USING A MARKET TO SOLVE A HIDDEN PROFILE TASK UNDER DIFFERENT INFORMATION AGGREGATION REQUIREMENTS

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Abstract

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This research addresses how to help computer-mediated groups make better decisions. The task/technology fit theory prescribes combining two different technological support structures to achieve maximum group performance for a hidden profile task in which group members have incomplete information. The two technological structures are synchronous computer-mediated communication (chat), which provides communication support, and participation in an electronic market (e-market), which provides information processing support. To our knowledge, a market-based tool has never been previously developed and used for small decision-making groups. This research examines the effect of chat and e-markets as technological support structures on group performance under different levels of information aggregation requirements. We have found evidence for information flows via an artificial stock market, but the net effect does not seem significant enough to affect group performance for this difficult task. While the technological support was found to cause differences in participants' perceptions of the process, there was no statistically significant difference with regards to group performance.

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1. Introduction

This study explores how to help computer-mediated groups make better decisions. Although groupware technology in the form of group decision support systems (GDSS) has been used for this purpose, when tasks require significant information aggregation, this type of support has not been enough to lead the groups to make better decisions (Dennis 1996). What is needed is new technological support, especially in the area of information processing. We expect that by having a technological support structure that emphasizes information aggregation, in addition to traditional communication support, group performance will improve. The two technological structures we employ are synchronous computer-mediated communication (chat), which provides communication support, and participation in an electronic market (e-market), which provides information processing support. We also examine their effectiveness under various levels of information aggregation requirements.

The main contributions of this research are the development of a market tool and the innovative use of a market mechanism to help small group decision-making. To our knowledge, there is no research that explores the use of a market-based tool for small group decision-making. Another contribution is the study of group performance by systematically varying the information aggregation requirements imposed by the task. While the initial asymmetric information distribution across team members has been manipulated in previous research (Dennis 1996), it has seldom been framed as an information aggregation requirement manipulation and studied from this perspective.

Our findings advance both the research and practice of group decision-making. This research provides the basis for a new type of group meeting where both computer-

mediated synchronous discussions and market trading are present in order to provide groups with technology support for the exchange and processing of information. Most tasks can benefit from increased information aggregation and markets provide this. In the future various market structures could be used to improve group performance for *every* task. By understanding the specifics of how group members exchange, process, and aggregate information, this research also advances theory in technology-supported group decision-making and market structure. The remainder of the paper presents the theoretical background and methodology to examine group decision-making followed by our results and discussions.

2. Relevant Literature on Group Decision Support Systems

In order to frame the entire problem we need to understand three key dimensions: the specific task, group characteristics, and the role of technology, as well as their interactions (Benbunan-Fich, 1997). The context in which the decision is taking place is another factor to be examined. This model will be used to review the literature in each area (Figure 1).

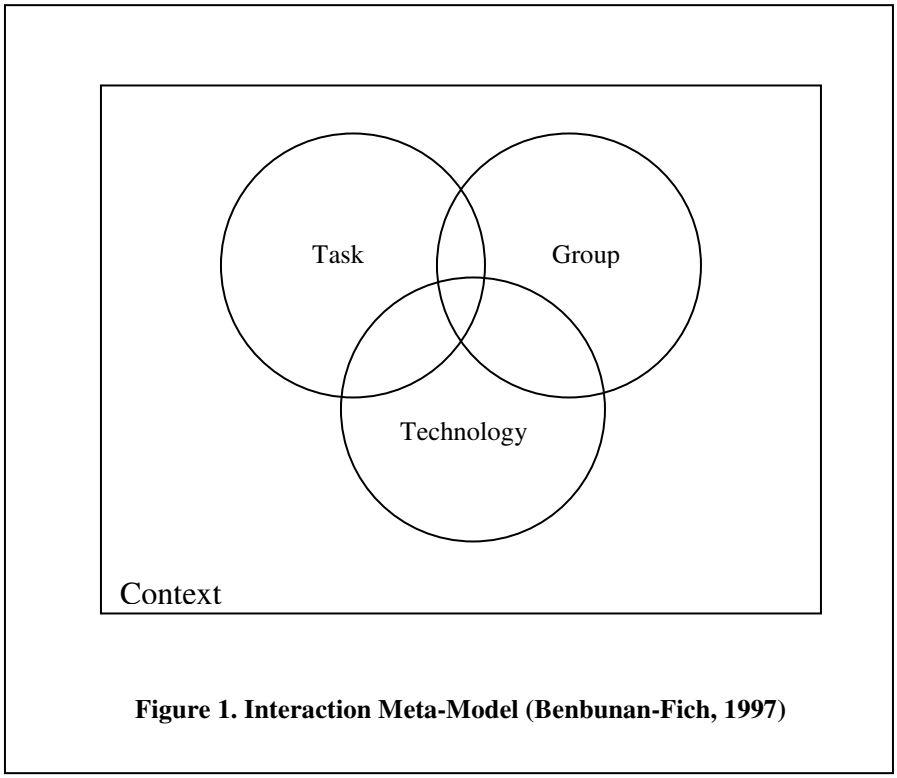


Figure 1. Interaction Meta-Model (Benbunan-Fich, 1997)

Only one specific type of task that requires communication between members is considered, many factors involving group dynamics are looked at, and all of the current technological effects are examined. Relevant theories in each dimension are also used to help explain various phenomena.

Ultimately what we are interested in is group productivity and performance. Steiner's (1972) theory of group performance states, "actual group productivity will be equal to the group's potential productivity minus process losses due to faulty processes." The potential group productivity is the ideal condition where all individual resources are used at the most efficient level. There are process gains from group decision-making as opposed to individual decision-making including access to more information and synergy (Nunamaker et al., 1991). If there were no faulty processes, groups would use individual resources to the best of their abilities, there would be prefect communications, and there would only be process gains. The result would be that every group process would be more efficient (quicker and better) at finding an optimal solution than individual decision-making. The fact is that when individuals work in groups, process losses are often created.

One way to overcome these process losses is with group techniques (Delphi) or through technology. GDSS attempt to overcome process losses, but the technology itself can also introduce new process losses. An example is that technology can allow for anonymity thereby reducing the process losses arising from personal issues, but typing is slower and might be a source of process losses. The technology needs to result in a net process gain or else it will be ineffective at improving group decision-making.

2.1 Hidden Profile Tasks

"The characteristics of a group's task have been shown to account for more than half the variation in group interaction" (Zigurs and Buckland, 1998). Our task is called a *hidden profile* task and has some unique characteristics (Stasser and Titus, 1985). The

task requires “finding the correct answer” to some problem that has a demonstrably correct answer. Furthermore it has a specified set of alternatives, one of which is the correct answer. The most important characteristic of the task is that the initial information distribution creates a bias against the correct answer in some of the group members; “a superior decision alternative exists but its superiority is hidden from individual group members because they each have only a portion of information that supports this superior alternative” (Stasser and Stewart, 1992). There are three important task factors: pre-discussion information distribution, information load, and implicational clarity (Stasser and Titus, 1987).

Pre-discussion information distribution

The asymmetric distribution of information resembles many real world situations. In fact it can be argued that all tasks have some commonalities with the hidden profile task. Group members often have different knowledge levels and some members may selectively disclose information because of political or social agendas. The initial information distribution can setup a majority/minority situation. This creates conflict where there are more group members on one side than the other. This setup usually has the majority with an incorrect bias and the minority with the correct bias. Another setup can be a uniform distribution where conflict exists but there is no majority. This can be done with two groups only or with more than two groups based on different initial biases. With two groups there can be two subgroups with incorrect biases (incorrect uniform) or one correct subgroup and one incorrect subgroup. If there are three or more alternatives,

there can also be three or more equal subgroups, given that subgroups have equal number of members.

Information load

Information load refers to "the amount of information available to decision makers" (Stasser and Titus, 1987). Low load situations should pose less of a problem in finding the optimal solution since cognitive abilities will be less challenged. From a statistical perspective, low information load requires less communications to acquire the entire information set. Suppose there are two situations, one with four pieces of information and one with twenty pieces of information, and in both cases fifty percent was shared. The low load situation would only require two pieces to be communicated, while the high load situation would require ten. This helps explain why low load situations exhibit more effective communications (Stasser and Titus, 1987).

Implicational clarity

The details of the task vary. There are many examples; choosing the best candidate for a job, choosing the murderer from a list of suspects (murder mystery), choosing between two professors to win an award, choosing the best professor out of three to teach an introductory course, choosing the best student council presidential candidates out of three that are running, diagnosing two hypothetical medical cases, etc. The common theme is that information is distributed in a hidden profile manner and there is an objectively correct answer. The group needs to choose the correct alternative.

The way that the correct answer is determined is to give all the information to some experts or to many experimental subjects. If there is high agreement on a single alternative, then there is increased confidence that an optimal solution exists and can be identified. For some tasks, such as the murder mystery, it can be demonstrated through logically piecing the information together, that there can only be one correct solution.

Obtaining the correct solution

The only way the group can identify the optimal choice is through effective communication and understanding, and the willingness to change their initial, incorrect preference. Communication and understanding encompasses three distinct functions: recall, exchange, and processing. A member must recall information. The member must choose to and have the opportunity to voice/exchange the piece of information. Other members need to receive and process the information correctly. This in turn can alter their knowledge, so that they might need to discount old information and recall new, more accurate information. If they recall, exchange, and process all the information given, the group can objectively reach the optimal solution; however, this seldom happens. Groups that have all the information shared and are told to solve the problem, can accomplish the task (100% of groups solved correctly), while groups with a hidden profile typically solve the problem less than 70% of the time (Stasser and Stewart, 1992).

Relevant theories

Group tasks require communication between group members. Communication theory provides the classic explanation of how this happens (Shannon and Weaver,

1949). There is an information sender and an information receiver. The information must travel across the communications medium that the sender and receiver use. The medium is always subject to some noise level. Good communications require information to arrive complete and timely. Various media have various information capacity and noise reducing characteristics.

Humans do not have unlimited mental resources. Human Information Processing theories describe how limited our cognitive abilities really are. Tools to improve a group's cognitive abilities can greatly impact the quality of their decision (Rao and Jarvenpaa, 1991). Empirically, the importance of cognitive abilities is demonstrated through varying the information saliency and information load. Increasing information saliency increases the percent of groups choosing the correct alternative, especially the pre-discussion information (versus the discussion information) (Stasser, 1992). These theories also attempt to explain when we seek answers and how we attain answers, given our limitations. Group members might simply rely on others to provide them with the solution rather than think about the answer. This brings up the important concept of member influence, which is further discussed in section 2.2.

2.2 Group Dynamics and Group Factors

There are many factors that can affect group characteristics. One that usually remains constant in experimental studies is *group history*. Experimental groups are typically formed ad-hoc and have no history together. Because groups who have a shared history might exchange information in a different way, especially in a non-anonymous setting, it is an important factor. The social structure of the group can influence group

behavior. Shared experiences, language, and behaviors can all impact the communications context the group operates in. It was found that established groups exchanged less unique information than ad-hoc groups, that there is no significant difference in the quality of the group decisions, that established groups are more satisfied, and that "group cohesion was found to be positively related to group history, satisfaction and decision quality" (Mennecke and Valacich, 1998).

Groupthink often occurs when groups are cohesive and under pressure to make a decision (Irving, 1972). Groups suffering from groupthink typically desire consensus and sacrifice decision quality. Groupthink can result in examining few alternatives, not being critical, and generally making poor decisions. Groupthink is categorized as "faulty" decision-making and is something to be avoided. Cohesiveness, pressure, and type of influence all impact the occurrence of groupthink.

Group size is a factor that affects many aspects of the group decision process. As group size increases so does the proportion of shared information versus unshared information (Stasser et al., 1989). This suggests that if important information lies within unshared information, larger groups will have a more difficult time reaching the optimal solution.

There is evidence that the social factors in groups are significant. There are social pressures for group members to agree and there is greater uniformity of opinions in groups of similar members. Group discussions seem to "push" members towards agreement. This process is faster for groups of similar (same social class, same initial beliefs) members (Wittenbaum and Stasser, 1998).

Relevant theories

In all hidden profile tasks, in order to reach the optimal solution, some members must change their pre-discussion preferences. Two different theories explain how this is done: normative influence theory and information influence theory (Kaplan, 1987). Normative influence theory considers the source of the information as the overriding determinant of value. If the sender of the information is deemed reputable, worthy, desirable, or popular the receiver might want to agree with the sender regardless of the information. Information influence theory states that the information is the most important item. If the information is particularly enlightening or persuasive, the receiver might change their preference.

The initial information distribution bias can establish a majority/minority situation where few members initially desire the optimal choice, while most favor a suboptimal choice. Minority influence theory states that the conflict between the groups can be beneficial and can lead to careful examination of the alternatives and creative problem solving (Nemeth, 1986); however, studies show that opinions of the majority subgroup often prevail. Combining the above theories yields the following: if the bias is established with a majority/minority situation and normative influence is dominant, then it is likely that the minority will quickly fall in line with the incorrect majority. If information influence is dominant, with the minority presenting persuasive, novel and enlightening information, then it will be possible that the incorrect majority's position can be overcome. The minority also has to be persistent and consistent and not give in to the majority because if the majority is more persistent, the group can quickly be caught in "faulty" decision-making (Nemeth et al., 1990).

Other explanations

The biased sampling model explains the main underlying reasons for poor group performance in hidden profile tasks (Stasser and Titus, 1985). The two main reasons are as follows; one is that discussions are biased in favor of shared information and the other is that discussions are biased in favor of the current majority preference. Further explanations as to why these two phenomena occur have been the focus of several studies.

The common information sampling (CIS) model uses pure probability to explain why groups discuss shared information more than unshared information. In order to be shared, some information needs to be duplicated. There are more occurrences of this shared information. Therefore if a group member randomly picks one item to contribute, there is a greater probability that it will be a shared item. This shared information bias only explains why groups mention shared information more often.

Not only do groups mention more shared than unshared information, but they also repeat shared information more often. The repetitions are more likely to happen as time goes on. Since more new information is being mentioned, the probability for repetition increases (Larson et al., 1996). Usually, there is a discussion timetable that corresponds to information distribution. Shared information is usually mentioned before unshared information (Larson et al., 1996). It is as if when more members become aware of the shared item (through discussion with repetition), there is a tendency to believe that it is important or correct.

Another explanation of why groups discuss more shared information is the "common knowledge effect" (see Carley, 1986 for a further explanation of the social factors regarding knowledge). The more members that possess a specific item before discussion, the greater the impact of that item on the group's decision (Gigone and Hastie, 1993). In a hidden profile with a majority/minority setup, group discussion can allow the minority to overcome the majority, but it is rare. This dual-process model attempts to explain group interactions and group decisions (Gigone and Hastie, 1997a). The model has two variables: pre-discussion member preferences and information pooling. The group's decision is based on common knowledge obtained pre-discussion and biased information pooling during discussion. A regression model has been developed that is good, but not perfect at predicting group decisions based on cues and weightings (Gigone and Hastie, 1997b). The weights can only be estimated after several group decisions but the model has great potential usefulness for explaining information flow within group decision-making.

A detailed study (Winquist and Larson, 1998) confirms other empirical works; it found that only one type of information is important during discussion. The more unshared information the group pools, the better their result, while the amount of shared information pooled has no effect. The importance of unshared information cannot be overstated. The "answer" to the hidden profile lies within the unshared information.

The differential cue weighting model attempts to explain how individuals, as opposed to groups, weigh items of information and how these weighted information items affect individual judgments. It is a mathematical process that sums up different categories of information. The categories are based on initial distribution, discussion,

and method of acquisition of the information. The information can be common or unique, discussed or not discussed, and acquired through discussion or initially owned. An empirical study supports the model and suggests, "for individual judgment, unique information can be just as influential as common information," but only for the sender of the information (Chernyshenko et al., 2003).

A quantitative model has been developed to explain the poor performance of groups in hidden profile tasks; however, the authors also realize that the discussion process is a social process (Stasser and Titus, 1985, 1987). Group discussions seem to be a "social validation" process for majority members to confirm their pre-discussion preferences. Discussions do not help the group in discussing the merits of all the alternatives.

Probability alone does not explain all of the shared information bias. An additional explanation that can be used in conjunction with the probabilistic models, but that offers a more social point of view is "mutual enhancement." When a member of the group hears a piece of information that they can recall and agree with, they feel good about themselves and about the other member. Likewise when a member receives positive feedback about what they said, they tend to feel good about themselves and about the senders of the feedback. Group members are also more likely to judge shared information as more accurate and more relevant (Wittenbaum et al., 1999).

Simple commitment to pre-discussion beliefs and member stubbornness might also be a plausible reason for poor group performance. Members may feel that they have to defend their initial position and may be contributing to the discussion by selectively mentioning information that supports their position (Stasser, 1992). Participants

essentially get stuck on a belief and do not want to change their position. This can be accentuated if the member had publicly stated their position and anonymity is not employed.

2.3 Technology's Role

GDSS use technology to try and introduce process gains and overcome process losses. The goal is that computer-supported groups should be able to outperform traditional face-to-face groups. Different systems incorporate different features that do provide process gains, but also introduce process losses. As long as the net result is a process gain, the GDSS is accomplishing its mission. Technology can eliminate physical constraints, provide anonymity, allow for parallel communications, provide a system memory, enforce specific group technique rules, and provide advanced decision-making tools (calculators and models) among other things.

An early framework for GDSS included a discussion of many goals and factors resulting in different "levels" of systems (DeSanctis and Gallupe, 1987). The first GDSS level provides computer-mediated communications and displays. Parallel communication is provided with electronic chat or bulletin board systems. System memory is provided with a central (searchable) display of all users' comments. The second GDSS level provides all the features of the first level and the addition of decision-making tools or models. These can be advanced quantitative models or rule enforcing techniques (Delphi). Various voting methods are also second level features. The third level incorporates advanced technological features including artificial intelligence to automatically manage group processes efficiently. Very little work has been done with

the third and most ambitious level. The goal of this paper is to build a foundation for a new decision-making tool to be used with the hidden profile task. A meta-analysis (Benbasat and Lim, 1993), a recent review of case and field studies (Fjermestad and Hiltz, 2000), and other reviews (Dennis et al., 1991; Fjermestad, 1998; Fjermestad and Hiltz, 1998; Turoff et al., 2001) provide the reader with an overview of the larger GDSS literature.

Theoretical technological effects

Technology attempts to eliminate the process losses and provide process gains; however, there are new process losses that come with using technology (Nunamaker et al., 1991). The goal is that the net effect be positive and aid the group decision. The three main technologies that have been shown to affect group discussion are parallel communications, system memory, and anonymity. An important mediating factor for the effect of technology is group size. Overall, technology has a positive impact on larger groups and a negative effect on smaller groups. To date, the net effect of technology use in hidden profile tasks has not been overwhelmingly positive.

The three facets of effective communication; information exchange, information recall, and information processing, can all be affected by technology. Communications theory explains that during group discussions only one person is speaking at any one time. It is difficult for a human to be a sender and a receiver at the same time. Computer-mediated communication allows parallel communications. All the members can enter comments into the system simultaneously, instead of waiting for somebody else to stop talking. This can overcome the process loss of taking turns (production blocking)

and improve information exchange. Parallel communication is also less themed than verbal. Different members can be discussing different ideas simultaneously as opposed to the entire group discussing one idea. Therefore it is thought that computer-mediated group discussions would result in more information being mentioned. Some studies find that computer-mediated groups do share more information (Dennis, 1996); while others find that they do not share significantly more information (Straus, 1996; Mennecke and Valacich, 1998).

In addition to the volume of communications, efficiency of communications can also be measured. Efficient communication involves gaining new pieces of information and discussing many alternatives (Hightower and Sayeed, 1996). Empirical results are very inconsistent. Computer-mediated groups have been found to be less efficient (Hightower and Sayeed, 1995, 1996; Dennis et al., 1998), as efficient (Warkentin et al., 1997), and more efficient than traditional groups (Lam and Schaubroeck, 2000).

Because comments are "written" into the system and can be made available long after their initial mentioning, information recall should be enhanced. The system memory can help individual and group memory by having easily referenced material available. The members do not have to use cognitive resources for memory. Having the system memory allows members to pause, think, and process instead of focusing on what the next member is saying. This helps each member process the information at his/her own pace, without the risk of missing any key facts. Processing can be enhanced with sophisticated software and algorithms to analyze data, but this need not be the case. As mentioned earlier, increased recall abilities aid information processing; but processing can also be viewed as part of the influence process. Processing new information can be

studied as influence since the change of preference sought out by influencers can only happen if the receiver processes the influencing message in the desired manner.

While technology does not appear to affect how often members try to influence each other (Zigurs et al., 1988), technology can affect which type of influence will be dominant. By incorporating anonymity (the sender is not identified) members can change preferences after publicly stating a preference without losing face. It also reduces the reluctance to mention information that contradicts the majority. This promotes more equal member participation and more uninhibited communication. Anonymity is a simple, yet powerful way to remove many social factors and emphasize discussion content. This reduces normative influence by eliminating social pressures including status (Tan et al., 1998; Hollingshead, 1996). When this does happen the computer-mediated groups are less able to exert social influence over each other and are less likely to reach consensus during the meeting (Tan et al., 1998). This might be one factor that explains why computer-mediated groups take longer to reach consensus. The GDSS members leave the meeting having more differences than face-to-face groups and not changing as many people's minds. Maybe this helps explain why they are less satisfied.

