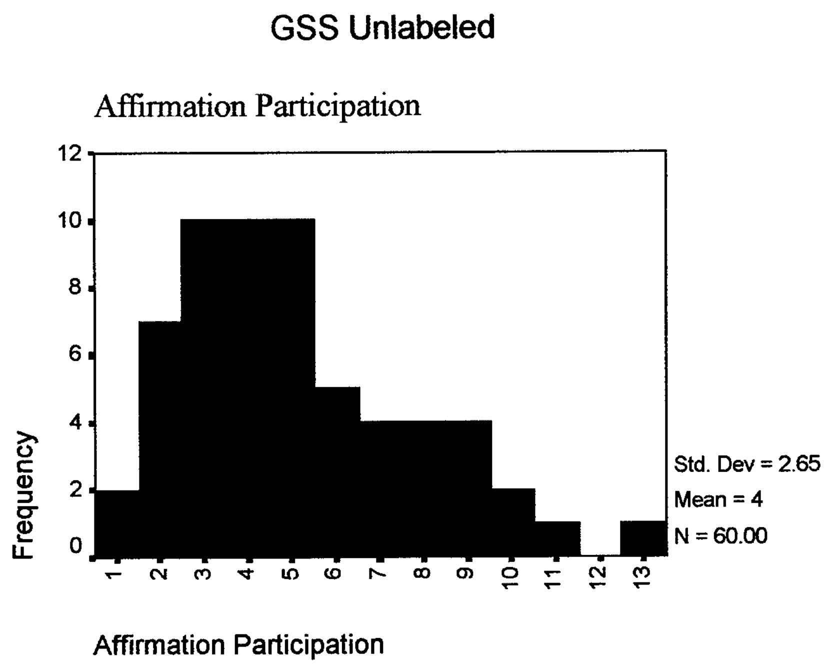

Normal Probability Plot

## GSS Unlabeled

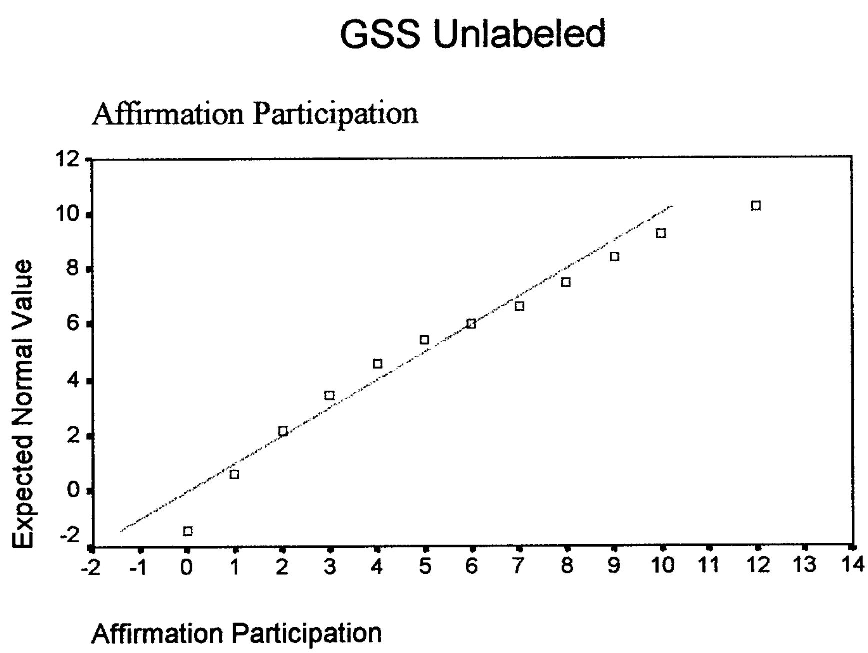
Intellective Participation



Relative Frequency Histogram



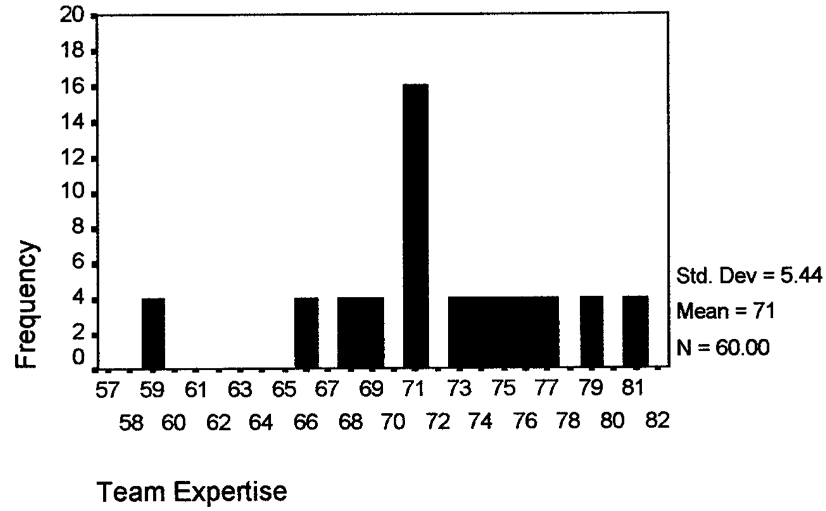

Normal Probability Plot



Relative Frequency Histogram

## GSS Unlabeled

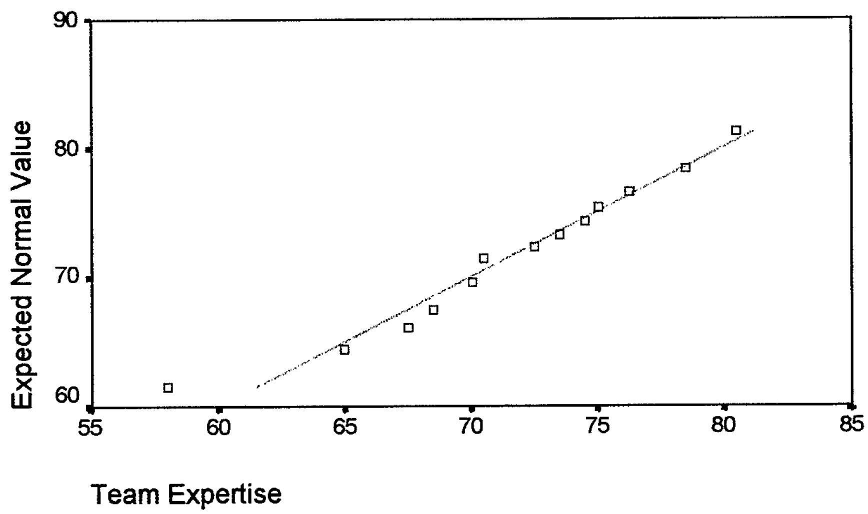
Team Expertise




Normal Probability Plot

## GSS Unlabeled

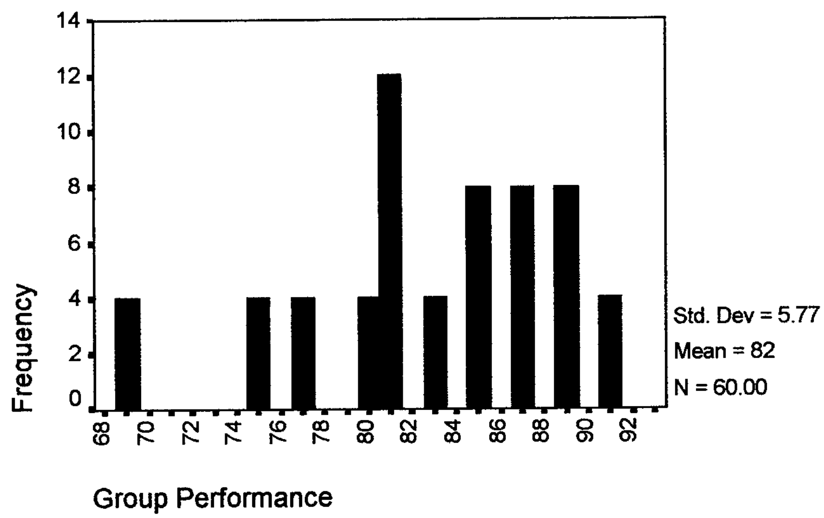
Team Expertise



Relative Frequency Histogram

## GSS Unlabeled

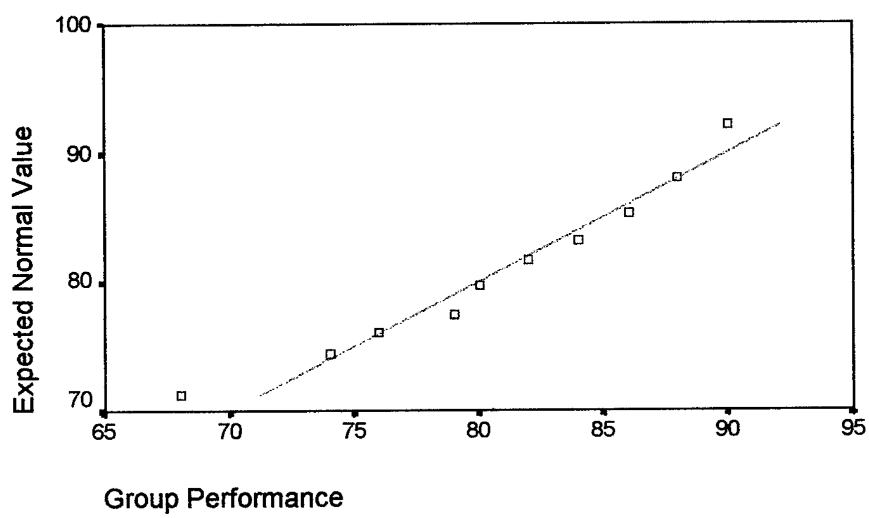
Group Performance




Normal Probability Plot

## GSS Unlabeled

Group Performance



# *Appendix I – LISREL Source Code*

```
FTF - GROUP 1

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CM