With computer-mediated communications and anonymity, the full benefit that minority influence theory describes can be realized. Technology makes it more likely that information influence will occur and in a majority/minority condition the minority will have a chance to persuade and overcome the majority and indeed this has been shown to be the case (Dennis et al., 1998). The majority/minority condition is essentially a choice of two alternatives. When the uniform condition exists between three alternatives (equal numbers of group members initially preferring choice A, B, and C)

minority influence does not seem to be prominent. Here a different process is at work and technology does not seem well suited for the job. Computer-mediated groups have been reported to perform worse than traditional groups in the uniform condition (Dennis et al., 1998).

In addition to the positive aspects of these technologies, there can be a negative side. Computer-mediated communication involves a less rich medium than face-to-face communications. With less communication cues, it can be harder to exchange information effectively (Daft and Lengel, 1986). Hightower and Sayeed (1996) have suggested other possible reasons for less efficient computer mediated communication. Parallel communication can be hard to follow if the software does not group comments into themes. Members might find it harder to have an interaction with each other and simply type their opinions and information into the system. This tends to reduce the efficiency of information exchange. The increased uninhibited communication, and conflict that comes with it, can mean an increase in personal attacks or vulgarities; "flaming" can be counterproductive to achieving an optimal group consensus. Computer-mediated groups actually "rely more on emotional and less on informational means to influence one another than face-to-face groups" (Hightower and Sayeed, 1995).

Other technological issues

Since the medium is not as familiar, the system might be awkward, and communication requires typing, it is thought that computer-mediated groups might be slower in reaching a decision; however there are mixed findings. Dennis (1996) finds no significant difference while others find that computer-mediated groups do take longer

(Hightower and Sayeed, 1996; Hollingshead, 1996; Straus, 1996; Lam and Schaubroeck, 2000). In the same study Dennis et al. (1998) found that when information is distributed with a majority/minority setup computer-mediated groups do not take more time than traditional groups; however under the uniform condition, computer-mediated groups do take more time.

Technology can eliminate physical restrictions that limit group meetings. Groups no longer have to meet in the same place at the same time. The Internet provides a virtual place to meet and communications can be left and accessed anytime. To date only one study has been found that uses a hidden profile task in an asynchronous setting. One of their findings is that groups communicating via the web felt less cohesive and less satisfied with the group process (Warkentin et al., 1997). Since it has been shown that group cohesion is positively related to decision quality (Mennecke and Valacich, 1998), it may follow that asynchronous teams will make poorer decisions than established or face-to-face groups (though this has not been tested or reported in any known study). Of course group decision-making is complex and there might be other gains that asynchronous groups have that may compensate for their reduced cohesion.

Review of relevant empirical studies

Studies concerning computer-mediated groups versus traditional groups solving a hidden-profile task have mixed results, but generally paint a disappointing picture for the role of technology in aiding groups to make better decisions. Computer-mediated groups have been found to be less satisfied with the decision-making process and less satisfied with the actual decision (Mennecke and Valacich, 1998) and also found to be less

satisfied with the interaction process (Warkentin et al., 1997). Also, there is no significant difference between computer-mediated and traditional groups when looking at the amount of influence behavior (Zigurs et al., 1988). It has been suggested that computer-mediation does not positively change group dynamics and probably only introduces new process losses (Straus, 1996). Typically these process losses include information overload, and providing a leaner communications medium. The leaner medium accounts for the process losses of increased flaming, more free riding, less feedback, and fewer information cues (Nunamaker et al., 1991). The system itself might be awkward and unfamiliar and might use additional cognitive resources.

Almost all the studies that compare traditional and computer-mediated groups solving a hidden-profile task find that computer-mediation does not help groups reach the optimal solution (Zigurs et al., 1988; Dennis, 1996; Hightower and Sayeed, 1996; Hollingshead, 1996; Warkentin et al., 1997; Dennis et al., 1998; Mennecke and Valacich, 1998). There are two exceptions. Computer-mediated groups with a majority/minority information distribution outperformed traditional groups with the same information distribution. Without the majority/minority condition computer-mediated groups performed worse (Dennis et al., 1998). Lam and Schaubroeck (2000) find that computer-mediated groups do choose the optimal solution more often than traditional groups. There are some notable differences in the Lam and Schaubroeck (2000) study: their findings show that computer-mediation can help; their study is the most recent (maybe subjects are becoming more comfortable with technology); their subjects were actual managers and not students; and their study was published in a psychology journal, not an IS journal.

2.3.1 Task/technology fit

All of the interactions between the three main factors (task, group, technology) are important; however, the most important might be the interaction between the task and the technology. The task is the most important single factor and technology should be coupled to it as closely as possible. Each system should contain technologies that are geared to aid a group facing a particular type of task (Figure 2). All GDSS should be based on the task/technology fit. The task/technology fit theory prescribes support levels based on type of task and technology dimensions (Zigurs and Buckland, 1998). The technology support dimensions are communication support, process structuring, and information processing. Levels of support can be high or low. It is prescribed that any GDSS designed for hidden profile tasks should provide high aid with information processing and high levels of communication support. Communication support can be provided with anonymous input, simultaneous input, and a group display. Information processing can be supported with features that promote the gathering, aggregating, evaluating, and structuring of information. A GDSS that provides communication and information processing support should significantly help groups facing a hidden profile task. It would appear that that technology can easily provide communication support; however, providing information processing support is less straight forward.

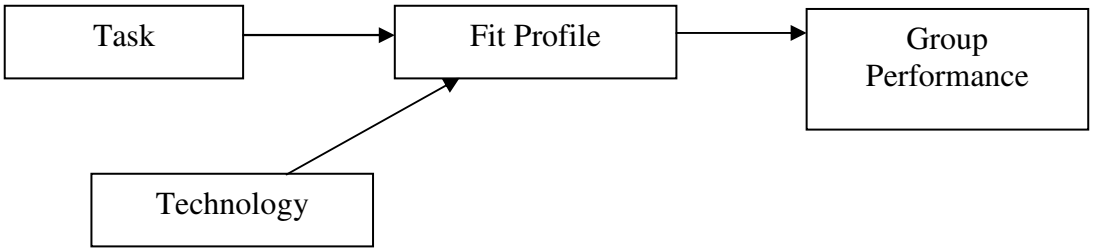


Figure 2. General model of task/technology fit theory (Zigurs and Buckland, 1998).

Summary

Researchers have used technology to attempt to address the problem of inefficient information aggregation in groups facing a hidden profile task. The results have shown that most GDSS do not provide net process gains and are generally ineffective. What is needed is a new decision making tool, specifically designed to maximize information aggregation, which can be used to complement other technological features. Anonymity, parallel communication, and a system memory, when combined with an information aggregation mechanism, might significantly improve group performance on hidden profile tasks by providing better "fit."

3. Relevant Literature on the Informational Efficiency of Markets

Markets have much in common with the hidden profile task. Markets consist of traders who possess both private and public information. Traders make decisions within the market context. Traders typically do not communicate directly, but there are information flows in a market. As discussed in the following section, prices aggregate information and transmit it to all the traders. Informational efficiency describes how well the market aggregates and transmits private information.

3.1 Market Efficiency

Adam Smith (1776) spoke of the "invisible hand" of markets allocating resources to their most efficient destinations. Smith observed that the self-interest of market participants ensures the greatest benefit to the whole society. This is known as allocation efficiency. Capitalists have long stated that markets are the most efficient mechanism at solving the economic problem: allocation of scarce resources. But how is this possible?

The most efficient allocation of scarce resources is a trivial logic problem *if* all possible information is known by a single intelligent entity (Hayek, 1945). The real problem is that this does not and *cannot* exist. No one person can ever know everything about every place at every moment of time. A market consisting of many individuals with limited knowledge produces the same results as an omniscient being. The allocative efficiency of the market is really due to the informational efficiency of the price mechanism. A system that can quickly communicate all relevant knowledge to all interested parties in a parsimonious manner is pure genius. The market mechanism is just that. A market participant can observe the price signal from the market and automatically

know how to adjust resources without need for any other information. The price communicates only the essential information. To know what time it is, one does not have to know how the gears in a clock work, but rather only where the hands are positioned. Likewise, to know how many widgets to produce, one does not need to understand why demand has shifted, but rather only look at the price as a proxy for demand. The market mechanism allows for an optimal solution to be obtained through the interactions of individuals with only partial information. Hayek's work (or the Hayek hypothesis) laid the foundation for the efficient market hypothesis and he won the Nobel Prize in 1974 "for [his] pioneering work in the theory of money and economic fluctuations" (Nobel Foundation, 2004).

The informational efficiency of markets has been categorized into weak, semi-strong, and strong forms (Fama, 1970). Weak form efficiency only includes historical price data as the information set. This also includes the random walk theory as a more precise model. Random walk theory predicts that prices move randomly around their historical prices. Prices should form a pattern of a normal distribution with a mean of the prior day's closing price. Semi-strong form efficiency includes historical prices and all publicly available information. Prices "fully reflect" historical prices and adjust when new public information becomes available. Strong form efficiency includes historical prices, public information and private information. Prices "fully reflect" all the information that exists and adjust immediately when new information arises, regardless of whether it is private or public. As of 1970, (experimental economics was not established yet) the empirical evidence overwhelmingly supported weak and semi-strong form efficiencies. There were mixed results with respect to strong form efficiency.

Some insiders seem to be able to use their private information to make more profit and arbitrage opportunities do exist; however, prices eventually converge and the typical investor cannot acquire private information that is worth anything. The strong form should be used as an ideal that is not realistic or practical. It can never be realized, but it is useful to understand how much information is contained in the price. Fama (1991) presents a "sequel" to his 1970 work and twenty years of research provide more support for the efficient market hypothesis. Anomalies found in the literature are also addressed (Fama, 1998). Most anomalies are results of methodology, metrics, and analysis. The Hayek and efficient market hypotheses explain why "economists find that orange juice futures predict the weather more accurately than even the National Weather Service in spite of all its … resources" (Ray, 1997).

Modeling informational efficiency

Prices are shown to have two distinct functions: to aggregate information and transmit or convey information (Grossman 1976, 1981; Grossman and Stiglitz 1976, 1980). Transmission implies that uninformed traders can gain information from informed traders through the price signal. Aggregation implies that the price can reflect the complete information set even if individual traders only have partial information.

Grossman and Stiglitz (1976) make an interesting prediction. They say "it would not be surprising if information increases the variance of prices … everyone is better off if no one is informed than if all are informed." Assuming that people are risk averse, an increase in variability brings an increase in uncertainty, which lowers utility. This is

extremely relevant in the information age of the Internet where so much information is available to so many and prices seem more volatile than ever.

Rational expectation theory says that the current price is the best predictor of future price. If traders believe that prices will go down in the future, prices should go down now. The potential future drives the actual present. Not only do traders have to worry about what they know, but they also have to worry about what others believe. Forecasting becomes more complicated and more important. Coupled with the concepts of information aggregation and information transmission, a rational expectation equilibrium (REE) exists such that the current price reflects the aggregate future expectation of prices (Grossman, 1981). The REE price assumes strong form informational efficiency. Initially traders have asymmetric information, which means that each trader has only partial information that is different from the other traders. Trading begins with only this private information as an input into the traders' decisions. Eventually the price becomes public information. The price is a sufficient aggregate statistic representing all the private information that has been incorporated into the formation of the price. It is like the private information goes into the price and then the price transmits this information to everybody. The equilibrium that is reached is "as if each trader had all of the economy's information" (Grossman, 1981) and they all agree on the future.

3.2 Establishment of Experimental Economics

The establishment of experimental economics opened a floodgate for testing the efficient market hypothesis. All of the papers mentioned above deal with mathematics

and statistics and rely on assumptions and economic generalizations. Experimental economics deals with real people and real, albeit simple, markets. This can actually improve the ability to understand the complexities (and assumptions) that traditional economics is concerned with (Smith, 1982).

An early study found many problems and little support for the efficient market hypothesis – its title: "An Experimental *Imperfect* Market" (Chamberlin, 1948). This casts some doubt on theory and/or methodology; however, the devil is in the details. This study used multiple parties conducting bilateral searches and negotiations. Many trades were extra-marginal, in that they were away from the market price. This highlighted irrationality and differences in negotiating skills rather than market competition.

Another market was also examined; a double auction system with a centralized public display including the best bid, best offer, and last trade price (Smith, 1962). Double auction markets typically include multiple buyers and multiple sellers. Buyers announce their bidding price and sellers announce their asking price. The bids and asks are saved and posted by a central authority, buyers and sellers do not communicate with each other directly. When a bid and an ask match, a trade is executed. In these markets, marginal traders effectively set the price because the central authority ensures that only the best bid and best ask can trade. The centralized public display board ensures that the prices and trade information is public information. The double auction system supported the efficient market hypothesis. These studies highlight the importance that market structure has on efficiency. They also set a precedent to use the double auction system in refining the REE model. Double auction markets have been widely researched and, in general, show support for REE. It has been suggested that the market structure of a

double auction system is more responsible for efficiency than rational traders (Gode and Sunder, 1993). Typical trading periods are very short (about four minutes), ample cash is given to allow for trading that is not restrictive, and short sales are not allowed or are discouraged (so that bankruptcy is less of a problem). All of the articles reviewed below use a double auction system unless otherwise noted.

Experimental economics proved that markets could be competitive and efficient with very small numbers of traders (Plott and Smith, 1978) and traders need not have perfect or complete information. REE prices have been achieved with four traders each having partial information (Plott and Sunder, 1988).

The REE (or perfect foresight equilibrium) has received much empirical support (Forsythe et al., 1982; Friedman et al., 1984; Copeland and Friedman, 1987, 1991, 1992; Plott and Sunder, 1982, 1988; Forsythe and Lundholm, 1990; Camerer and Weigelt, 1991; Sunder, 1992). Prices adjust to REE prices and profits of insiders (those with accurate information about the final state) are not significantly different from those with no information. This strengthens the notion that price aggregates and transmits information. While pure theoretical strong form efficiency has been proven not to be possible in practice, the strong form model still outperforms the semi-strong form models, as actual prices approach theoretical strong form efficiency equilibrium prices.

Refining theory

An exception is found in one particular type of experiment (Plott and Sunder, 1988). The condition involves a single asset that represents three states and different classes of traders. The security has different values to different traders based on what the

final condition is determined to be. REE was supported with two modifications. One modification is to only have one class of traders so that all traders have uniform payouts. This condition supports REE. Another modification is to use a complete set of state contingent claims or Arrow-Debreu securities instead of a single security. For three states (X, Y, Z), there would be three securities (x, y, z). If the final state is Y, certificate y is worth 100 and all other certificates are worthless. This condition supports REE. There are two factors that are jointly sufficient to "fix" the above anomaly: "trading experience and common knowledge of payoffs" (Forsythe and Lundholm, 1990). Taken together these factors adjust the original condition that failed (for Plott and Sunder, 1988) back to the REE, but either one alone does not. Once a trader has trading experience and knowledge of all the different classes of trader's payoffs, the REE is achieved. This is achieved by having multiple sessions. Each participant has a chance to trade in the role of every class of trader. The results achieved REE prices on the second day of trading, but not on the first day of trading.

Price might not be the key factor in the dissemination of information. It has been suggested that bids and asks are the first and most important part of information transmission (Plott and Sunder 1982, 1988). Technically the price of a security is the last trade that actually happened. Bids and asks happen before trades do. Suppose an insider knows that the security he is holding is worthless. He might ask a low price for it, say $1. Just from the low ask price a non-insider might deduce that the security is worthless. Here no trade has occurred and no price has been made public; however, information has been disseminated through the asking price. Another relevant source of information is who is acting. In the above example the first person to act was the insider since he has

information, while the non-insider is too uncertain to act. The fact that any action was made initially might signal that the initial actor is an insider. For the contingent claims (Arrow-Debreu) market two actions have been shown to occur with significance. The initial action will be a "sell" of the worthless security and the first action in the market that has worth will be a "buy". These are other ways in which important information can be transmitted.

The above has some potential implications in the design of the market. Bids can be publicly announced or privately negotiated. Just the highest bid and lowest offer can be public or the entire set of bids and offers can be public. Bids and offers can be displayed in real-time or delayed. Bids and offers can be anonymous or identifying. Real-time double auctions can be used or call auctions can be implemented. Basically the above suggests that various market microstructures be researched within a double auction system.

An interesting model states that under certain conditions, individuals with asymmetric private information will converge to a consensus if a sufficient aggregate statistic is made public (McKelvey and Page, 1984, 1986). In other words, if traders with initially different beliefs about the future, trade in a market with the price being public information, then eventually REE will be achieved and a consensus will be formed about the likelihood of future states. Their model has been used for market settings, but perhaps more interestingly it has been applied on a group using a Delphi process (McKelvey and Page, 1984). A theorem has been derived from the model proving that "observation of an aggregate leads to common knowledge" given some assumptions regarding rationality and probabilities (Nielsen et al., 1990). Common knowledge means

that everybody knows something, and everybody knows that everybody knows it. Common knowledge is concept that is related to REE The model is a Bayesian learning model. A subject starts with private information and forms a belief. Then an aggregate of the entire group is made public. The new information is incorporated and the subject forms a new belief. The model states that the entire group should pool their information together and reach a consensus quickly. When testing the mathematical theories with actual human subjects, some inconsistencies have been found (McKelvey and Page, 1990). Actual behavior is less informationally efficient than the theory states. It takes much longer to agree and sometimes consensus is not reached, but information aggregation does occur to some degree. This is similar to some findings in GDSS research.

Many mathematical and statistical methods of pooling subjective probabilities have been reviewed and compared with a market mechanism (Pennock and Wellman (1997, 2001). Markets serve the same function as other methods of aggregating opinions, given some assumptions. Markets aggregate information and handle appropriate weightings by design. Proper incentives encourage honest revelation of beliefs. Equilibrium prices are equivalent to mathematical opinion pooling. Belief aggregation is conceptually similar yet different than information aggregation. Opinions are really a subset of private information, but they are perhaps the internal evaluation and aggregation of private information. In that respect, opinions might be the most relevant private information. It is suggested that there are applications that can benefit from markets' abilities to pool opinions.

Markets are essentially different from previously developed groupware tools that allow voting and polling because markets participants can appreciate not only the actions of others but also their level of confidence and change their own actions and opinions in an interactive setting. 'Investing' large amounts of money or buying large quantities of securities signals a conviction in an alternative that other group members can perceive. This helps all group members identify confident members and can lead groups to make better decisions. In an empirical investigation of this concept, a simple market mechanism was used for the simple task of achieving consensus on an unknown fact (Bloomfield et al. 1996). For example, a group would have to agree on an estimate of "what percent of electrical power in France was derived from nuclear power in 1992" (Bloomfield et al. 1996). The market mechanism allowed the group to perform as well as the most accurate group member and significantly better than the average individual (Bloomfield et al. 1996).

Isolating experimental factors

There are several factors that have been shown to affect informational efficiency. The number of traders might have an effect. In general markets are assumed to be more efficient with more participants, but experimental economics has shown that even with small numbers of traders competitive markets can be achieved. The question is then how small is small. A market with six traders has better informational efficiency than a market with four traders (Forsythe and Lundholm, 1990). REE prices are achieved with six traders where others have failed with four.

Computer-mediated markets were suggested to aid in the reduction of trader confusion (by possibly notifying a trader of an obviously bad order) and to help avoid

information overload (by possibly storing relevant information) (Friedman et al., 1984). Results of oral markets and computerized markets are very similar so market setting has not been a relevant factor (Copeland and Friedman, 1987; Sunder, 1992). Most early systems merely automated the trading process and offered little if any advanced features such as real-time charts, order book displays, technical analysis capabilities, etc. DeJong et al. (1992) studied the differences between oral markets and computerized markets. While there are some statistical differences (how long it takes to achieve equilibrium, trader mistakes, etc), both markets demonstrate adherence to the REE model. DeJong et al.'s computerized market is an extreme example. It has no identifying features of who is trading. Traders are physically isolated and the only source of information is the best bid/ask and the last trade price.

3.3 Artificial Markets

Markets have been shown to be informationally efficient in real capital markets and in experimental asset markets under laboratory conditions. A case is made for the relevance and implications of the efficient market phenomenon (Plott, 2000). It has been shown that a) markets can aggregate information; b) prices can disseminate information; and c) markets can solve problems where no one trader has enough information alone to solve the problem. Most importantly this makes markets a powerful and valuable tool. This knowledge helped give rise to various markets that attempt to explicitly harness informational efficiency.

Information aggregation markets are field implementations of experimental markets that are not capital markets. Markets have been established to predict political

events, scientific breakthroughs, sporting events, and the levels of sales for various products. They are known by many names (information markets, knowledge markets, artificial markets, idea futures, opinion markets, prediction markets, forecasting markets, decision markets, and virtual stock markets) and come in several forms. Market microstructure differs slightly between the various markets. The majorities resemble the markets described above (continuous double auction with Arrow-Debreu securities); all are computerized, and most are Web-based. One important similarity among these markets is that the goal of each market is to predict something in the future. The difference between these prediction markets and traditional laboratory markets is that outcomes are not abstract (X, Y, Z), but rather real; Gore winning the popular vote, number of PC's sold in a quarter, discovery of a new atomic element before 2010, the Yankees winning the World Series next year, etc.

A driving force behind the popularity and success of these markets is the Internet. Computerization and automation of markets allow them to constantly remain open and be free of physical restraints. Many interested parties can trade in a virtual environment for profit or for fun with just an Internet connection. It can be looked upon as a type of gambling and many non-U.S. companies have "cashed-in" on this phenomenon by opening websites trading on sporting events. The accurate predictions of these markets lend more support to the efficient market and Hayek hypotheses.

Most prediction markets consistently make accurate predictions (Forsythe et al., 1992; Forsythe et al., 1999; Pennock et al., 2001a; Pennock et al., 2001b; Spann and Skiera, 2003). Market predictions are often more accurate than alternatives, such as

polling or single expert predictions, in both the short-term and long-term (Berg et al., 2003).

Potential decision-making applications

An innovative incentive-based market mechanism has been designed for a peer review system (Vragov and Levine, 2004). Coupled with electronic distribution, journals and editors could theoretically be eliminated. The "review market" system would replace the editor's decision-making responsibilities and provide many other beneficial features. Market data could be used to judge the quality of reviewers and articles. The system would promote objectivity, speed, and quality through proper alignment of incentives and use of technology.

An argument is made for "decision markets" based on the same theoretical concepts as Idea Futures (Hanson, 1999). These markets help evaluate the potential future outcomes for particular decisions. These are *conditional* prediction markets in that they begin with something that has not happened yet and predict outcomes assuming that it will happen. The prediction market is conditional upon the given state. Once quantified into market prices it becomes easy to choose the best alternative. An appropriate use for these markets would be to trade on issues that policy makers are debating. For example, gun control. The market could predict burglaries, murders, and government revenues given various gun control measures. Predicted statistics are conditional on the policy given for each particular market. Policy makers could look at market results as an input to their decision-making.

Instead of elected officials or governmental policy makers they suggest that any decision maker can use markets to make better decisions (Berg and Rietz, 2003). A good way to use the power of markets is to establish markets with both traditional predictions and conditional predictions. An example is the United States 2004 elections especially concerning Democrats (they use the 1996 elections concerning Republicans). Traditional prediction markets can be set up to predict the winner of the Democratic primaries. Conditional prediction markets can be set up to predict outcomes assuming a particular Democratic nominee. The conditional prediction markets can be set up with the current top three nominees versus Bush. For instance the traditional prediction markets might show that Dean should win the primaries followed by Lieberman. The conditional prediction markets might show that if the election were Dean vs. Bush, Bush would win and if it were Lieberman vs. Bush, Lieberman would win. If we assume the prediction markets are accurate and the Democratic Party takes no actions, they will ultimately lose. Dean will win the primaries, but lose the general election. Instead the party can try to convince Dean to drop out and endorse Lieberman. The markets suggest that if Lieberman were the Democratic nominee, the Democrats would win the White House. Prediction market insight can suggest the appropriate actions to take to achieve desired results.

The accuracy and power of markets allows them to be used as forecasting tools by business organizations (Spann and Skiera, 2003). Corporations have much more flexibility than public web sites. While the government heavily regulates gambling and markets that are open to the general public, corporations have leeway in deciding bonuses and creating internal markets (Hanson, 1999). Business procedures such as quotas and

politics can make collecting honest information from those that have it complicated. With proper incentives a market can solicit and aggregate this important and potentially valuable data. Hewlett-Packard (HP) established a prediction market to forecast sales (Plott and Chen, 2002). Market participants were actual salesmen (thought to have the best information). The market forecasts were compared to the internal official HP forecasts (created by back office personnel) and were found to be significantly better overall. The market was more accurate 75% of the time.

4. Hypotheses development

The literature review has provided us with a theoretical background which allows us to formulate several hypotheses.

4.1 Group Performance

The single largest factor for success in a group decision-making process is the task (Zigurs and Buckland, 1998). Hidden profile tasks are unique in many ways, but one obvious characteristic is that two important things must occur in the group; communication and processing. It is not enough to just list of all the clues, and its not enough for one person to silently figure out the correct answer. Clearly communication is important in all group meetings, but for a hidden profile task, the important factors (pre-discussion information distribution, information load, and implicational clarity) (Stasser and Titus, 1987) revolve around having and processing information correctly. Also these important factors all have to do with the cognitive difficulty of the task and the Human Information Processing theory (Rao and Jarvenpaa, 1991) shows how humans can be limited by their cognitive abilities and could benefit from support.

Technological support effects

Recall the various "levels" of GDSS (DeSanctis and Gallupe, 1987). With GDSS in general and with this type of task in particular, a large number of studies have been carried out that incorporate level one type of systems. The results have been less than encouraging for hidden profile tasks. It seems that a level one system is not enough. Level two systems involve more than just communications support and should result in better performance. To be more specific, the task/technology fit theory suggests that an

appropriate fit between technological support and the task type will maximize performance. Furthermore it prescribes the levels of the types of support for given tasks (Zigurs and Buckland 1998). Zigurs and Buckland (1998) categorize every task. They then prescribe an appropriate mix of technological support in one of three areas: communication, information processing, and group process. According to their model, the hidden profile task should benefit from high levels of communication and high levels of information processing support. This follows because to solve this type of task, clues need to be communicated to members of the group and need to be pieced together (processed) correctly. This task involves communication *and* information processing (as opposed to tasks such as brainstorming, which are mainly communication tasks). The task/technology fit theory prescribes two types of support, which correspond to a level two type system. Both frameworks lead us in the same direction.

Taking all the above into consideration we can formulate our first hypothesis:

H1: In hidden profile tasks, group performance when groups have both communication and information processing support will be higher than when groups have communication support only.

Information aggregation required level effects

Information distribution is one of the key factors for this type of task (Stasser and Titus, 1987). There are many types of distributions and they can vary some properties of the task. For example the level of difficulty of the task (saliency and complexity) will be altered based on how much information is shared. Also different information distributions will affect the interactions within the group because of the number of of group members with shared information and the number of group members with similar

biases. The level of conflict in the group can be manipulated by adjusting the information distribution. Group dynamics shifting due to task properties being manipulated reflects the fact that none of the three major aspects of GDSS (the group, the task, and the system) are easily isolated (Benbunan-Fich, 1997). Here we develop a concept called "information aggregation level" that involves the interaction between the group and the task. By manipulating this property of the task, different group dynamics will exist.

We consider information distribution to be a proxy for the information aggregation level required of the group. Groups are required to exchange, integrate, synthesize and aggregate different amounts of information, in different ways. There can essentially be different levels of how 'hidden' a hidden profile task can be and thus how difficult it will be to solve.

Group interactions involve social concepts such as peer pressure and mutual enhancement (Wittenbaum et al., 1999). The number of people that are biased in the wrong direction will greatly impact the group decision-making process and ultimately the outcome. There is an inherent bias which favors the majority (Stasser and Titus, 1985). Again social reasons help explain this (Wittenbaum and Stasser, 1998). The level of conflict will be affected by how many participants favor each answer. This can be a good thing (minority influence theory) (Nemeth, 1986) or a bad thing (Nemeth et al., 1990) depending on group dynamics.

The number of people with different types of clues is also important. The information aggregation level will be impacted by how many people have unique information and how many have shared information (Chernyshenko et al., 2003). Shared

information is more likely to be stated and repeated, but unshared information is the only valuable information (Larson et al., 1996; Winquist and Larson, 1998).

An example of a high level of information aggregation required would be where no member is initially biased to the correct answer. Here a lot of information needs to be aggregated and processed, with many members who are required to change their minds, to solve the task. An example of a low level of information aggregation required would be where a majority initially favors the correct solution or a majority of the group has the full case. Here few people would be required to change their initial belief and there would be a greater proportion of shared, critical clues.

Our second hypothesis refers to the level of information aggregation required of the group and the expected impact on group performance.

H2: Group performance is inversely related to the level of information aggregation required in order to solve the task. Group performance will increase from low to high as the information aggregation required decreases from high to low.

Interaction effects

H1 suggests that having communication and information processing support will result in better performance. H2 suggests that having a low information aggregation requirement will result in better performance. As both H1 and H2 deal with aspects of group performance, we can further hypothesize and develop H3.

H3a: Group performance will be the highest when groups have both communication and information processing support with low information aggregation requirements.

H3b: Group performance will be the lowest when groups have only communication support with high information aggregation requirements.

4.2 Group perceptions of the process

Technological support effects

Whenever additional technological support is added or changed in a group decision-making process there is potential for process gains, as well as, process losses (Nunamaker et al., 1991). It has been suggested that computer support yields a net process loss (Straus, 1996). When compared to face to face groups, computer-mediated groups have been found to be less satisfied with the decision-making process, less satisfied with the actual decision (Mennecke and Valacich, 1998) and also found to be less satisfied with the interaction process (Warkentin et al., 1997). The system supports the decision-making process and it is an important factor when considering the group's perceptions of the process. We *add* information processing support by providing additional tools and more technology. These tools might be even more unfamiliar than communication support tools. This newness and possible difficulty might impact the group's perceptions of the system (and the process) in a negative manner, as seen in other research using new technology (Daft and Lengel, 1986). Also by having more tools, more technology, and more information, group members could suffer from information overload, thus negatively impacting their perceptions of the system and the process.

With respect to the hidden profile task, information processing support should help the group realize many members are wrong initially, as explained in the performance hypotheses. The information processing support might emphasize the conflict within the group and increase their dislike of the system, by providing a better view of the group's situation. Also recall that in order for a hidden profile task to be solved, some group members must doubt their initial impressions and reverse their initial incorrect beliefs

(Stasser and Titus, 1985). This is a difficult and unsatisfying experience (Wittenbaum et al., 1999) and should happen more often as explained H1. Adding certain technologies can change the decision-making process itself, as well as alter the usability of the system. Taking these together (new technology and better group awareness) we can formulate our fourth hypothesis:

> *H4: In hidden profile tasks, group perceptions of the process when groups have both communication and information processing support will be worse than when groups have communication support only.*

Information aggregation required level effects

By altering the level of information aggregation there could be a different decision-making process at work. The level of information aggregation required is in some sense a measure of how difficult the case is given the initial information distribution. Higher levels of information aggregation required can be considered more difficult cases and require groups to work harder to overcome higher levels of conflict as explained above in H2. This should lead to a worse perception of the decision-making process.

Keeping technological support constant, group perceptions of the process will be influenced by how many people have to change their initial impressions for the group to be correct. A high information aggregation requirement level requires more group members to change their initial impression. Since the number of people that have to reverse their initial belief is a direct reflection of the information aggregation requirements and it is an unsatisfying experience (Wittenbaum et al., 1999) we can formulate our fifth hypothesis:

H5: Group perceptions of the process are inversely related to the level of information aggregation required in order to solve the task. Group perceptions of the process will increase from low to high as the information aggregation required decreases from high to low.

Interaction effects

H4 suggests that having only communication support will result in better perceptions of the process. H5 suggests that having a low information aggregation requirement will result in better perceptions of the process. Taken together we can derive H6.

H6a: Group perceptions of the process will be the highest when groups have only communication support with low information aggregation requirements.
H6b: Group perceptions of the process will be the lowest when groups have both communication and information processing support with high information aggregation requirements.

Our final research model is presented in Figure 3.

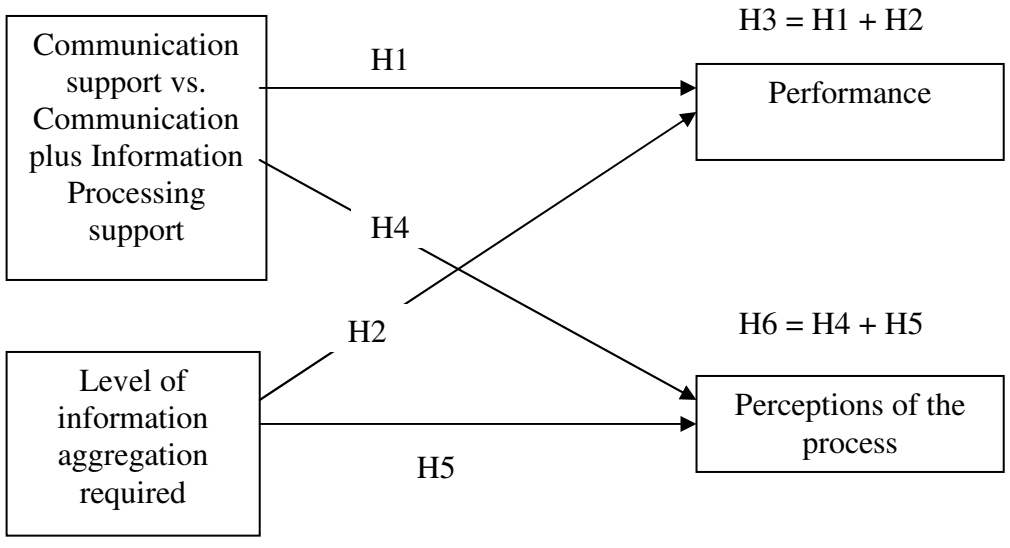


Figure 3. Experimental Model.

5. Methodology

Task Specifics

We obtained the classic "murder mystery" hidden profile task from Prof. Stasser; however, being Business/Information Systems people, we did not feel that it was particularly relevant. We wrote up an entirely new case that also has only one logical conclusion (see Appendix A). Prof. Stasser's murder mystery is a dialogue of interviews with suspects. It has elaborate maps and timelines and is quite rich and lengthy. His is designed only to be split into a majority/minority setup. Ours contains simple statements of facts only, which is relatively short. Ours can (and needed to) be distributed in multiple ways.

Our task involves a cyber-security crime. A corporate network has been broken into and some files have been stolen. There are three suspects: an insider, a competitor, and a known hacker. The case has a set of clues with one set incriminating the guilty party. The remainder of the clues also contain subsets that eliminate the possibility of the innocent suspects committing the crime. This provides us with several versions that create a bias towards implicating the 'wrong' suspect and one version which creates a bias implicating the 'right' suspect. This effort provided us with a relevant case that had only one correct answer out of three choices, and was complex enough to be broken up in a variety of ways to cause a bias (right or wrong) in individual readers while having all the clues available within the group.

Technological Support

In prior studies, results of oral markets and computerized markets are very similar thus market setting has not been a relevant factor (Copeland and Friedman, 1987; Sunder, 1992). Also there has been virtually no difference found between face-to-face and computer-mediated groups for this task (Zigurs et al. 1988; Dennis 1996; Hightower and Sayeed 1996; Hollingshead 1996; Warkentin et al. 1997; Dennis et al. 1998; Mennecke and Valacich 1998). This is why our experimental design does not involve any face-to-face groups.

We use two technology tools in order to operationalize technological support structures. For communication support, we use synchronous computer-mediated communication (chat) that allows parallel communication, a group display, and anonymity (see Appendix B). Our system is consistent with the literature in its effort to provide communication support. It is a java applet that has a one line input, with a large text area to see all the comments in the system. It is scrollable to be able to see the entire session's chat comments. It operates in real-time and all chats are identified by the author's ID, which is provided by us. Our chat retains all the features that many computer-mediated systems use: system memory, parallel communication, and anonymity. Anonymity should push the groups towards information influence and help them to solve the case (Kaplan, 1987).

We use an electronic continuous double auction market with automated order matching (e-market) to support the information processing function of the groups (see Appendix B). Much like the virtual prediction markets described in section 3.3, our market has stocks that represent suspects. At the end of the experiment, the correct

suspect is identified and holders of the corresponding stock receive a dividend, while the other stocks expire worthless. One way to profit is to discover 'whodunit' and buy those shares.

Both modules (chat and market) of the system were developed from scratch using a variety of java technologies. Both are essentially applets operating in a JSP-enabled webpage. This allows the system to be fully web-based so that experimental location is not an issue. Applets also allow the simulation of real-time interaction so that the users do not have to refresh their web page. The entire system is secured via password protected sessions and a login password that changes based on the session, experimental condition, and user. All messages (chat, trades, or trade executions) are recorded in a MySQL database. While not implemented here, this allows for asynchronous use, since prior data is pulled from the databases. The system is integrated with online surveys throughout the experiment. The system uses the database entries on the server to ensure that sessions only start when all the members are ready. This is necessary for accurate timing of the experiment, but it can cause some members to wait and some groups to move faster than others through the survey portions. The market is the more complicated of the two modules with orders, trades, and portfolios constantly updating. The market rules are similar to NASDAQ with the exception of a "no short-selling" rule. All current information about the market is displayed to the trader (user), but historical data is not available market-wide (a trader can see their own trading history only). Our market uses evidence from the literature in an attempt to maximize informational efficiency. The double auction mechanism using Arrow-Debreu securities has the most support for informational efficiency. It has been suggested that bids and asks are the first and most

important part of information transmission (Plott and Sunder 1982, 1988). This is why our software displays the entire order book (see Appendix B).

The literature above demonstrates the powerful information aggregation properties of asset markets (Forsythe et al. 1982; Friedman et al. 1984; Copeland and Friedman 1987, 1991, 1992; Plott and Sunder 1982, 1988; Forsythe and Lundholm 1990; Camerer and Weigelt 1991; Sunder 1992). This can also serve as information processing support especially considering the confidence signaling aspects of bids and asks. Despite the well-known information aggregation properties of markets, to our knowledge, they have never been implemented as a small group decision-making tool. As the literature reveals, there has been much research on communication support and some research on process structuring, but none on technological information processing support for this task. According to the task/technology fit theory, adding a market to a chat mechanism should provide better fit for the hidden profile task (Zigurs and Buckland 1998). This should in turn improve group performance. When both chat and markets are present, groups have both communication and information processing support, which should result in significant improvements in performance.

Information Aggregation Requirement

We rely on the information distribution to operationalize the information aggregation requirement level. The majority/minority distribution condition essentially requires enough information aggregation for the minority to overcome the majority's initial bias (as discussed in section 2). Our uniform condition establishes one half of the group initially favoring one incorrect solution and the other half initially favoring another

incorrect solution. In this uniform condition the entire group must aggregate enough information so that every member changes their initial bias. The majority/minority distribution requires less information aggregation because there are some members whom are initially correct, while the incorrect uniform condition has no members that are initially correct. The majority/minority distribution represents a medium level and the incorrect uniform distribution represents a high level of information aggregation requirements.

Experimental design

The experimental design involves two factors: technological support structure and information aggregation requirement level. We employ two kinds of technological support structures: communication support only (synchronous computer-mediated or chat), and communication and information processing support (chat and a market). We have two levels of information aggregation required: medium (minority/majority) and high (incorrect uniform). These two manipulations result in a 2 X 2 factorial design (Figure 4).

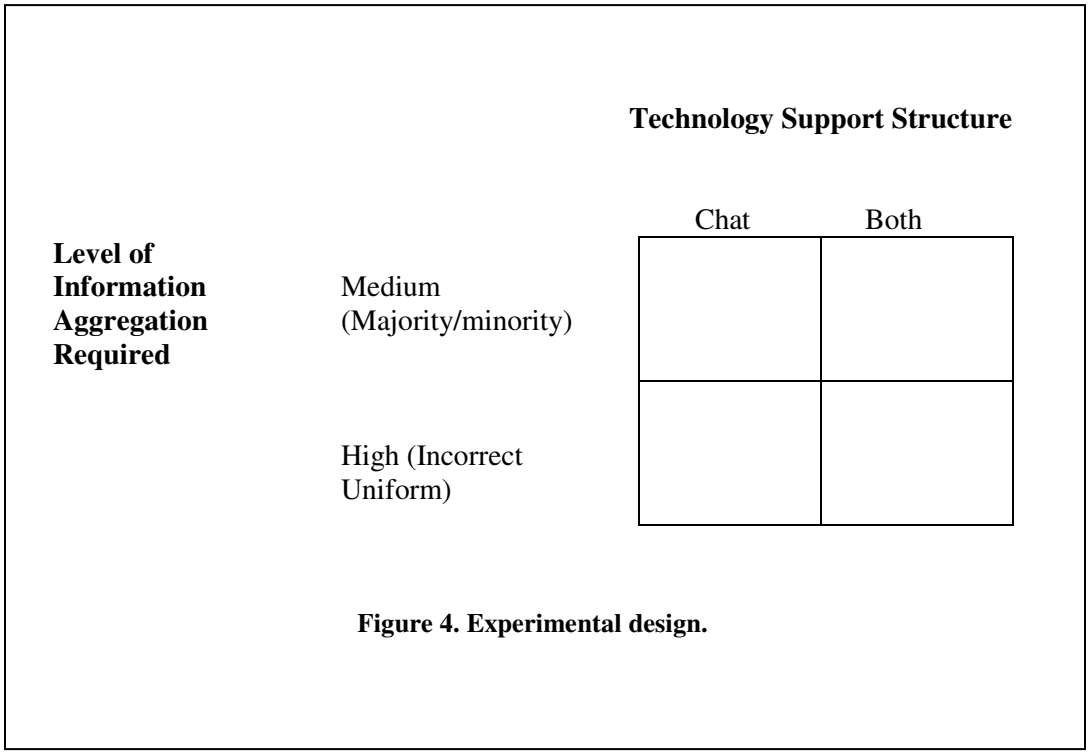


Figure 4. Experimental design.