!IS          AIS          AC           IC           TS
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-14.21228771 -4.788336663 28.82667333
28.59407259  -4.077339327 17.20879121  343.2321012
12.33233433  12.6022311   4.83016983   55.73759574  72.71262071

SE
AC IC TS IS AIS

MO NK=2 NX=2 NE=3 NY=3 LX=FU,FR, LY=FU,FR TD=SY,FR TE=SY,FR
PH=SY,FR BE=FU,FR GA=FU,FR PS=SY,FR

LK
IS AIS

LE
AC IC TS

PA LX
!IS AIS
1 0 !IS
0 1 !AIS

FI LX(1,1) LX(2,2)
VA 1.0 LX(1,1) LX(2,2)

PA LY
!aff_comm int_comm team_scr
1 0 0 !aff_comm
0 1 0 !int_comm
0 0 1 !team_scr

FI LY(1,1) LY(2,2) LY(3,3)
```

```
VA 1.0 LY(1,1) LY(2,2) LY(3,3)

PA TD
!eIS eAIS
0   !eIS
0 0  !eAIS

MA TD
0
0 0

PA TE
!eAC eIC eTS
0  !eAC
0 0   !eIC
0 0 0   !eTS

MA TE
0
0 0
0 0 0

PA PH
!IS AIS
1   !IS
1 1 !AIS

PA BE
!aff_comm int_comm team_scr
0 0 0   !aff_comm
0 0 0   !int_comm
1 1 0   !team_scr

PA GA
!ind_scr avg_scr
 1 0       !aff_comm
 1 0       !int_comm
 0 1       !team_scr

PA PS
!E_aff_comm E_int_comm E_team_scr
1          !E_aff_comm
1 1        !E_int_comm
0 0 1      !E_team_scr
```

OU ME=ML RS EF MI SC AD=OFF

!______________________________________________________________

GSS LWP - GROUP 2

DA NO=84

LA
IS AIS AC IC TS

CM

| !IS | AIS | AC | IC | TS |
|---|---|---|---|---|
| 101.96 | | | | |
| 12.44 | 12.44 | | | |
| -1.7 | -0.47 | 9.645438596 | | |
| 12.78666667 | 4.063333333 | 11.66070175 | 61.55578947 | |
| 11.12 | 11.12 | -4.627368421 | 0.644210526 | 90.90245614 |