Measurements

We have two dependent variables: group performance and group perceptions of the process. There is more than one way to measure both of these. For performance there are two categories; efficiency and effectiveness. Efficiency can be measured by any of the following:

- number of clues discussed
- number of critical clues discussed
- number of repeated clues
- number of trades
- length of time to reach decision.

Our system is fully computerized and has captured much data, which can be analyzed for efficiency; however, our hypotheses deal directly with effectiveness.

Effectiveness involves two concepts: degree of agreement or degree of correctness. Consensus is a goal of many group decision-making meetings; however, we do not make it a requirement. Rather we measure individual responses and measure the degree of agreement within the group (Dickson et al. 1993). If the all the members of the group agree and there is unanimity (6, 0, 0), then the group has a high level of agreement. If the group members are evenly split among the three possible choices (2, 2, 2), then the group has a low level of agreement. Since the hidden profile task has a correct answer, we also measure the degree of correctness of the group. If all the group members choose the correct answer, then the group has a high degree of correctness. If all the group members choose the incorrect answer, then the group has a low degree of correctness. Notice that these can be opposite within the same group decision; for example having a group that totally agrees on the wrong answer (high consensus, low correctness). Both of these measurements are derived from the same source: individual decisions. The individual decisions are aggregated to measure both group agreement and group correctness.

Group perceptions of the process can be measured with questions involving the process directly, but also with other non-direct questions. Group dynamics and the system used are integral parts of the decision-making process and as such provide a means to measure the group perceptions of the process. The system enables the process to occur and the process is a group one involving interactions with other participants. We measure all of these and they provide us with an in-depth look at group perceptions of the process.

There are 3 questionnaires (see Appendix D). The first is a general demographic questionnaire, and it also collects data on prior experience with technology and financial

concepts. The second is a pre-meeting questionnaire. This captures the initial impressions of each member and checks for the correct initial bias. It can also be used to examine any changes of beliefs and/or confidence when combined with the post-meeting questionnaire. The last questionnaire is a post-meeting questionnaire. It duplicates the pre-meeting questionnaire and also captures satisfaction and fit perceptions.

All of our measures are on self-reported survey instruments filled out by individuals independently; however, for proper analysis we need group measurements. For performance, individuals were asked to choose an answer to the case. They are either wrong or right. We can aggregate these individual responses to get a group performance measure. The group receives a score equal to the number of correct individuals in the group. This results in a number ranging from 0 (none correct) to 6 (all correct).

Training

Participants were recruited and randomly assigned to groups, which were randomly assigned to conditions. Instructions and training were given to all participants (see Appendix C) as follows:

- 'Chat' groups are able to type anything they want into the system (see Appendix B, "Chat screen"). Once the user clicks the 'Send' button or hits enter, their comment is visible to all the members of the group. However, there is no way for a member to chat with a member privately or one-to-one. Members are able to see the comment and the author's ID. Questions and comments can be directed to specific member by addressing this ID, but all members are able to see all the comments. This condition uses simple communication software and only requires

the subjects to type and read each others' comments while trying to reach a decision.

- The 'chat & market' groups essentially combine the above chat system with a market tool. The subjects are given an identical mock portfolio consisting of 5 "JOHN" stocks, 5 "NALI" stocks, 5 "ALEX" stocks, each representing the three possible suspects, and 2500 fake dollars or points. They were instructed on how to place various (buy or sell) orders. Simply clicking on a single button places a market order. Limit orders require the user to fill out a short web form and click on a submit button. Trades are posted with the IDs so that all members of the group can observe other members actions and possibly infer their beliefs. The ID is the same on both the chat and market areas so that members can correlate textual discussion with market behavior. This condition allows subjects to type and electronically chat while simultaneously allowing them to place trades in a simulated stock market.

Incentives

Traditionally market research provided individual performance incentives (Plott and Sunder 1988), while small group research provided uniform compensation (Dennis 1996). Our research implements and depends on proper incentive alignment to increase performance by combining elements of both research areas' (GDSS and experimental economics) participant compensation methods. Groups that perceive the task as important perform better (Larson et al., 1994) and our incentive system is designed to make solving the task more important than simply participating.

Each participant received a $5 gratuity for participating in this experiment for every condition with the possibility of more based on his or her overall performance.

- Under the 'chat' condition, an additional $5 was distributed to all members in a group that correctly (by majority) identified the solution and an additional $5 was distributed to individuals who correctly identified the solution (regardless of the group decision). Individual decisions were recorded with a post-condition questionnaire and group decisions were based on a majority rule. The total amount of compensation for an individual participating under a chat condition was between $5 and $15.
- Under the 'chat & market' condition, there is an individual and group component. The individual component was calculated as follows: participants were ranked by total portfolio value. A scale was used to determine the appropriate payment. The scale runs from $0 to $7 with the average being $3. The individual earnings have nothing to do with the survey question about the guilty party. It comes from their market performance (including how many guilty suspect stocks they hold). The group component is equal to the individual component, if the group is correct. In other words, if the group is correct, a trader receives double their individual earnings. If the group is incorrect, there is no group payout and a trader only receives their individual earnings. The determination of group correctness is identical to the 'chat' condition (it does deal with the survey question), where a majority of individuals must be correct for the group to be deemed correct. The total amount of compensation for an individual participating

under a chat condition was between $5 and $19 (although $19 is very difficult to get).

Experimental procedures

We chose to have 6 members per group. The reasoning is because 6 allows there to be a minimum of 2 people with any piece of information. This alleviates the problem of unique information that exists when information cannot be verified. Prior research has found that verifiable facts were accepted into discussion when mentioned, but unverifiable facts required two members advocating the facts as truth to be accepted into discussion (Parks and Cowlin, 1996). This suggests that unique information, given to only one member, that is not verifiable, will have little influence in the group discussion and outcome. Another reason comes from the economics literature; a market with six traders has better informational efficiency than a market with four traders (Forsythe and Lundholm, 1990). A final reason is that 6 is an even number and an even number needs to be chosen so that our incorrect uniform condition yields two subgroups with the same number of participants.

Our groups consisted of college students (mostly undergraduates) that were recruited using an IRB approved recruitment statement. The difficulty was that we needed groups of 6 or perfect multiples of 6. Obviously our groups were ad-hoc groups, and theoretically this is good since group history and group cohesion have been linked to poor information exchange and poor performance under a hidden profile task (Irving, 1972; Mennecke and Valacich, 1998).

Once the participants were seated, they were given a set of handouts. This included a consent form, simple instructions on how the experiment would be conducted, a detailed description of the incentive structure, and the actual case (all surveys were web-based). They were also given a login sheet, which contained their session, user ID, and password. They were then directed to our 'home page' for our experiment. On the 'home page' there are two links; one for training, and one for the real experiment. After clicking on training, the initial demographic questionnaire appeared on the screen. Once every group member finished that survey, the entire group would simultaneously be forwarded to the next page based on what condition they were in.

The 'chat only' groups had a page asking "How many U.S presidents had zero legitimate children?" Under this there were 3 choices (2, 4, and 6) (this is comparable to the pre-meeting questionnaire). Once every group member guessed they were all simultaneously forwarded to a practice meeting where the chat applet appeared and they could discuss the question (this is comparable to the meeting session). After 3 minutes, they were all automatically forwarded to a page that appeared to be identical to the 'question page' they saw before the chat session; however, this one stated that "now it counts" (this one is comparable to the post-meeting questionnaire). After all the member chose their final answers they were all forwarded to a 'results page' which stated "had this been the actual experiment, you would have received $(5, 10, or 15) because you were (right or wrong) and there (was or was not) a majority of the group correct."

The 'both' groups had a different type of training session. Before even using the system, the market applet was explained by the experiment conductor. The differences between limit orders and market orders, the portfolio setup and display, the 'no short-

selling' rule, the fact that only one dividend paying stock existed, why trading over the dividend amount was silly, and the incentive system was fully explained. Once they logged in under the training mode the first page they saw stated that there are three stocks with one paying a dividend and the other two worthless. Every trader had a clue though. Half the traders had a clue that "the dividend-paying stock was not B" and the other half had a clue that "the dividend-paying stock was not C". They were asked to guess which would be the dividend paying stock (comparable to the pre-meeting questionnaire). Once all the members of the group guessed, they were forwarded to the market applet only (the practice group session). Here they would trade on their information (where most traders would realize that the dividend-paying stock was A) for 5 minutes and then automatically get forwarded to the next page. Then they were asked again, which did they think was the dividend-paying stock (comparable to the post-meeting questionnaire). After all the group members responded, they were all forwarded to the results page where it displayed how much they would have received had this been the real session. Again this reward was based on their trading and whether or not there were a majority of group members choosing correctly the practice post-meeting questionnaire. It was noted that no one had perfect information, no communications outside the market had occurred, yet many members knew the correct answer. It was explained that this was because of information flows in the market and market efficiency.

At this point the training was complete and they could then click a link which would bring them back to the home page. At the home page they would then click on the 'real' link, which would have them login again. This time the page said please read the case first (by now the appropriate case was handed to them). When they were done

reading they would run through a similar process to the training mode they went through. They filled out the pre-meeting questionnaire, then the group would participate in the meeting (either chat only or chat and market), then they would fill out post-meeting questionnaire. The major differences between the real and training modes were that the real mode had a 20 minute time limit for the group session and the questionnaires were much longer. Once the result screen would appear, they would remain seated with the screen visible, so that we could come around and distribute the payouts for participation. Throughout the entire session an experiment conductor was present to answer questions and guide the session. This person was the only person to fulfill this roll for all the groups to ensure consistency.

Pilot studies

Even before the IT portions of our system were completed, we began pilot testing our case. The initial version read like a transcript of interrogations and interviews with the suspects and a detective. Lessons learned were how far we could push the technical jargon without confusing or alienating students. We added a technical glossary shortly after the first tests. Items identified were student's bias to the insider being guilty, student's not paying attention to the timeline, and other fine points regarding clues. This led us to keep revising the story in an effort to better define the initial biases. Full version cases were also used to ensure the solvability of the entire case.

Technical pilot testing initially occurred independent of the case, where students volunteered to look for bugs and chat about anything or make improbable trades to see if

the system held up. Bugs were fixed regarding lost data, confusing survey choices, bad links, as well as many others.

Eventually pilot testing occurred with the case together with the system and with incentives being given out. An important lesson learned was that reading the case took too long. The case was then converted to a 'clue statement only' and the dialogue was eliminated. This meant that we had to re-pilot test the case and see if it was still solvable. The final version of the case was readable in a much shorter amount of time. The software only had one 'crash' after pilot testing was complete. Pilot/bug testing lasted several months and probably included about as many students as the 'live' experiment did, but it greatly improved our case, our technology, and our methods.

6. Results

After pilot testing, 54 groups consisting of 324 individuals participated in our experiment. Three groups had a technical bug, which resulted in unusable data. This results in useable data of 51 groups and 306 individuals. The breakdown by condition was as follows: 13 groups in the 'majority/minority'-'chat' condition, 11 groups in the 'majority/minority'-'both' condition, 14 groups in the 'incorrect uniform'-'chat' condition, and 13 groups in the 'incorrect uniform'-'both' condition (Figure 5).

		Technology Support Structure	
		Chat	Both
Level of Information Aggregation Required	Medium (Majority/minority)	13 groups 78 members	11 groups 66 members
	High (Incorrect Uniform)	14 groups 84 members	13 groups 78 members

Figure 5. Experimental design with useable Ns.

Uniform groups

Recall that the first survey was a demographic and background information survey. At this point there had been no group interaction and most participants did not even know who was in their group; therefore, this data is analyzed at the individual level.

The entire purpose is to ensure or control for, similar groups of participants. Most of the variables had no statistically significant differences leading us to the conclusion of similar groups across conditions (see Appendix E for N's, means, standard deviations, and significance values for variables from the initial questionnaire). One statistically significant variable from the Initial survey was question 1, which asked about the degree pursued by the student. There were very few graduate students so the different types of graduate students (MBA, MS) caused a statistically significant finding. The variable was then reduced to strictly undergraduate and graduate choices, which resulted in no statistically significant differences across conditions. Another statistically significant variable, which could not be 'corrected', was gender. It is only statistically significant as an interaction effect (.029). 'chat'-'incorrect uniform' groups have a larger proportion of females, while 'both'-'incorrect uniform' groups have a larger proportion of males. This study does not use the gender factor in its theoretical foundations, so while interesting to note, we will not explore this factor further. The final statistically significant variable from the initial survey is question 22, which asks if gambling is exciting. This variable is statistically significant only at the information aggregation level (.028) with 'incorrect uniform' groups being slightly more excited by gambling than 'majority/minority' groups. This variable might have an impact if it was significant at the technology level, but it is not, so we feel it is possibly a random statistical artifact that has no real bearing on our experiment results. We feel that we successfully implemented randomized ad-hoc groups, which resulted in conditions having similar demographics.

Data analysis

We have a 2X2 factorial design which lends itself nicely to analysis using ANOVAs. All of our pre-meeting data analysis (initial demographics survey and pre-meeting survey) was conducted with traditional standard ANOVAs; however, post-meeting data should be treated differently. All of our hypotheses deal with post-meeting results, so this is very relevant for hypothesis testing. Because we are concerned with group results (as opposed to individual results) and group interaction has taken place and possibly influenced the group, we should not analyze at the individual level. The dilemma is that our data is collected at the individual level with members working individually on their own survey while our analysis should be at the group level. This is a common statistical pit fall when conducting GDSS research (Walczuch and Watson, 2001). There are two valid methods to use individual data for a group-level analysis. One method consists of aggregating individual answers within groups and then performing a standard ANOVA. The other consists of using individual responses analyzed with a hierarchical ANOVA that uses the group as an error term (Walczuch and Watson, 2001). The group term in the modified hierarchical ANOVA has the added benefit of allowing us to determine the significance of the group dynamics during the group meeting. This is powerful as we do expect that the actual meeting influences the members of a group. Our preference is to use the modified HANOVA method; however, when data are nominal or binary (such as is an individual correct yes/no) then we must aggregate individual responses and use a standard ANOVA. For most measures we use the modified HANOVA; there are only two exceptions. For two performance measures

(group correctness, and group consensus level) we had to use the aggregation method with the standard ANOVA because the individual data is nominal.

The final post-meeting questionnaire has 51 questions (see Appendix D). The types of questions and data vary, but a majority of the survey questions deal with perceptions and have Likert scales. We recoded the answers to reflect high scores for positive perceptions (agreeing with a positive statement and disagreeing with a negative statement have high scores). A factor analysis was done to reduce the variables into underlying factors as many questions are related. Keeping factors with Eigen values of over 1, we were left with 13 factors. We then checked the reliability of these factors using Cronbach's alpha. Only six had alpha values greater than 0.7. We then examined the loadings to identify and name each remaining factor. We use a loading value of .4 in the rotated matrix to be the cutoff for loading. The first factor had loadings from questions dealing with the system being a hindrance, the system not having enough tools, feeling frustrated, having a bad meeting, the system being limited, having bad information, and having good group skills (questions 25, 39, 23, 38, 16, 31, and 43 respectively). Many of the questions deal with the system so we chose to name the first factor "IS quality". The second factor had loadings from questions dealing with reaching consensus, agreeing with a majority of the group, reconsideration, having good group skills, learning in the meeting, having a good information medium, being influenced by others, and having an effective meeting (questions 9, 35, 14, 43, 13, 11, 26, and 45, respectively). Many of the questions deal with group influence and considering many groups performed poorly, we chose to name the second factor "groupthink". The third factor had loadings from questions dealing with having a structured approach, conducting

a systematic analysis, having necessary skills, and satisfaction with the solution (questions 7, 10, 6, and 15, respectively). All of the questions have an individual focus and most deal with the solution so we chose to name the third factor "individual analysis". The fourth factor had loadings from questions dealing with the fairness of the case, fairness of the system, how fun the system was, how interesting the case was, learning from the experience, and the influence of others (questions 27, 28, 24, 8, 21, and 26, respectively). This factor seemed split between fairness and fun and also had a learning element so we chose to name the fourth factor "enjoyability". The fifth factor had loadings from questions dealing with having knowledge of others' conviction, having knowledge of others' knowledge, having an effective meeting, others' knowledge of member's feelings, and having good group skills (questions 44, 33, 45, 34, and 43, respectively). This factor dealt with knowledge sharing and a group understanding of its members so we chose to name the fifth factor "group awareness". The sixth factor had loadings from questions dealing with the difficulty of the case, the case being too difficult and having bad information (questions 5, 30, and 31, respectively). This factor dealt with the solvability of the case so we chose to name the sixth factor "case complexity". The variables making up each of these six factors were summed to created summated scores corresponding to these six factors. There were 19 variables that did not load to any of these factors so they will also be included in our analyses; questions 2, 12, 17, 18, 19, 20, 22, 29, 32, 36, 37, 40, 41, 42, 46, 47, 48, 49, and 50. Together, these 19 variables have a Cronbach's alpha of .701.

6.1 Hypothesis testing

Group performance

Recall that we had three hypotheses concerning group performance:

H1: In hidden profile tasks, group performance when groups have both communication and information processing support will be higher than when groups have communication support only.

H2: Group performance is inversely related to the level of information aggregation required in order to solve the task. Group performance will increase from low to high as the information aggregation required decreases from high to low.

H3a: Group performance will be the highest when groups have both communication and information processing support with low information aggregation requirements.
H3b: Group performance will be the lowest when groups have only communication support with high information aggregation requirements.

(See Appendix F for N's, means, standard deviations, and significance values for performance variables). We measure group performance by aggregating individual data to figure out how many people in the group were correct. This number will range from 0 – 6. This individual data is binary data (correct/not correct) so we could not use the modified hierarchical ANOVA. It is in fact this number that determined a portion of the rewards the participants received, recall that if this number is 4 or greater it means that a majority of the group was correct and the participants would enjoy an additional financial reward. We found no statically significant difference across groups (.246 for interaction effect, .084 for information aggregation main effect, .776 for technological support main effect). Group performance is not affected by the type of technological support structures that we used or by the level of information aggregation that we implemented. We do not find support for H1, H2, or H3.

An alternate measurement that can be used as a proxy for performance is how much is 'bet' on the guilty suspect and/or the other suspects. A hypothetical question is asked of the participants regarding how much they would bet on each suspect given $100. This really combines solution choice (suspect) with solution confidence (how big the bet is), so it is not as direct as the above measurement. We use the modified hierarchical ANOVA with individual members' bet amounts to test for statistically significant differences. We only find a statistically significant group effect (.000) for every suspect, but no interaction or main effects due to our test conditions. This means that the group interaction does impact how much the group bets on each suspect. Again we see that group dynamics do play a key role in how well the group performs, but we do not find support for H1, H2, or H3.

Group perceptions of the process

Recall that we had three hypotheses concerning group performance:

H4: In hidden profile tasks, group perceptions of the process when groups have both communication and information processing support will be worse than when groups have communication support only.

H5: Group perceptions of the process are inversely related to the level of information aggregation required in order to solve the task. Group perceptions of the process will increase from low to high as the information aggregation required decreases from high to low.

H6a: Group perceptions of the process will be the highest when groups have only communication support with low information aggregation requirements.
H6b: Group perceptions of the process will be the lowest when groups have both communication and information processing support with high information aggregation requirements.

The group perceptions of the process hypotheses are tested with data from the perception questions on the post-meeting survey. Once the factor analysis was complete we could look for differences across groups (see Appendix G for N's, means, standard deviations, and significance values for perception factors/variables). There is an interaction between the system, the group, and the task, when considering the process, since the decision-making process involves aspects of all three. All of our post-meeting perception measures deal with process perceptions, group interaction perceptions, task perceptions, or system perceptions. The group and the system allow a computer-mediated group decision-making process to occur. And the task is one of the most important variables concerning the group decision-making process (Zigurs and Buckland, 1998). The factors and questions measure the individual's perception of the process, either directly, indirectly via the system, or indirectly via group interactions. When these factors and variables are used in conjunction with the modified hierarchical ANOVA we can measure and test the group's perceptions of the process.

The first thing we must consider is whether the error or group term is statistically significant. The group term is statistically significant for "groupthink" (.003), "group awareness" (.014), being motivated by money (q.18, .000), being stubborn (q.32, .041), and having enough information (q.40, .005). This suggests that the group process, group dynamics, and/or personal interactions within the group are relevant for these factors and variables. Group members have an influence on each other when it comes to these factors. This demonstrates that the actual group meeting is not meaningless and individual members are being affected by group dynamics with regards to these factors.

Next we must consider the interaction effects between our two test conditions. There is only one statistically significant interaction effect; the variable dealing with being a leader (q.36, .035). The 'both'-'incorrect uniform' group has the lowest score (less leaders) while the 'chat'-'incorrect uniform' group has the highest score. This suggests that for the 'both' condition, the 'majority/minority' group felt they were leaders more than the 'incorrect uniform' group, but for the 'chat' condition the opposite was true. This finding supports H6b, but not H6a.

There is only one statistically significant main effect due to the level of information aggregation required; the variable dealing with frequency of expression (q.49, .031). The 'majority/minority' group has a higher score (more frequent) than the 'incorrect uniform' group. That means that the 'majority/minority' group felt they were able to express their views more often than the 'incorrect uniform' group. This suggests a greater perception for this variable by the 'majority/minority' group, and provides support for H5.

When looking for main effects due to type of technological support, we find many statistically significant differences. As one might expect, some of them deal with the system being used, but others are not directly related to technology. "Groupthink" (.001), "individual analysis" (.048), "group awareness" (.000), honesty (q.12, .000), valuing others' opinion (q.22, .001), being a leader (q.36, .015 [this question also has an interaction effect as mentioned above, which takes precedence]), being able to influence (q.37, .009), having enough information (q.40, .039), system being distracting (q.46, .001), and perception of intimacy (q.50, .006). Again, all the answers have been recoded to make higher scores correspond with better perceptions. The 'both' group has a lower

score than the ‘chat’ group for every factor and variable that had a statistically significant finding. This means that the ‘both’ group had a worse perception than the ‘chat’ group for all the above factors and variables. Specifically it means the ‘both’ group could not connect as well as a group and suffered more from the technology (distracting, less intimate, etc). As a result, the ‘both’ group has a worse perception of their process than the ‘chat’ group. This finding supports H4.

While we do not have a statistically significant finding for every factor and variable tested, we believe we have enough to show support for H4. H5 has only one statistically significant finding and as such we only have partial support for H5. H6 has a statistically significant finding but it is only partially as hypothesized (supports only H6b). By combining the findings regarding H4 and H5, we have some support for H6, but no direct full support. None of the statistically significant findings are opposite of our hypotheses. Either we found support or we found no statistically significant differences.

Other findings

One measure sometimes used as a proxy for group performance is the amount of consensus within each group. We have two methods for evaluating the level of consensus within a group. Both methods result in each group having a single number that derives from aggregating individual data. The first method aggregates individual data and counts the number of group members agreeing with each other for each suspect choice. The maximum is assigned to the group and it represents the largest number of people that agree on a choice. So if everybody agrees and there is total consensus it meant that 6 people where in agreement. Other consensus options include the perfect

split, with 2 people for each choice and an uneven balance. An uneven balance example might be 3 for choice A, 2 for choice B, and 1 for choice C. This would result in a consensus score of 3 (it is the highest number of agreement). Scores in any group of 6 people have to range from 2 – 6. The analysis shows that there is a statistically significant difference across the technology support manipulation (.019) (see Appendix H for N's, means, standard deviations, and significance values for this consensus variable). 'Chat' groups have a higher level of consensus than 'both' groups have (4.5 people vs. 3.8 people).

The second method is an entropy measure as described by information theory (Shannon and Weaver, 1949). Entropy is a measure of disorder in a system and we can apply it to the individual decisions in our group. Perfect unanimity (6, 0, 0) would result in the lowest level of entropy (0) since there is no disorder when it comes to the member of the group choosing the answer. Maximum entropy (1) occurs when there is a perfect split (2, 2, 2) of choices within the group. By aggregating the individual choices we can calculate an entropy score for the decision of the group (see Figure 6).

$$H(X) = -\sum_{x \in \mathcal{X}} p(x) \log_b p(x).$$

Figure 6. Formula for entropy where p(x) is the probability of choosing a given suspect based on the suspect voting distribution of the group.

After we calculated each group's entropy score, we ran an ANOVA to check for difference across experimental conditions (see Appendix H for N's, means, standard deviations, and significance values for this entropy variable). There were no statistically significant differences, but the difference associated with type of technological support did approach statistical significance (.052). This finding mirrors the above consensus measurement, but the statistical significance is not present. This could be due to entropy being constrained to between 0 and 1 and our limited number of possible outcomes effectively constraining it to between 0 and .5.

Keep in mind that consensus can be viewed in a positive light or in a negative light. One viewpoint is that the goal of a group is to come to a unanimous decision, while others value correctness over conformity and in fact value conflict if it ultimately leads to the right solution; quick agreement on a poor decision is not good. We value correctness over consensus and as such we chose not to use these measures for testing our performance related hypotheses.

After reading the case, but before any interaction occurred, the participants filled out the pre-meeting questionnaire. This questionnaire yielded only one variable with a statistically significant difference (see Appendix I for N's, means, standard deviations, and significance values for variables from the pre-meeting questionnaire). Question seven asks about the level of difficulty of the case. There is no interaction effect (.319), but there is a statistically significant difference with regards to the information aggregation level (.018). The 'majority/minority' individuals find the case slightly more difficult than the 'incorrect uniform' individuals.

7. Discussions

Perception measures discussed

A statistically significant interaction effect was found for being a leader; the 'both' condition, the 'majority/minority' group felt they were leaders more than the 'incorrect uniform' group, but for the 'chat' condition the opposite was true. If we take a look at the 'chat' condition (and we remember that we have many failures) we can imagine that the majority is simply taking charge and leading the group in the wrong direction. Since the case and the distribution are not as straightforward in the 'incorrect uniform' condition, leadership becomes suppressed (as evidenced by a lower score for the leader question). With the market added in, we can say that it is somewhat harder for the majority to keep chatting and take charge because of the added features (and less chat comments too); however, the market does add value for some key members of the uniform group. The first member to realize there is a split might ask the group about this, which might be considered a leader-like step. Also the first person that trades on the 'third choice' (correct one) should feel like they led the rest of the group. So there really exists an interaction effect in both of these factors that requires a look at the combination of experimental conditions. Our possible explanations are not meant to be definitive, but rather an educated guess that derives from our experiences with conducting these experiments.

The statistically significant process perception differences due to technological support main effects present an interesting view of technology. We see three reasons that might explain these findings; the difficulty of the market, cheap talk, and media richness.

They can be considered individually, but we believe they all have a role and should be considered together.

Our experiment has an advanced market with very little training time. This results in a complicated, stressful, hectic system as compared to the familiar chat room. There is also a time-limit imposed which could be adding to the pressure. Also remember that our incentive structures for the two systems are slightly different. In the 'chat' situation it is a right or wrong individual incentive; however, when the market is added in, the individual incentive becomes a performance reward. This too adds some pressure to constantly be doing well in the market. This might be causing participants to be less systematic, to feel that they do not have the appropriate skills, not be structured, and to be less satisfied with their decision. These are all the variables that contribute to the "individual analysis" factor and might explain why the 'both' group have a lower score than the 'chat' group.

Honesty and valuing other's opinion are conceptually linked. If members of a group are not being honest, or if one knows they themselves are not being honest, then there is less value from what others say. Comments are taken with a grain of salt when there is no trust in their truthfulness. In a market setting this is referred to as cheap talk and it occurs from traders realizing that a strategy exists to maximize individual rewards by not being completely honest and/or completely transparent when it came to their information (Farrell and Rabin, 1996). Even though our incentive system attempts to reward individual effort *and* group effort, every market rewards reliable private information. Being dishonest in a market setting does have potential rewards. When all the traders know this, they tend to not value others' opinions. This behavior would come

at the expense of the group reward (via group performance), but some members might not have wanted to put their fate and/or trust in the other members of their group. This helps us understand why 'both' groups have lower scores for honesty and valuing others' opinion.

When considering media richness the connection between technology and social interaction becomes clearer. A clear signal with perfect feedback and many cues maximizes understanding across the channel. A richer medium allows the sender and the receiver to feel closer by providing a better virtual link. Media richness theory discusses cues and feedback. Remember, our 'both' system only adds a market; it does not take anything away. So from a purely abstract perspective we have added available cues, and the information flows in the market (especially when there is a trade) do provide some fast feedback; however, what seems to be missing from the equation is that real people are using these systems. Humans have limited cognitive abilities, have typing/input speed limits, and require training to adequately use all the features of a system. There are systems that are too complicated and unfamiliar to be used to their fullest potential. What we have seen in our experiment is that adding features and cues, runs the risk of having a system that is too complicated to be used to its fullest potential. Also humans can usually only focus and interact in one mode at a time. By adding the market we reduce the emphasis on textual communication as evidenced by the reduction in chat comments. Its not as if we retain the same level of chat comments and add market transactions, instead we reduce the use of textual communications. If we consider "real media richness" as the interaction of "ideal media richness" and the actual time spent interacting with that medium, and we consider our 'both' system to be consisting of two media (lean – market,

rich – chat) then we are effectively reducing the media richness by adding and using the market mechanism. This richness reduction affects the social aspects of the group and helps us understand the lower scores for the 'both' groups in "groupthink", "group awareness", being able to influence, having enough information, the system being distracting, and perception of intimacy.

We believe that taken together, a complicated system, cheap talk, and media richness might address the statistically significant difference in process perceptions due to the technological support condition. Cheap talk and a complicated system should result in fewer comments being entered into the system. Cheap talk and reduced media richness should result in the value and clarity of the messages being reduced. A complicated system and reduced media richness should result in the understanding of the messages being reduced. Also markets tend to promote competition rather than cooperation and this might result in a perceived shift to the individual away from the group, which does not promote group cohesion. Together these help to explain how technology has a social effect and why our 'both' group has lower scores for all the factors/variables mentioned above. It is interesting to note that in addition to perceptions, these phenomena should affect performance. By shifting the group away from cooperation and information exchange, which is critical for a hidden profile task, we would expect a poorer performance from the 'both' group; however, this is not the result we find. This is probably a disconnect between an effective system in terms of performance and participants perceptions of that system. This disconnect is seen in many GDSS studies where computer-mediated groups perform better, but their perceptions of the computer-mediated system are worse.

Perception non-findings

The hypothesis testing (reported in section 6.1) highlights the statistically significant findings from the perception measurements; however, several factors and variables show no statistically significant difference. Recall that the perception hypotheses include a total of 6 factors and 19 other variables that were tested. For H4, 3 factors and 7 variables show support. The following are the non-statistically significant findings: "IS quality" (.546), "enjoyability" (.510), "case complexity" (.435), confidence level (q.2, .133), effort (q.17, .160), motivated by money (q.18, .166), not caring about one's self (q.19, .102), not caring about one's group (q.20, .332), level of anonymity (q.29, .462), being stubborn (q.32, .718), having too much information (q.41, .790), system having sufficient tools (q.42, .916), system constraining (q.47, .119), suffering from information overload (q.48, .213), and frequency of expression (q.49, .411). Many of these deal with technology *directly*, which makes this non-finding so interesting. It raises an important question: Why do some factors and variables like "IS quality", system tools, and the system being constraining, not show statistically significant differences across technological support groups?

The only direct technological difference that was statistically significant was the frequency of being distracted by the system, with 'both' groups being distracted more often. We were expecting the 'both' group to complain more about the system. It seems that the process introduced of buying and selling alternatives to figure out the solution to the problem is more important than the system details. The statistically significant

findings emphasize information flow and problem understanding over system limitations and complications. It might be that the process of chatting and the process of trading in a market are so different that details of the system become less important. To emphasize this, an effect size analysis was run on all the post-meeting perceptions (see Appendix G). The "IS quality" factor has a partial ETA squared for the technological support condition effect of .007, while "groupthink" is .216 and "group awareness" is .282. We believe that this demonstrates that practical significance lies more in the functionality of the process that the technology supports and less in the details of how it's implemented. In other words, supporting innovative group processes (like a virtual market) might be more important than marginally increasing the effectiveness of traditional group processes (like verbal communication).

As we have seen before, no one area of a GDSS exists in isolation from the other areas. The findings and non-findings emphasize that technology has a social effect. The type of technological support can affect group characteristics, group dynamics, and the decision-making process.

Experimental conditions affecting group performance

The above findings are interesting in their own right, but much was learned through conducting the experiments. Our experiences and other findings can shed more light and provide relevant discussions of lessons learned. One of the most important facts to keep in mind is that all the post-meeting data analyses are conducted at the group level and as such we only have 51 observations across a 2 X 2 factorial design. Another interesting note regarding performance is that our task and its information distribution,

results in a very difficult case. We have an overall failure rate of about 77% which is higher than the range in the literature of 40% – 70%. This might help explain some of our performance results. Also interesting, but not statistically significant, is the finding that 'both' groups do slightly better than 'chat' groups and 'incorrect uniform' groups do a little better than 'majority/minority' groups (almost significant, it is close at .084). Also interesting with regards to performance and information aggregation required levels is the finding noted above (last paragraph of section 6) about predicting the difficulty of the case, before meeting with the group. The pre-meeting question seems to accurately predict performance based on how difficult the case is. It could be that as the case was being dissected for the various information aggregation levels, the level of clarity became different. This clearly should impact performance. An alternate explanation might be a self-fulfilling prophecy notion. Perhaps the pre-meeting setup seems harder to the 'majority/minority' groups, and maybe those groups do not give it as much effort because they feel the case is unsolvable. Since they essentially give up before even discussing things they perform worse. We do not find a difference in effort across groups with different information aggregation required levels, so either the self-fulfilling prophecy explanation is wrong (and the 'majority/minority' case is really harder) or the participants are not confessing to giving up. It could also be both; the majority/minority case is difficult and the incentive and the setting in which the data was collected were not enough to motivate students to conscientiously participate but due to social desirability issues associated with questionnaire responses, no participant admitted to giving up and not trying their best.

We would also like to note how our experiment differs from a majority of the experiments in the literature. Generally groups are asked to come up with a group decision or agree that they are deadlocked. Time is not a constraint and the group meetings are open-ended. If a group agrees that they are deadlocked, that group will not be used in the analysis. Our experiment is time constrained. The group has a maximum of 20 minutes (they never actually report a group decision; rather we aggregate their individual decision and use a majority-rule to determine group correctness). Several studies report average times to reach a group decision. For computer-mediated groups (all of ours are) the reported average times are 24.5 minutes (Lam and Schaubroek, 2000), 24.45 minutes (Dennis, 1996), and 23.25 minutes (Hollingshead, 1996). This means that many groups spend more than 20 minutes to come up with a group decision. Ours have a maximum of 20 minutes and our 'both' groups have many more tasks to accomplish than just communicate (which is all the literature groups have to do). This could be an important performance consideration and a content analysis specifically looking for comments about time and/or time until group decisions will shed light on this issue. This is another reason why content analysis is an important future study.

Group meeting

The group meetings all lasted 20 minutes. While not directly addressing any hypotheses, what happens in these sessions is interesting and insightful. Easiest to see and explain is the amount of chatting that goes on (see Figure 7). The chat comment counts were tallied and the counts were analyzed using the modified HANOVA (see Appendix K for N's, means, standard deviations, and significance values for chat

comment counts). There are statistically significant findings for the group term (.016), a main effect from technology support (.000), and a main effect from information aggregation requirement (.049). There was no statistically significant interaction effect (.318). This means that both of our experimental conditions affect the amount of chat comments. Assuming that there is consistency across groups when it comes to non-experiment chat, this means that there is a difference between groups concerning the amount of information exchanged via the chat mechanism. This is another interesting finding as the amount of information exchanged should be linked to performance. It is also evidence for information flows within a market setting as 'both' groups chat much less, but do not perform worse.

		Technology Support Structure	
		Chat	Both
Level of Information Aggregation Required	Medium (Majority/minority)	2399 comments 30.8 per member 184.5 per group	1013 comments 15.3 per member 92.1 per group
	High (Incorrect Uniform)	3274 comments 39.0 per member 233.9 per group	1402 comments 18.0 per member 107.8 per group

Figure 7. Comments per experimental condition.

The biggest difference is between the technology conditions. 'Chat' has a total across all groups of 5673 comments entered into the system. The 'both' condition has a

total across all groups of 2415. There are more groups in the 'chat' condition, but we can get an average per group to directly compare. With 27 'chat' groups, there were about 210 comments per group. With 24 'both' groups, there were about 101 comments per

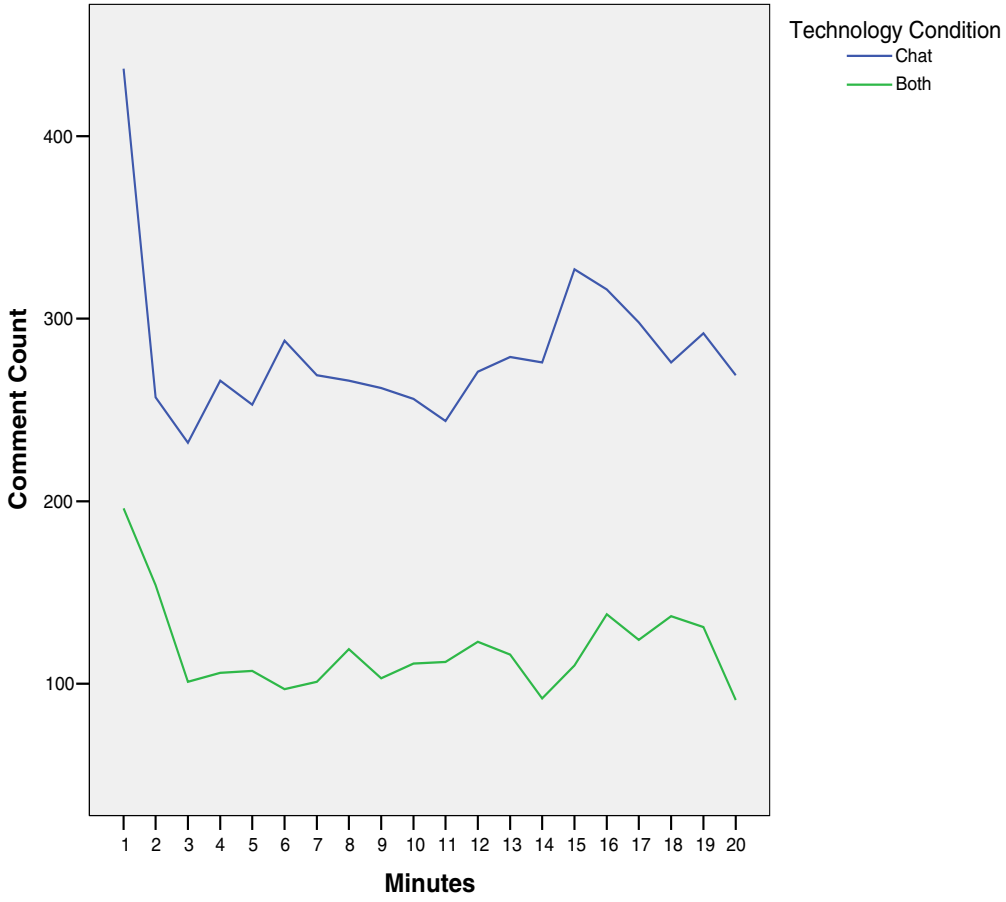


Figure 8. Chat comments over time by technology support condition.

complex market while simultaneously chatting. Plotted over time (see Figure 8), nothing major stands out, besides the volume differences mentioned above.

Important observation: This does have relevance though when considering information flow. If the market cannot or does not transmit information, and information could only flow through communications using textural language, then we would expect the 'both' condition to perform worse than the 'chat' condition; however, (as we will see in more detail) this is not true. This reinforces the theory that information does flow in a market. Our case represents complex information in a small group setting and we have evidence for information flow in markets under these extreme conditions.

Interestingly when comparing chat messages across information aggregation conditions we also see a difference in the volume of chat messages. The 'incorrect uniform' condition has a total across all groups of 4676 comments entered into the system. The 'majority/minority' condition has a total across all groups of 3412. There are more groups in the 'incorrect uniform' condition, but again we can get an average per group to directly compare. With 27 'incorrect uniform' groups, there were about 173 comments per group. With 24 'majority/minority' groups, there were about 142 comments per group. Plotted over time, there are some subtle differences that might reflect the nature of the group discussions (see Figure 9).