SE
AC IC TS IS AIS

MO NK=2 NX=2 NE=3 NY=3 LX=PS LY=PS TD=PS TE=PS PH=PS BE=PS GA=PS PS=PS

LK
IS AIS

LE
AC IC TS

OU ME=ML RS EF MI SC AD=OFF

!______________________________________________________________

GSS LABELED - GROUP 3

DA NO=76

LA
IS AIS AC IC TS

CM

| !IS | AIS | AC | IC | TS |
|---|---|---|---|---|
| 118.220979 | | | | |
| 25.72657343 | 25.58391608 | | | |
| -5.096503497 | -1.289160839 | 6.101864802 | | |
| -3.036363636 | -4.24965035 | 8.714452214 | 89.06969697 | |
| 10.53986014 | 10.37202797 | 1.67972028 | -5.970629371 | 20.54265734 |

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SE
AC IC TS IS AIS

MO NK=2 NX=2 NE=3 NY=3 LX=PS LY=PS TD=PS TE=PS PH=PS BE=PS GA=PS
PS=PS

LK
IS AIS

LE
AC IC TS

OU ME=ML RS EF MI SC AD=OFF
!_____________________________________________________________________
GSS UNLABELED - GROUP 4

DA NO=60

LA
IS AIS AC IC TS

CM
!IS          AIS         AC          IC          TS
126.94322
29.54068     29.54068
2.82881      2.97288     7.04068
23.64407     9.72881     3.08475     81.31073
19.71186     19.71186    2.35593     2.94350     33.31073

SE
AC IC TS IS AIS

MO NK=2 NX=2 NE=3 NY=3 LX=PS LY=PS TD=PS TE=PS PH=PS BE=PS GA=PS
PS=PS

LK
IS AIS

LE
AC IC TS

EQ BE(3,3,1) BE(4,3,1)

OU ME=ML RS EF MI SC AD=OFF
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*Vita*

Captain Kevin V. Thompson was born on [redacted] in Union City, Tennessee. He graduated from Greenway High School in Phoenix, Arizona in 1981. He enlisted in the United States Air Force in September, 1981 and spent 12 years as a Morse Systems Intercept Operator. He graduated from Hawaii Pacific University in Honolulu, Hawaii with a Bachelor of Science Degree in Computer Science in August 1993. He received his commission through Officer Training School in August, 1994.

His first assignment after commissioning was at Offutt AFB where he served as Chief of the Software Systems Engineering Branch of Detachment 3, Space Systems Support Group. His next assignment was in Air Combat Command at the 612 Air Communications Squadron, Davis-Monthan AFB, Arizona where he was he was Chief, Air Operations Center Systems Flight in charge of Theatre Battle Management Core Systems deployment and operations for Headquarters 12$^{th}$ Air Force.

In August, 1999 he entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, he will be assigned to the 333$^{rd}$ Training Squadron as an Air Force Communications Officer Training instructor at Keesler AFB, Mississippi.

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**14. ABSTRACT**

Group Support System (GSS) research has found that content and process anonymity influence problem solving groups. However, previous studies report mixed results on how GSS technology changes social influence processes and recognition of expertise which affect group performance.

This thesis explored content and process anonymity's affect on influence and perceived expertise using three treatments to derive possible explanations for the mixed results found in previous GSS research. The study developed a theoretical model of influence, perceived expertise, and performance. Using structural equation modeling, the study tested the relationships between expertise and participation rates, and overall group performance. An experiment was developed to explore how content and process anonymity affect informational influence processes and recognition of expertise.

Groups participated in conditions of complete anonymity, process only anonymity, and no anonymity. The results of this study suggest that varying levels of anonymity affect the influence processes exhibited by decision-making groups. In general, it was found that in face-to-face groups, perceived expertise is based mostly on participation rates than actual expertise. In GSS-supported groups, influence and perceived expertise occur through different interaction processes and expertise is based mostly on the quality and merits of individual participants' comments.

**15. SUBJECT TERMS**

Group Support System (GSS), Anonymity, Content Anonymity, Process Anonymity, Group Problem Solving, Informational Influence, User Participation, Decision Quality, Perceived Expertise, Performance

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