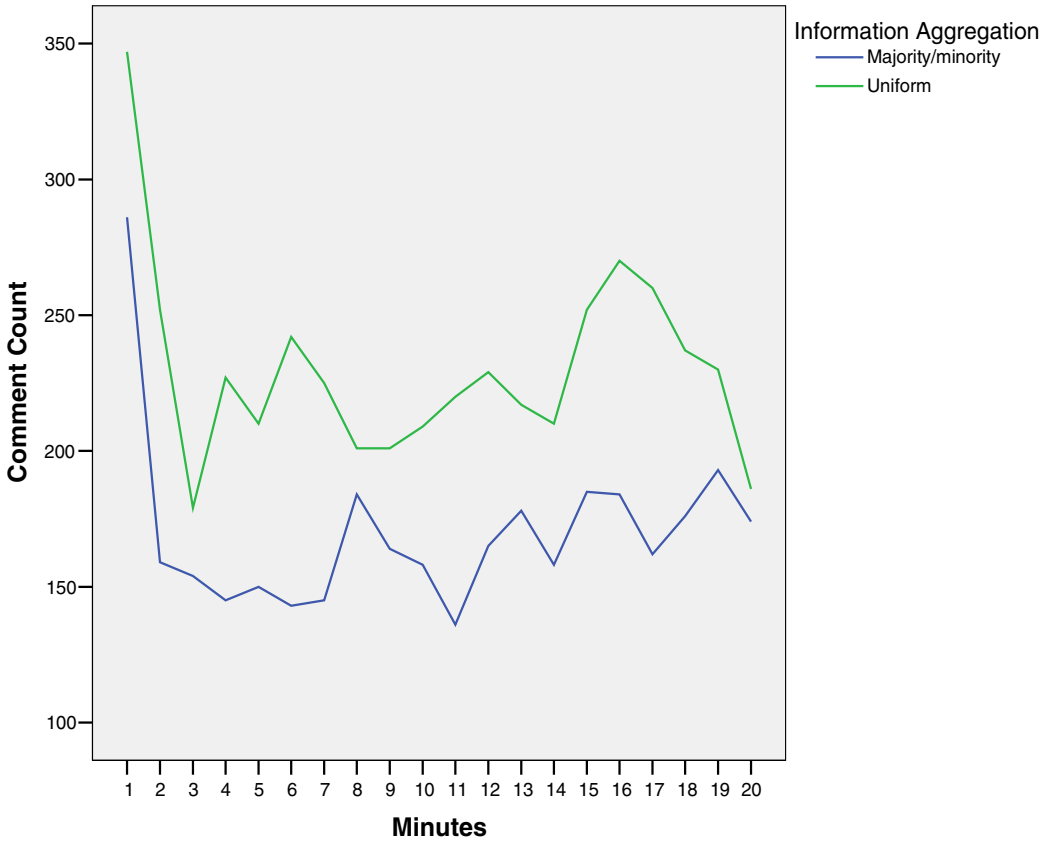


Figure 9. Chat comments over time by information aggregation level.

Important observation: This difference is not as drastic as the difference with regards to technology, but also not as easily explained. Here the only difference is the case and recall, the 'majority/minority' groups initially believed it would be more difficult, so we might expect them to talk more, but they do not. Without doing a full qualitative study to analyze the content of the messages, one can only speculate; however, there is one theory that helps. As mentioned in the literature review above (section 2.2), minority influence theory states that the conflict between the groups can be beneficial and can lead to careful examination of the alternatives and creative problem solving (Nemeth, 1986). Here the name of the theory is deceiving because we are applying it to the 'incorrect uniform' condition, not the 'majority/minority' condition. The theory evolved from majority/minority group interactions, but it really discusses the potential benefits of conflict in groups, specifically avoiding groupthink and encouraging discussion. Both of our information aggregation levels have some form of conflict, but the conflict levels differ. There is conflict in the 'minority/majority' condition but there is actually more conflict in the 'incorrect uniform' condition. There are two reasons for this. The first is pure numbers. Under the 'majority/minority' condition there is a 4 versus 2 setup, while under the 'incorrect uniform' condition there is an even 3 versus 3 setup. The other reason involves suspects. Under the 'majority/minority' condition the arguments revolve around one innocent suspect versus the guilty suspect or right versus wrong. Under the 'incorrect uniform' condition it starts out as one innocent suspect versus one innocent suspect, but can and should evolve into a choice of all 3 suspects when a member makes the connection between both sides' information. The higher level of conflict under the 'incorrect uniform' condition might be causing increased discussion

and evaluation of ideas and might ultimately help the 'incorrect uniform' groups outperform the 'majority/minority' groups. **NOTE:** This is contrary to some of our performance hypotheses. There is a discrepancy in the theory between informational difficulties being hard to overcome (information salience and information load; Stasser and Titus, 1987) and information difficulties causing conflict which can be good (minority influence theory; Nemeth, 1986). We thought our conditions would more likely match the pessimistic or negative view of informational difficulties, but perhaps we were wrong. With regards to comments over time, we would like to make another speculation. Many groups start with a vote to see where all the members stand. The time between 3 and 7 minutes might therefore be significant. In the 'majority/minority' groups this might be a period of reconsideration for the minority where they sit back and doubt themselves; however for the 'incorrect uniform' groups the conflict is equal and apparent so that both sides jump in to defend their viewpoint or question the other side. Again it remains speculation until a content analysis is conducted (which is beyond the scope of this study).

Important conjecture: Considering the above observations regarding chat frequencies, the small Ns at the group level, and also the performance data (no significant difference, but 'both' doing slightly better), we believe that we at least have evidence that information did flow through our markets and adding markets did not hurt group performance. The net effect of adding markets is either zero or too small to measure with a small number of groups.

Limitations

As previously discussed our data comes from ad-hoc inexperienced college students, so generalizability to the business world is difficult. While we strived for ad-hoc groups with no past history and perfect anonymity, this is hard to achieve in a college environment. Our small Ns at the group level make it hard to find significant differences and results in a low power for some of our statistical analyses. Our incentives were limited by our resources and might not have provided the motivation we intended (many college students in Manhattan do not value $5 like struggling PhD students do). Perhaps higher incentive levels yields higher motivation and performance levels. It would be nearly impossible for our pre-meeting biases to be 100% as intended. This is a limitation in itself, but it is compounded in group research. If the intent is to have an 'incorrect uniform' group with 3 group members on each side of the fence and one or two members are not biased as intended, it could affect the group dynamics. It could even cause an intended 'incorrect uniform' group to become a majority/minority group. This is difficult to control for. One way might be to have larger groups so that one person not going as intended becomes less significant. Of course this costs more because of rewards. Another way would be to group members after you test for their initial bias. This costs time and would probably only work if many participants were in a single room simultaneously. It is rare in the GDSS literature for this to be thoroughly checked. Despite these limitations we have learned a lot and believe there are valuable contributions in this study.

8. Contributions and conclusions

This study included a series of firsts (market with small group, new system, and new task) and in some sense it was exploratory. This research combines two distinct research areas to show that 1) they are perhaps closer than we originally thought and 2) we can use lessons from one to improve the other. This research represents the first time that markets are used as a small group decision-making tool. We have enhanced understanding of recent innovative prediction markets and uses of communications in other market settings. We have developed a technological artifact with our two (deployable as three distinct) systems. This robust system can be used synchronously or asynchronously. It can be used for 'real' decision-making. Actual organizations can use the system, or use lessons learned from the research to develop new approaches to decision-making. The system also has educational benefits when used in the classroom. We have also developed a case which has multiple versions allowing testing of the same case under different information distribution strategies. This research lays the foundation for many more studies and much future work.

While the majority of our hypotheses were not strongly supported, we have learned a great deal from this experiment. We cannot forget that our study analyzes data at the (correct) group level and it is hard to find statistical differences with these small Ns. The entire GDSS universe is difficult to study and there are many papers with no significant findings. Our market is also fairly complex and the majority of our participants did not even know how financial markets work, let alone limit orders, and a level two look at the order book. Our task is also complex and some technical jargon may intimidate some less tech savvy participants. Taking all this into account and

finding no negative effects due to the market mechanism is a testament to market efficiency and information flows in a market setting. We think this research also opens the door to using a market mechanism in small group decision-making. With a simpler task, a simpler market system, more market training, more time, or more groups, we would guess that the market would indeed be found to improve performance. As with most technology solutions there seem to be good and bad things and nothing highlights this more than our findings regarding the perceptions of the system. While more features are good, usability is always a concern.

Another potential way to increase the differences would be to use more extreme conditions. A natural extension of this work would be to look at groups that use only a market as technological support and groups that have the one of the lowest information aggregation requirements by having some members have the full case and others having no information. These extremes might highlight differences that might have been muffled by our choosing of 'medium' conditions. Our choices were theoretically driven by the Task-Technology Fit theory, but perhaps, market efficiency theories, communication theories, and/or media richness theories offer some better explanations of the phenomena at work here.

Future Work

An enormous amount of learning has taken place and we are much better prepared for future research. An immediate need for future work lies in a qualitative content analysis of the comments captured during this study. Types of information exchanged,

critical clues, time-pressures and other group interactions could shed valuable light on this type of group decision-making process.

The application of the efficient market hypothesis is yielding very accurate forecasts in prediction markets. Further studies might be able to increase our understanding in a variety of related areas: 1) information flow in a market, 2) individual, group, and market behavior, 3) rationality theories, 4) information theories including communications theory, and 5) market microstructure. New artificial markets are being created rapidly and seem to be doing a better job at solving problems than other traditional methods. Researchers now have data and methodologies to better understand the phenomena at hand.

There are opportunities for interdisciplinary studies involving markets and group decision-making. Markets are also groups of people making decisions, albeit individual decisions. Individual traders' decisions are based on prices others set and there is some interaction between traders (some markets even require bilateral negotiations). Markets have information aggregation properties without any formal communications. As noted above there are many more information distribution schemes and the market only technological support to be tested. There is of course the plethora of group factors that can be isolated and checked within a market or hybrid market-chat system such as gender, size, leadership, presence of facilitator, etc. There are also many different market structures that can be explored and tested as well as factors influencing market efficiency. Also our research, as well as others, questions the importance of incentives. This area seems to be lacking in the literature especially within GDSS.

We believe that the greatest contribution of this research is the merging of ideas from different disciplines that both try to explain human behavior. We hope that this opens the door to more interdisciplinary research in this exciting area.

Appendix A – Full version of our task

Disclaimer: All names and incidents are entirely fictitious. Any similarities to real entities are purely coincidental. The entire scenario is copyrighted by Levine.
The following is all classified information. Please do not reveal any clues or information to anybody outside your group or Levine. Thank you.
****

There has been a cyber crime; an electronic robbery; a hack. A preliminary investigation has limited the suspects to three individuals. Your team has been called in to help the District Attorney make their case against one of the 3 suspects.

The victim is Mr. Hanson, owner of decisionmarkets.com. He has developed some automated market-making algorithms that could revolutionize how electronic markets are used.

The suspects are Mr. Nali, John Donahue, and Alex Mansi.

Biographies:

Alex Mansi is a college student studying computer science; however, he is no ordinary student. At age 16 under the pseudonym nukez, he was suspected of breaking into various government servers and posting the classified documents online. He is also suspected of authoring several viruses and worms.

John Donahue works at Mr. Hanson's firm. He is head of the IT department and has worked for Mr. Hanson for 3 years. John's major responsibilities include managing the help desk, upgrades, backups and ordering hardware.

Mr. Nali owns giftcardoptions.com and is the direct competitor of Mr. Hanson. There has been a rivalry, bitter at times, between Mr. Hanson and Mr. Nali for the past 5 years. Together Mr. Hanson and Mr. Nali have eliminated all the other players in the industry.

Every statement was made under oath and should be considered truthful. Mr. Hanson should not be considered a suspect or "in on it". The FBI has determined that the act was probably done alone and the FBI does not think there is more than one guilty party. The FBI feels that the lead detective has collected sufficient evidence and there is no need to create "what if" scenarios.

The rest of this package contains notes/facts collected by the lead detective. They are roughly grouped by suspect. There is glossary of technical terms for your reference.

The detective's first meeting was with Hanson and John in Hanson's house.

Hanson thinks the stolen software could be worth a lot of money (billions).

The stolen software was on the corporate network, but also at Hanson's home computer.

Hanson has tracking software in his program.

The tracking software showed that only one copy was made so far.

A "guest" user was in the system around the time of the incident with the following IP address: 24.59.123.195. The logs show all the actions of this user.

After about 33 hours, the file was decrypted. The FBI was notified by Hanson via his notification software.

The tracking software showed that the file was decrypted without the key.

A wireless user gained "admin" access and privileges to the corporate network around the time of the incident. Their IP address was faked or spoofed so it is not easy to track.

Using a process of elimination and the available logs, the FBI has concluded that the software was stolen by the "admin" user. Because the actions of this user are not logged, the FBI knows nothing further.

An ATM camera shows Alex in his car, parked by Hanson's office, during the time of the incident.

Hanson closed the office for two days after the incident and told the college to shutdown the supercomputer, which they did.

A ransom caller tries to sell Hanson back his software. The voice is disguised. The caller asks for $5 million.

The ransom caller states that "Microsoft blows; crappy software."

Hanson is very happy with John as an employee and is always impressed by John's technical knowledge, especially because John has no computers in his house.

Hanson does not allow anyone else to do any computer programming at the office. John has expressed interest in programming and is upset that Hanson will not allow it.

The last thing Hanson was doing before the incident was using his wireless laptop. John told him he was going to be doing some maintenance, so he got off the wireless network and went home.

John describes the IT infrastructure at Hanson's office as follows: a few servers, a few PCs, all the major operating systems (Windows, Linux, Solaris), a standard network, a wireless network, and access to a powerful supercomputer that Hanson donated to a college.

John was doing maintenance at the time of the incident.

John claims that he is no expert, that the maintenance did not go smoothly, and holes might have been left open for a short while.

John was very surprised to learn of Hanson's tracking software.

John does not log any actions of the "admin" user. He claims only he and Hanson know the password.

Alex will only be interviewed with his lawyer present.

Alex claims that he can break into any network given enough time.

Alex has control of thousands of computers that are connected to the Internet, which can be very powerful if used together.

Wireless gear was found in Alex's car. Alex claims that the holidays are coming up and the wireless gear are gifts, albeit open gifts.

Alex is getting a new job at a bank.

Alex claims that Microsoft is a horrible company and Linux is a superior product.

Alex posts, then deletes the following message to his website: "$ I am about to get seriously paid $".

Nali often checks Hanson's website and noticed that it was down the morning after the incident.

Nali thinks that Hanson is trying to blame him because Nali has made a great computer programming job offer to John.

The IP address: 24.59.123.195 belongs to Nali.

Nali admits to being on the network via a hole on the website, but claims to have only looked around.

Nali was at Hanson's house a week before the incident and they discussed work a lot. Hanson was showing Nali some software but his Windows 95 PC froze and they never got to look at any specifics.

Nali admits to knowing Hanson was working on something big.

Nali admits to having some of the most powerful computers on the east coast.

Nali's office is 100% Microsoft Windows.

Network Security Glossary (some parts from www.webopedia.com)

Administrator (admin, system administrator) – A computer role that has unlimited privileges. Most operating systems control privileges based on users and their roles. This is the most powerful user.

Algorithm – A formula or set of steps for solving a particular problem.
Computer logs – A system of files that record various actions and information about the actor.

Decryption – The process of decoding data that has been encrypted. After decrypting, the data is easily readable.

Encryption – The translation of data into a secret code. Encryption is an effective way to achieve data security. To quickly read an encrypted file, you must have access to a secret key that enables you to decrypt it. There are "brute force" ways to unlock the code, but they require more time and computing power.

Firewall – A system designed to prevent unauthorized access to a network.

Hacker (cracker) – Individuals who gain unauthorized access to computer systems for the purpose of stealing and/or corrupting data.

IP Address – An identifier for a computer on a network. Messages are routed to their destination based on an IP address. Each message also contains the IP address of the sender.

IT – Information Technology

Key (encryption key) – A type of password that can encrypt and/or decrypt data using an encrypting system. The key is what is needed to easily break the code.

Network – A system of connections that allow computers to communicate with each other.

Operating System – The most important program that runs on a computer. Every computer must have an operating system to run other programs. Operating systems perform basic tasks, such as recognizing input from the keyboard, sending output to the screen, and keeping track of files. Some operating systems are also responsible for security, ensuring that unauthorized users do not access the system.

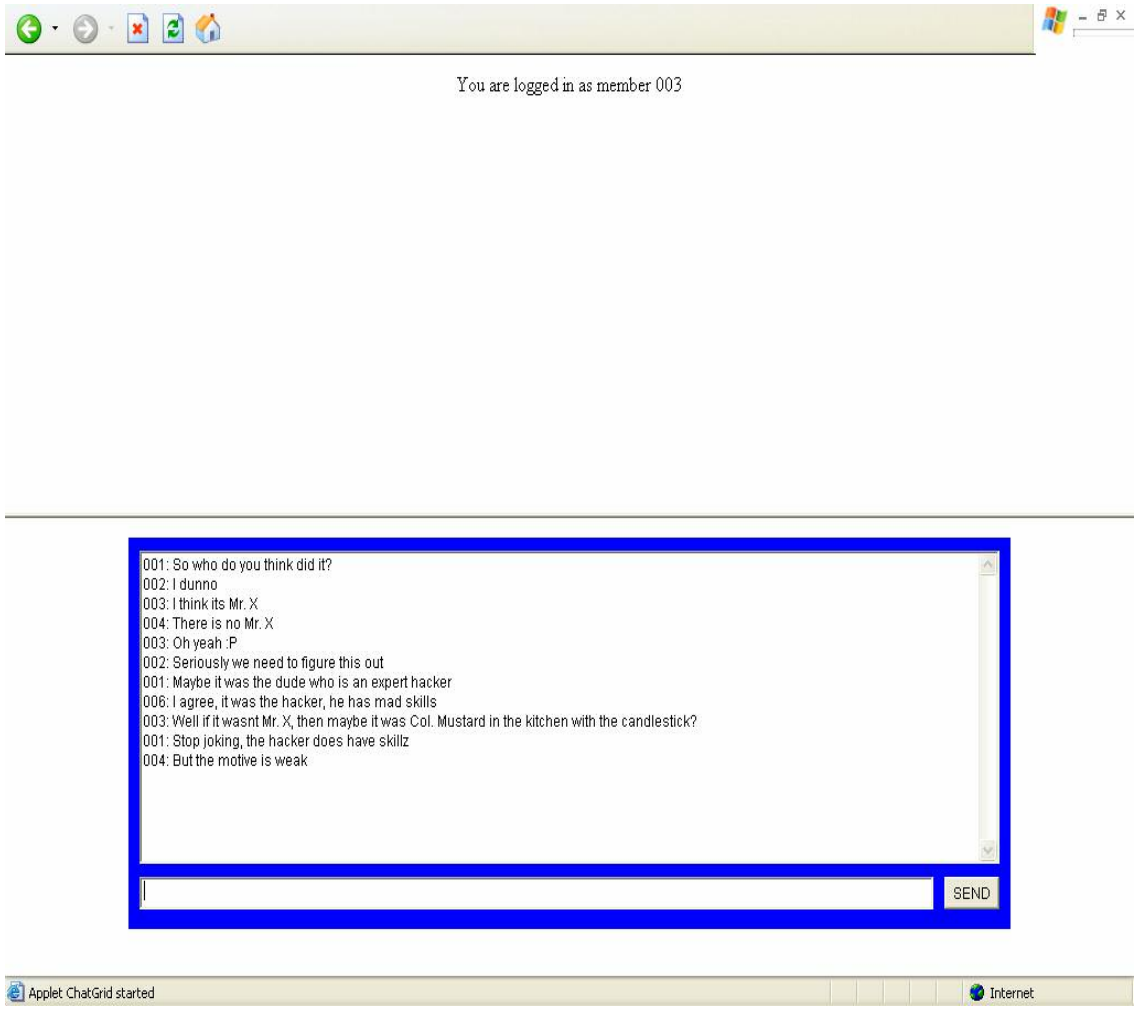
Patch (security or service patch) – A piece of software used to fix problems in a primary program.

Port Scanning – The act of systematically scanning a computer's ports. Since a port is a place where information goes into and out of a computer, port scanning identifies open doors to a computer.

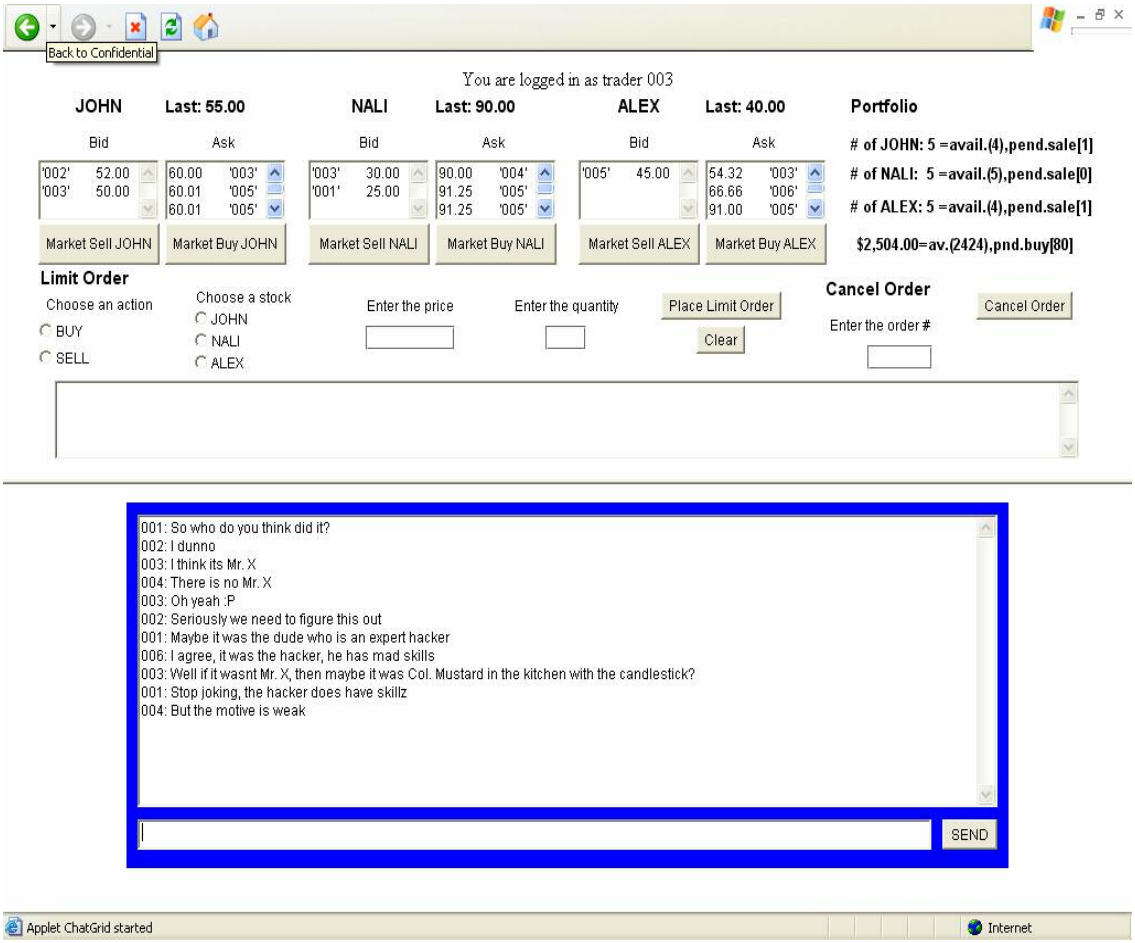
Spoofing (IP spoofing) – A technique used to gain unauthorized access to computers, where the intruder masks his own IP address and replaces it with a different IP address.

Wireless Network – A network that uses signals that travel through the air, rather than through wires.

Appendix B – Chat screenshot



Appendix B – Chat & Market screenshot



Appendix C – Specific Instructions for Participants

Part I: Participant instructions for the 'chat' conditions

Thank you for agreeing to participate in this experiment.

You will be part of a group that is trying to reach a decision. The only method for you to communicate with your other group members is by logging in to a chat system. How to log in will be provided to you by the experiment facilitator shortly.

You will be given four tasks that require decisions. The first three will be purely for training purposes. These will allow you to get familiar with the chat system. We will also track your compensation so that you understand how our reward system works (see below). The first three sessions have nothing to do with your actual reward. The actual reward is entirely based on the fourth and final decision you and your group make.

Your final reward has three components:

- Congratulations, just being here has earned you $5.
- The individual component is based on your decision alone. Every task you face will have a right answer. If you choose the right answer on the final task (it does not matter what the rest of the group thinks) you will receive an additional $5.
- The group component is based on the majority of group members decisions. If the majority of group members are correct (it does not matter what you think alone) then you, as a group member, receive an additional $5.
- The minimum is $5 (which you already earned) and the maximum is $15 (if you and the majority of group members are correct).

The chat system allows you to see what all the group members enter. Once entered a comment cannot be removed from the system. There are no filters on any comments. Group members will be identified by their login IDs and every comment will contain the ID of the author. The group decision does not need to be unanimous (although it can be). Members can all agree on the same thing, or agree to disagree and have members with different viewpoints.

In order to be successful you must read the case and background **very carefully**. Each member might receive a different (but not conflicting) set of information.

Before and after group the final group chatting session, you will be provided with a questionnaire to record your individual decision.

Thanks again for being here and good luck!

Part II: Participant instructions for 'both' conditions (chat with markets)

Thank you for agreeing to participate in this experiment.
You will be part of a group that is trying to reach a decision. You will be able to communicate with your other group members by logging in to a chat system. How to log in will be provided to you by the experiment facilitator shortly. You will also be able to participate in a market, buying and selling stocks. There will be three stocks to trade at the same time. The special thing about this market is that only one stock will be worth something at the end, the other two will be worthless. Among the members there are clues and information as to which stock it will be. You and all the other members will be given some information before trading begins for each session.

You will be given four tasks that require decisions. The first three will be purely for training purposes. These will allow you to get familiar with the system. We will also track your compensation so that you understand how our reward system works (see below). The first three sessions have nothing to do with your actual reward. The actual reward is entirely based on the fourth and final decision you and your group make and takes into account how well you traded in the market.

Your final reward has three components:

- Congratulations, just being here has earned you $5.
- Additional monies will be distributed based on individual performance. All participants in your session will be ranked by total portfolio value. A scale will be used to determine your appropriate payment (see below).
- There is also a group component based on the majority of group members decisions. The case has a right answer. Every member in the group will be asked to give an answer individually. If the majority of group members are correct (it does not matter what you think alone) then you, as a group member, double your individual winnings (from the scale). Example – you end up with 3150 points, the scale says you earn $4, the majority of the group picks the correct answer, your earnings double to $8, plus the $5 just for playing = total of $13 today.
- The minimum is $5 (which you already earned) and the maximum is $19 (if you perform very well and the group chooses the correct answer).

Up to	$ Paid	Up to	$ Paid	Up to	$ Paid	Up to	$ Paid
1600	0	2300	1	3000	3	3700	6
1700	0	2400	1	3100	4	3800	6
1800	0	2500	2	3200	4	3900	6
1900	1	2600	2	3300	5	4000	6
2000	1	2700	2	3400	5	4100	6
2100	1	2800	2	3500	5	4200	6
2200	1	2900	3	3600	5	4300+	7

The chat system allows you to see what all the group members enter. Once entered a comment cannot be removed from the system. There are no filters on any comments. Group members will be identified by their login IDs and every comment will contain the ID of the author. The group decision does not need to be unanimous (although it can be). Members can all agree on the same thing, or agree to disagree and have members with different viewpoints.

The best way to learn how the market works is through experience and trading in it, but we provide a little background here. All traders will be provided with an ID (same as their chat ID). This ID will be visible on most orders that are entered (so you can check to see if a member is saying one thing and trading a different way). There are two types of orders, market and limit orders. A market order is an order that happens immediately. In our system it is for only one share. If it is a market buy order, you will immediately buy a share of that stock for the best available price listed in the order book. If it is a market sell order, you will immediately sell a share of that stock for the best available price listed in the order book. In our system, to enter a market order you simply click once on the appropriate button under the stock that you want to trade. Use care when using market orders as a double click will result in two shares and in fast trading you might not get the top price since a different order might be a fraction of a second ahead of yours. The order book contains orders that are waiting to trade. These are orders that specify a price and no trader has agreed yet with that price. This type of order is a limit order. On a limit order you specify a price that you want. A buy limit order is also called a bid, because you are bidding on a stock that you want. A sell limit order is also called an ask, because that is how much you are asking for your stock. To enter a limit order you have to specify the stock, the type (buy or sell), the limit price (maximum price willing to pay for a buy or minimum price willing to accept for a sell), and the quantity.

There are two ways to profit in our market. One is the traditional buy low, sell high method, the other is by holding the right stock until the end. Remember at the end of the market session, one stock will be worth something, to be specific one share of the right stock will be worth 100 points. All the other shares will be worthless. If you bought any shares of the wrong stock, that will be a loss, but if you sell shares of the wrong stock that will be a gain. The more right shares you have (and the more wrong shares you can sell) the more points you will receive at the end of the session.

In order to be successful you must read the case and background **very carefully**. Each member might receive a different (but not conflicting) set of information. Markets like ours are very efficient and you can get a lot of information by watching the bids, asks, and trades.

Before and after group the final group session, you will be provided with a questionnaire to record your individual decision.

Thanks again for being here and good luck!

Appendix D – Questionnaires
Initial Questionnaire

The purpose of this questionnaire is to gather some background information.

1. Degree pursued?
BBA BA/BS MBA MS other

2. Your major: _____

3. Is English your native or first language?
Yes No

4. Gender?
Male Female

5. Age? _____

6. What is your level of experience in working in groups in general? (Select one)

Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High

7. What is your level of computer use? (Select one).

Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High

8. What is your level of knowledge of IT security? (Select one)

Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High

9. What is your level of knowledge of financial markets (NYSE, NASDQ)? (Select one)

Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High

10. Have you ever traded stock before? (Select one)
Yes No

11. How well do you type? (Select one)
Hunt and peck Rough or casual typing Good typing Excellent typing (>30 wpm error free)

12. How frequently have you used a computer to instant message or chat with someone? (Select one)

Never	A few times in my life	A few times a year	A few times a month	A few times a week	At least everyday

13. I dislike participation in group discussions. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

14. Engaging in group discussions with new people makes me tense and nervous. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

15. Generally, I am comfortable participating in group discussions. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

16. I am very calm and relaxed when I am called upon to express an opinion at a meeting. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

17. $10 is pretty valuable to me. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

18. Working with computers is so complicated it is difficult to understand what is going on. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

19. I do not trust computer storage of important information. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

20. Computers are not for me. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

21. I do not like statistics and probability. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

22. Gambling is very exciting. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

23. I like finance. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

24. I do not perform well under pressure. (Select one)

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

Appendix D – Questionnaires
Pre-Meeting Questionnaire

Please answer the following questions ONLY after you are finished reading. Thank you.
Note: Your answers here have no impact on your final payment. They are for information purposes only.

1. Who do you think is guilty? (Select one)
John Donahue Alex Mansi Mr. Nali

2. What is your confidence level in your guess of who is guilty?

Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High

3. If you had $100 total to bet on any/all three choices, how much money would you put on each?
Note: Any combination as long as total equals $100. Do not use cents, only whole dollars. Do not leave any blank.
_____$ on John Donahue is guilty
_____$ on Alex Mansi is guilty
_____$ on Mr. Nali is guilty

4. How much effort is required to solve this case?

Extremely Little	Very Little	Just Below Average	Average	Just Above Average	A lot	An Extreme Amount

5. To what degree do you think the case is interesting to you?

Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High

6. How important is it for you to solve this case?

Extremely Unimportant	Very Unimportant	Somewhat Unimportant	Average	Somewhat Important	Very Important	Extremely Important

7. How easy/difficult do you find the case as an individual?

Extremely Easy	Very Easy	Somewhat Easy	Average	Somewhat Difficult	Very Difficult	Extremely Difficult

8. How unpleasant/enjoyable do you think you will find it to work on this case using the procedures or system provided (same as training)?

Extremely Unpleasant	Very Unpleasant	Somewhat Unpleasant	Average	Somewhat Enjoyable	Very Enjoyable	Extremely Enjoyable

9. Does the case make it clear, what the decision is about?

Extremely Unclear	Very Unclear	Somewhat Unclear	Average	Somewhat Clear	Very Clear	Extremely Clear

10. Does the case present you with enough information to make a decision?

Not at all	Most Likely, No	Maybe Not	Not Sure	Maybe Yes	Most Likely, Yes	Definitely

Appendix D – Questionnaires

Post-Meeting Questionnaire

Thank you for participating. You are almost done.
Please answer the following questions.
Note: These answers are what your final payment is based on.

1. Who do you think is guilty? (Select one)
John Donahue Alex Mansi Mr. Nali

2. What is your confidence level in your guess of who is guilty?

Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High

3. If you had $100 total to bet on any/all three choices, how much money would you put on each?
Note: Any combination as long as total equals $100. Do not use cents, only whole dollars. Do not leave any blank.
_____$ on John Donahue is guilty
_____$ on Alex Mansi is guilty
_____$ on Mr. Nali is guilty

4. If you changed your answer (who, confidence, and/or $ amount) from before the meeting, why? (If no change, leave blank)
_____

5. I thought the case was difficult.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

6. I had the skills needed to complete the task.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

7. My approach to formulating my actions was very structured.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

8. The case was interesting to me.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

9. In the end, we all agreed on the same person.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

10. My analysis of the case was systematic.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

11. The meeting was a good way of exchanging information.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

12. I was completely honest during the meeting.

Absolutely	Strongly				Strongly	Absolutely

Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

13. I learned a great deal about the case from the meeting.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

14. The meeting made me reconsider my initial impression.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

15. I am satisfied with the quality of my solution.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

16. The system limited me/us while trying to solve the case.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

17. I gave my best effort in this assignment.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

18. I was purely motivated by money.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

19. I do not care if I am personally right or wrong.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

20. I do not care if my group is right or wrong.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

21. Solving this case was a good learning experience.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

22. I value others' opinions.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

23. I felt frustrated by the system.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

24. Using the system was fun.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

25. The system was a hindrance.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

26. The actions of others influenced me.

Absolutely	Strongly				Strongly	Absolutely

Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

27. The case was fair.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

28. The system was fair.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

29. I could not tell who had what ID.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

30. The case was too difficult.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

31. I had bad information.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

32. No one can ever make me change my mind.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

33. I had a good understanding of what the others thought.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

34. The others knew how I felt.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

35. I agreed with most of the group.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

36. I was a leader during the meeting.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

37. I feel I was able to influence the group.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

38. The quality of the meeting was poor.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

39. The system did not provide enough tools.

Absolutely	Strongly				Strongly	Absolutely
Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

40. The meeting generated enough information for all of us to get the right answer.

Absolutely	Strongly				Strongly	Absolutely

Agree	Agree	Agree	Undecided	Disagree	Disagree	Disagree

41. There was too much information for me to really figure out the problem.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

42. The system provided us with all the tools that we needed to solve the case.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

43. Overall, the group had good problem-solving skills.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

44. I knew how strongly the others felt.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

45. The meeting was effective.

Absolutely Agree	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Absolutely Disagree

46. How often were you distracted by the mechanics of the system?

Never	Very Infrequently	Somewhat Infrequently	Sometimes	Somewhat Often	Very Often	Constantly

47. How often were you constrained in the types of contributions you could make?

Never	Very Infrequently	Somewhat Infrequently	Sometimes	Somewhat Often	Very Often	Constantly

48. How often were you overloaded with information?

Never	Very Infrequently	Somewhat Infrequently	Sometimes	Somewhat Often	Very Often	Constantly

49. How often were you able to express your views?

Never	Very Infrequently	Somewhat Infrequently	Sometimes	Somewhat Often	Very Often	Constantly

50. How often were you able to get an impression of personal contact with other participants?

Never	Very Infrequently	Somewhat Infrequently	Sometimes	Somewhat Often	Very Often	Constantly

51. Comments/Suggestions/Questions

_____

Appendix E – Statistics
Initial Questionnaire Results

ANOVA – Initial Questionnaire

Descriptive Statistics

	Technology Condition	Information Aggregation Condition	Mean	Std. Deviation	N
English native language	Chat	Majority/Minority	1.551	.5006	78
		Uniform	1.655	.4783	84
		Total	1.605	.4904	162
	Both	Majority/Minority	1.561	.5001	66
		Uniform	1.603	.4925	78
		Total	1.583	.4947	144
	Total	Majority/Minority	1.556	.4986	144
		Uniform	1.630	.4844	162
		Total	1.595	.4917	306
Gender	Chat	Majority/Minority	1.372	.4864	78
		Uniform	1.500	.5030	84
		Total	1.438	.4977	162
	Both	Majority/Minority	1.439	.5001	66
		Uniform	1.321	.4697	78
		Total	1.375	.4858	144
	Total	Majority/Minority	1.403	.4922	144
		Uniform	1.414	.4940	162
		Total	1.408	.4924	306
Age	Chat	Majority/Minority	22.7692	4.90143	78
		Uniform	22.4524	4.45704	84
		Total	22.6049	4.66433	162
	Both	Majority/Minority	22.3030	4.21342	66
		Uniform	22.4872	5.07283	78
		Total	22.4028	4.68343	144
	Total	Majority/Minority	22.5556	4.58910	144
		Uniform	22.4691	4.74855	162
		Total	22.5098	4.66675	306
Group Experience	Chat	Majority/Minority	4.167	1.1098	78
		Uniform	4.500	1.0921	84
		Total	4.340	1.1099	162
	Both	Majority/Minority	4.379	1.1336	66
		Uniform	4.359	1.2165	78
		Total	4.368	1.1752	144
	Total	Majority/Minority	4.264	1.1218	144

		Uniform	4.432	1.1522	162
		Total	4.353	1.1393	306
Computer Use	Chat	Majority/Minority	4.962	1.1332	78
		Uniform	4.964	1.0579	84
		Total	4.963	1.0914	162
	Both	Majority/Minority	5.106	1.0397	66
		Uniform	5.064	1.0971	78
		Total	5.083	1.0676	144
	Total	Majority/Minority	5.028	1.0900	144
		Uniform	5.012	1.0748	162
		Total	5.020	1.0802	306
IT Security Knowledge	Chat	Majority/Minority	3.500	1.1137	78
		Uniform	3.476	1.2171	84
		Total	3.488	1.1649	162
	Both	Majority/Minority	3.758	1.2777	66
		Uniform	3.526	1.2764	78
		Total	3.632	1.2778	144
	Total	Majority/Minority	3.618	1.1944	144
		Uniform	3.500	1.2424	162
		Total	3.556	1.2195	306
Financial Market Knowledge	Chat	Majority/Minority	3.321	1.0989	78
		Uniform	3.250	1.4301	84
		Total	3.284	1.2780	162
	Both	Majority/Minority	3.288	1.4117	66
		Uniform	3.115	1.3190	78
		Total	3.194	1.3602	144
	Total	Majority/Minority	3.306	1.2475	144
		Uniform	3.185	1.3751	162
		Total	3.242	1.3159	306
Stock Trader	Chat	Majority/Minority	1.744	.4395	78
		Uniform	1.786	.4128	84
		Total	1.765	.4250	162
	Both	Majority/Minority	1.727	.4488	66
		Uniform	1.808	.3967	78
		Total	1.771	.4218	144
	Total	Majority/Minority	1.736	.4423	144
		Uniform	1.796	.4040	162
		Total	1.768	.4228	306
Typing Skills	Chat	Majority/Minority	2.821	.7515	78
		Uniform	2.964	.7983	84
		Total	2.895	.7771	162
	Both	Majority/Minority	3.000	.7646	66
		Uniform	2.987	.6931	78
		Total	2.993	.7242	144
	Total	Majority/Minority	2.903	.7602	144
		Uniform	2.975	.7473	162

		Total	2.941	.7530	306
CMC Frequency	Chat	Majority/Minority	4.538	1.6956	78
		Uniform	4.833	1.5969	84
		Total	4.691	1.6467	162
	Both	Majority/Minority	4.864	1.3574	66
		Uniform	4.641	1.6114	78
		Total	4.743	1.4994	144
	Total	Majority/Minority	4.688	1.5531	144
		Uniform	4.741	1.6018	162
		Total	4.716	1.5767	306
Dislike group participation	Chat	Majority/Minority	4.846	1.3297	78
		Uniform	4.893	1.3534	84
		Total	4.870	1.3381	162
	Both	Majority/Minority	4.545	1.2549	66
		Uniform	4.962	1.3527	78
		Total	4.771	1.3207	144
	Total	Majority/Minority	4.708	1.3002	144
		Uniform	4.926	1.3493	162
		Total	4.824	1.3287	306
New groups make me nervous	Chat	Majority/Minority	4.692	1.3893	78
		Uniform	4.869	1.2780	84
		Total	4.784	1.3315	162
	Both	Majority/Minority	4.682	1.3028	66
		Uniform	5.103	1.3347	78
		Total	4.910	1.3323	144
	Total	Majority/Minority	4.688	1.3456	144
		Uniform	4.981	1.3068	162
		Total	4.843	1.3312	306
Comfortable with groups	Chat	Majority/Minority	3.218	1.0889	78
		Uniform	3.167	1.3956	84
		Total	3.191	1.2537	162
	Both	Majority/Minority	3.212	1.1165	66
		Uniform	2.949	1.2782	78
		Total	3.069	1.2098	144
	Total	Majority/Minority	3.215	1.0978	144
		Uniform	3.062	1.3407	162
		Total	3.134	1.2328	306
Calm at meetings	Chat	Majority/Minority	3.769	1.2371	78
		Uniform	3.643	1.4532	84
		Total	3.704	1.3508	162
	Both	Majority/Minority	3.712	1.1867	66
		Uniform	3.372	1.3590	78
		Total	3.528	1.2898	144
	Total	Majority/Minority	3.743	1.2104	144
		Uniform	3.512	1.4109	162

		Total	3.621	1.3232	306
$10 is valuable	Chat	Majority/Minority	3.603	1.4713	78
		Uniform	3.155	1.3125	84
		Total	3.370	1.4049	162
	Both	Majority/Minority	3.455	1.3380	66
		Uniform	3.397	1.4535	78
		Total	3.424	1.3972	144
	Total	Majority/Minority	3.535	1.4088	144
		Uniform	3.272	1.3832	162
		Total	3.395	1.3992	306
Computers are complicated	Chat	Majority/Minority	5.641	1.0687	78
		Uniform	5.524	1.0808	84
		Total	5.580	1.0733	162
	Both	Majority/Minority	5.576	1.1102	66
		Uniform	5.679	1.1452	78
		Total	5.632	1.1266	144
	Total	Majority/Minority	5.611	1.0846	144
		Uniform	5.599	1.1115	162
		Total	5.605	1.0972	306
Dont trust computer storage	Chat	Majority/Minority	4.615	1.3602	78
		Uniform	4.762	1.4024	84
		Total	4.691	1.3799	162
	Both	Majority/Minority	4.848	1.4806	66
		Uniform	5.051	1.3377	78
		Total	4.958	1.4037	144
	Total	Majority/Minority	4.722	1.4164	144
		Uniform	4.901	1.3751	162
		Total	4.817	1.3953	306
Computers not for me	Chat	Majority/Minority	5.962	1.0744	78
		Uniform	5.893	1.0757	84
		Total	5.926	1.0723	162
	Both	Majority/Minority	5.985	1.3977	66
		Uniform	6.026	1.1279	78
		Total	6.007	1.2543	144
	Total	Majority/Minority	5.972	1.2287	144
		Uniform	5.957	1.0997	162
		Total	5.964	1.1603	306
Dont like stats	Chat	Majority/Minority	4.423	1.4729	78
		Uniform	4.429	1.6153	84
		Total	4.426	1.5436	162
	Both	Majority/Minority	4.530	1.3035	66
		Uniform	4.551	1.1914	78
		Total	4.542	1.2396	144
	Total	Majority/Minority	4.472	1.3940	144
		Uniform	4.488	1.4240	162

		Total	4.480	1.4077	306
Gambling is exciting	Chat	Majority/Minority	3.731	1.6878	78
		Uniform	3.595	1.4237	84
		Total	3.660	1.5531	162
	Both	Majority/Minority	3.682	1.6092	66
		Uniform	3.038	1.4183	78
		Total	3.333	1.5374	144
	Total	Majority/Minority	3.708	1.6467	144
		Uniform	3.327	1.4439	162
		Total	3.507	1.5518	306
Like finance	Chat	Majority/Minority	3.244	1.4787	78
		Uniform	3.214	1.2807	84
		Total	3.228	1.3754	162
	Both	Majority/Minority	3.197	1.3836	66
		Uniform	3.026	1.1949	78
		Total	3.104	1.2831	144
	Total	Majority/Minority	3.222	1.4311	144
		Uniform	3.123	1.2399	162
		Total	3.170	1.3320	306
Dont do well under pressure	Chat	Majority/Minority	4.282	1.5110	78
		Uniform	4.655	1.5090	84
		Total	4.475	1.5168	162
	Both	Majority/Minority	4.364	1.5052	66
		Uniform	4.654	1.5777	78
		Total	4.521	1.5463	144
	Total	Majority/Minority	4.319	1.5036	144
		Uniform	4.654	1.5376	162
		Total	4.497	1.5284	306

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	English native language	.532(a)	3	.177	.731	.534
	Gender	1.475(b)	3	.492	2.049	.107
	Age	8.388(c)	3	2.796	.127	.944
	Group Experience	4.570(d)	3	1.523	1.176	.319
	Computer Use	1.168(e)	3	.389	.331	.803
	IT Security Knowledge	3.533(f)	3	1.178	.790	.500
	Financial Market Knowledge	1.876(g)	3	.625	.359	.783
	Stock Trader	.305(h)	3	.102	.567	.637
	Typing Skills	1.574(i)	3	.525	.925	.429
	CMC Frequency	5.492(a)	3	1.831	.734	.532

	Dislike group participation	7.033(j)	3	2.344	1.332	.264
	New groups make me nervous	8.798(k)	3	2.933	1.666	.174
	Comfortable with groups	3.720(f)	3	1.240	.814	.487
	Calm at meetings	7.146(l)	3	2.382	1.365	.253
	$10 is valuable	8.443(m)	3	2.814	1.444	.230
	Computers are complicated	1.144(e)	3	.381	.315	.815
	Dont trust computer storage	7.772(j)	3	2.591	1.335	.263
	Computers not for me	.751(n)	3	.250	.184	.907
	Dont like stats	1.038(n)	3	.346	.173	.914
	Gambling is exciting	23.700(o)	3	7.900	3.357	.019
	Like finance	2.261(g)	3	.754	.422	.737
	Dont do well under pressure	8.787(p)	3	2.929	1.257	.289
Intercept	English native language	769.810	1	769.810	3175.122	.000
	Gender	601.854	1	601.854	2508.322	.000
	Age	153748.439	1	153748.439	6999.013	.000
	Group Experience	5748.191	1	5748.191	4436.235	.000
	Computer Use	7663.556	1	7663.556	6524.666	.000
	IT Security Knowledge	3858.465	1	3858.465	2589.330	.000
	Financial Market Knowledge	3194.070	1	3194.070	1833.060	.000
	Stock Trader	946.991	1	946.991	5274.556	.000
	Typing Skills	2629.726	1	2629.726	4634.359	.000
	CMC Frequency	6761.648	1	6761.648	2712.662	.000
	Dislike group participation	7028.987	1	7028.987	3994.360	.000
	New groups make me nervous	7102.025	1	7102.025	4034.083	.000
	Comfortable with groups	2986.651	1	2986.651	1961.711	.000
	Calm at meetings	3987.569	1	3987.569	2285.616	.000
	$10 is valuable	3514.663	1	3514.663	1802.971	.000
	Computers are complicated	9538.628	1	9538.628	7870.467	.000
	Dont trust computer storage	7051.687	1	7051.687	3634.274	.000
	Computers not for me	10807.626	1	10807.626	7963.577	.000
	Dont like stats	6102.795	1	6102.795	3054.715	.000
	Gambling is exciting	3743.990	1	3743.990	1590.751	.000
	Like finance	3051.290	1	3051.290	1709.936	.000
	Dont do well under pressure	6117.139	1	6117.139	2625.197	.000
condition2	English native language	.035	1	.035	.144	.705
	Gender	.238	1	.238	.990	.321
	Age	3.532	1	3.532	.161	.689
	Group Experience	.096	1	.096	.074	.786

	Computer Use	1.133	1	1.133	.965	.327
	IT Security Knowledge	1.789	1	1.789	1.200	.274
	Financial Market Knowledge	.531	1	.531	.305	.581
	Stock Trader	.001	1	.001	.003	.954
	Typing Skills	.777	1	.777	1.370	.243
	CMC Frequency	.335	1	.335	.134	.714
	Dislike group participation	1.022	1	1.022	.581	.447
	New groups make me nervous	.944	1	.944	.536	.465
	Comfortable with groups	.950	1	.950	.624	.430
	Calm at meetings	2.044	1	2.044	1.171	.280
	$10 is valuable	.170	1	.170	.087	.768
	Computers are complicated	.155	1	.155	.128	.721
	Dont trust computer storage	5.180	1	5.180	2.670	.103
	Computers not for me	.462	1	.462	.341	.560
	Dont like stats	1.003	1	1.003	.502	.479
	Gambling is exciting	6.963	1	6.963	2.958	.086
	Like finance	1.050	1	1.050	.589	.444
	Dont do well under pressure	.123	1	.123	.053	.818
majuni2	English native language	.401	1	.401	1.656	.199
	Gender	.002	1	.002	.007	.934
	Age	.334	1	.334	.015	.902
	Group Experience	1.865	1	1.865	1.440	.231
	Computer Use	.029	1	.029	.025	.875
	IT Security Knowledge	1.241	1	1.241	.833	.362
	Financial Market Knowledge	1.121	1	1.121	.643	.423
	Stock Trader	.285	1	.285	1.587	.209
	Typing Skills	.325	1	.325	.573	.449
	CMC Frequency	.099	1	.099	.040	.842
	Dislike group participation	4.064	1	4.064	2.310	.130
	New groups make me nervous	6.774	1	6.774	3.848	.051
	Comfortable with groups	1.879	1	1.879	1.234	.267
	Calm at meetings	4.133	1	4.133	2.369	.125
	$10 is valuable	4.838	1	4.838	2.482	.116
	Computers are complicated	.003	1	.003	.003	.957
	Dont trust computer storage	2.316	1	2.316	1.193	.276
	Computers not for me	.015	1	.015	.011	.917
	Dont like stats	.013	1	.013	.007	.935
	Gambling is exciting	11.512	1	11.512	4.891	.028

	Like finance	.764	1	.764	.428	.513
	Dont do well under pressure	8.339	1	8.339	3.579	.059
condition2 * majuni2	English native language	.072	1	.072	.296	.587
	Gender	1.159	1	1.159	4.828	.029
	Age	4.763	1	4.763	.217	.642
	Group Experience	2.367	1	2.367	1.826	.178
	Computer Use	.038	1	.038	.032	.858
	IT Security Knowledge	.822	1	.822	.552	.458
	Financial Market Knowledge	.197	1	.197	.113	.737
	Stock Trader	.028	1	.028	.155	.694
	Typing Skills	.465	1	.465	.820	.366
	CMC Frequency	5.082	1	5.082	2.039	.154
	Dislike group participation	2.589	1	2.589	1.471	.226
	New groups make me nervous	1.130	1	1.130	.642	.424
	Comfortable with groups	.854	1	.854	.561	.455
	Calm at meetings	.869	1	.869	.498	.481
	$10 is valuable	2.897	1	2.897	1.486	.224
	Computers are complicated	.926	1	.926	.764	.383
	Dont trust computer storage	.060	1	.060	.031	.860
	Computers not for me	.227	1	.227	.168	.683
	Dont like stats	.005	1	.005	.002	.962
	Gambling is exciting	4.894	1	4.894	2.079	.150
	Like finance	.383	1	.383	.215	.644
	Dont do well under pressure	.129	1	.129	.055	.814
Error	English native language	73.220	302	.242		
	Gender	72.463	302	.240		
	Age	6634.082	302	21.967		
	Group Experience	391.312	302	1.296		
	Computer Use	354.715	302	1.175		
	IT Security Knowledge	450.022	302	1.490		
	Financial Market Knowledge	526.229	302	1.742		
	Stock Trader	54.221	302	.180		
	Typing Skills	171.367	302	.567		
	CMC Frequency	752.773	302	2.493		
	Dislike group participation	531.438	302	1.760		
	New groups make me nervous	531.673	302	1.761		
	Comfortable with groups	459.787	302	1.522		
	Calm at meetings	526.880	302	1.745		

	$10 is valuable	588.711	302	1.949		
	Computers are complicated	366.009	302	1.212		
	Dont trust computer storage	585.979	302	1.940		
	Computers not for me	409.854	302	1.357		
	Dont like stats	603.344	302	1.998		
	Gambling is exciting	710.787	302	2.354		
	Like finance	538.903	302	1.784		
	Dont do well under pressure	703.710	302	2.330		
Total	English native language	852.000	306			
	Gender	681.000	306			
	Age	161690.000	306			
	Group Experience	6194.000	306			
	Computer Use	8066.000	306			
	IT Security Knowledge	4322.000	306			
	Financial Market Knowledge	3744.000	306			
	Stock Trader	1011.000	306			
	Typing Skills	2820.000	306			
	CMC Frequency	7563.000	306			
	Dislike group participation	7658.000	306			
	New groups make me nervous	7718.000	306			
	Comfortable with groups	3469.000	306			
	Calm at meetings	4546.000	306			
	$10 is valuable	4125.000	306			
	Computers are complicated	9979.000	306			
	Dont trust computer storage	7694.000	306			
	Computers not for me	11295.000	306			
	Dont like stats	6747.000	306			
	Gambling is exciting	4497.000	306			
	Like finance	3616.000	306			
	Dont do well under pressure	6900.000	306			
Corrected Total	English native language	73.752	305			
	Gender	73.938	305			
	Age	6642.471	305			
	Group Experience	395.882	305			
	Computer Use	355.882	305			
	IT Security Knowledge	453.556	305			
	Financial Market Knowledge	528.105	305			
	Stock Trader	54.526	305			

	Typing Skills	172.941	305			
	CMC Frequency	758.265	305			
	Dislike group participation	538.471	305			
	New groups make me nervous	540.471	305			
	Comfortable with groups	463.507	305			
	Calm at meetings	534.026	305			
	$10 is valuable	597.154	305			
	Computers are complicated	367.154	305			
	Dont trust computer storage	593.752	305			
	Computers not for me	410.605	305			
	Dont like stats	604.382	305			
	Gambling is exciting	734.487	305			
	Like finance	541.163	305			
	Dont do well under pressure	712.497	305			

a R Squared = .007 (Adjusted R Squared = -.003)
b R Squared = .020 (Adjusted R Squared = .010)
c R Squared = .001 (Adjusted R Squared = -.009)
d R Squared = .012 (Adjusted R Squared = .002)
e R Squared = .003 (Adjusted R Squared = -.007)
f R Squared = .008 (Adjusted R Squared = -.002)
g R Squared = .004 (Adjusted R Squared = -.006)
h R Squared = .006 (Adjusted R Squared = -.004)
i R Squared = .009 (Adjusted R Squared = -.001)
j R Squared = .013 (Adjusted R Squared = .003)
k R Squared = .016 (Adjusted R Squared = .007)
l R Squared = .013 (Adjusted R Squared = .004)
m R Squared = .014 (Adjusted R Squared = .004)
n R Squared = .002 (Adjusted R Squared = -.008)
o R Squared = .032 (Adjusted R Squared = .023)
p R Squared = .012 (Adjusted R Squared = .003)

Appendix F – Statistics
Performance Results

ANOVA – Group Correctness

Descriptive Statistics

Dependent Variable: # of correct members in group

Technology Condition	Information Aggregation Condition	Mean	Std. Deviation	N
Chat	Majority	1.9231	2.06000	13
	Uniform	3.3571	1.69193	14
	Total	2.6667	1.98068	27
Both	Majority	2.6364	1.68954	11
	Uniform	2.9231	1.44115	13
	Total	2.7917	1.53167	24
Total	Majority	2.2500	1.89393	24
	Uniform	3.1481	1.56165	27
	Total	2.7255	1.76724	51

Tests of Between-Subjects Effects

Dependent Variable: # of correct members in group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	14.551(a)	3	4.850	1.610	.200
Intercept	371.614	1	371.614	123.341	.000
condition	.247	1	.247	.082	.776
majuni	9.365	1	9.365	3.108	.084
condition * majuni	4.163	1	4.163	1.382	.246
Error	141.606	47	3.013		
Total	535.000	51			
Corrected Total	156.157	50			

a R Squared = .093 (Adjusted R Squared = .035)

Modified HANOVA – Bet on guilty suspect

Descriptive Statistics

	Technology Condition	Information Aggregation Condition	Mean	Std. Deviation	N
$ on John	Chat	Majority	43.4744	30.60631	78
		Uniform	30.1190	25.16184	84
		Total	36.5494	28.62177	162
	Both	Majority	29.2121	28.92777	66
		Uniform	33.6026	30.20980	78
		Total	31.5903	29.60755	144
	Total	Majority	36.9375	30.58799	144
		Uniform	31.7963	27.67517	162
		Total	34.2157	29.14755	306
$ on Alex (guilty)	Chat	Majority	37.1538	29.12627	78
		Uniform	47.5119	31.39507	84
		Total	42.5247	30.67263	162
	Both	Majority	47.4848	31.53471	66
		Uniform	44.3974	34.89105	78
		Total	45.8125	33.31540	144
	Total	Majority	41.8889	30.58591	144
		Uniform	46.0123	33.05745	162
		Total	44.0719	31.93294	306
$ on Nali	Chat	Majority	20.0128	23.69037	78
		Uniform	22.3690	23.36240	84
		Total	21.2346	23.47737	162
	Both	Majority	23.3030	25.77236	66
		Uniform	22.0000	26.89566	78
		Total	22.5972	26.30305	144
	Total	Majority	21.5208	24.63381	144
		Uniform	22.1914	25.04742	162
		Total	21.8758	24.81520	306

```
Test
EFFECT .. SESSION2 WITHIN CONDITION2 BY MAJUNI2 (ERROR 1) (Cont.)
 Univariate F-tests with (47,255) D. F.

 Variable   Hypoth. SS   Error SS Hypoth. MS   Error MS    F  Sig. of F

 q3a      90293.8994 163946.667 1921.14679  642.92810   2.98812    .000
 q3b      88584.4625 218551.000 1884.77580  857.06275   2.19911    .000
 q3c      62152.7812 124694.667 1322.39960  488.99869   2.70430    .000

 Variable   ETA Square

 q3a            .35515
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 q3b            .28842
 q3c            .33264

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Interaction

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EFFECT .. CONDITION2 BY MAJUNI2 (Cont.)
 Univariate F-tests with (1,47) D. F.

 Variable   Hypoth. SS   Error SS Hypoth. MS   Error MS    F  Sig. of F

 q3a     2542.75322 90293.8994 2542.75322 1921.14679    1.32356    .256
 q3b     1038.16529 88584.4625 1038.16529 1884.77580     .55082    .462
 q3c      237.55207 62152.7812  237.55207 1322.39960     .17964    .674

 Variable   ETA Square

 q3a            .02739
 q3b            .01158
 q3c            .00381

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Information Aggregation

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 EFFECT .. MAJUNI2 (Cont.)
 Univariate F-tests with (1,47) D. F.

 Variable   Hypoth. SS   Error SS Hypoth. MS   Error MS    F  Sig. of F

 q3a     2031.14681 90293.8994 2031.14681 1921.14679    1.05726    .309
 q3b     2734.06285 88584.4625 2734.06285 1884.77580    1.45060    .234
 q3c      103.83878 62152.7812  103.83878 1322.39960     .07852    .781

 Variable   ETA Square

 q3a            .02200
 q3b            .02994
 q3c            .00167

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Technological Support

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EFFECT .. CONDITION2 (Cont.)
 Univariate F-tests with (1,47) D. F.

 Variable   Hypoth. SS   Error SS Hypoth. MS   Error MS    F  Sig. of F

 q3a      307.29866 90293.8994  307.29866 1921.14679     .15996    .691
 q3b      104.72771 88584.4625  104.72771 1884.77580     .05557    .815
 q3c      628.44231 62152.7812  628.44231 1322.39960     .47523    .494

 Variable   ETA Square

 q3a            .00339
 q3b            .00118
 q3c            .01001

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Appendix G – Statistics
Perception Results

Modified HANOVA – Perception factors and variables

Note: Scores are summated scores for factors, and survey scores for the variables. Ns reflect the individual numbers corresponding to the source of the raw data, but significance tests are carried out on a group level by grouping together individuals in the same group and then testing.

Descriptive Statistics

	Technology Condition	Information Aggregation Condition	Mean	Std. Deviation	N
Confidence Level	Chat	Majority	5.115	.9667	78
		Uniform	5.179	1.1940	84
		Total	5.148	1.0876	162
	Both	Majority	5.061	1.1619	66
		Uniform	5.038	1.0864	78
		Total	5.049	1.1178	144
	Total	Majority	5.090	1.0572	144
		Uniform	5.111	1.1421	162
		Total	5.101	1.1012	306
Honest	Chat	Majority	5.564	.9749	78
		Uniform	5.738	1.0193	84
		Total	5.654	.9989	162
	Both	Majority	4.818	1.4241	66
		Uniform	4.923	1.4751	78
		Total	4.875	1.4478	144
	Total	Majority	5.222	1.2541	144
		Uniform	5.346	1.3203	162
		Total	5.288	1.2889	306
Gave best effort	Chat	Majority	5.410	1.1559	78
		Uniform	5.560	1.1756	84
		Total	5.488	1.1649	162
	Both	Majority	5.273	.9852	66
		Uniform	5.372	.9949	78
		Total	5.326	.9883	144
	Total	Majority	5.347	1.0795	144
		Uniform	5.469	1.0930	162
		Total	5.412	1.0866	306
Motivated by $	Chat	Majority	4.487	1.6960	78
		Uniform	3.583	1.4329	84
		Total	4.019	1.6246	162
	Both	Majority	3.530	1.4907	66
		Uniform	3.590	1.6071	78
		Total	3.563	1.5497	144

	Total	Majority	4.049	1.6697	144
		Uniform	3.586	1.5145	162
		Total	3.804	1.6035	306
Dont care myself	Chat	Majority	4.590	1.4544	78
		Uniform	4.726	1.4341	84
		Total	4.660	1.4410	162
	Both	Majority	4.000	1.5492	66
		Uniform	4.410	1.4633	78
		Total	4.222	1.5119	144
	Total	Majority	4.319	1.5221	144
		Uniform	4.574	1.4524	162
		Total	4.454	1.4886	306
Dont care group	Chat	Majority	4.449	1.4652	78
		Uniform	4.869	1.4952	84
		Total	4.667	1.4912	162
	Both	Majority	4.288	1.6986	66
		Uniform	4.628	1.4692	78
		Total	4.472	1.5820	144
	Total	Majority	4.375	1.5728	144
		Uniform	4.753	1.4831	162
		Total	4.575	1.5351	306
Value others opinion	Chat	Majority	5.487	.9500	78
		Uniform	5.500	1.0355	84
		Total	5.494	.9922	162
	Both	Majority	5.000	1.0077	66
		Uniform	5.051	.9521	78
		Total	5.028	.9748	144
	Total	Majority	5.264	1.0034	144
		Uniform	5.284	1.0183	162
		Total	5.275	1.0097	306
Anonymity	Chat	Majority	4.756	1.7070	78
		Uniform	4.929	1.4378	84
		Total	4.846	1.5706	162
	Both	Majority	4.985	1.3416	66
		Uniform	4.808	1.4688	78
		Total	4.889	1.4098	144
	Total	Majority	4.861	1.5492	144
		Uniform	4.870	1.4495	162
		Total	4.866	1.4948	306
Stubborn	Chat	Majority	4.833	1.3331	78
		Uniform	4.655	1.2369	84
		Total	4.741	1.2832	162
	Both	Majority	4.379	1.1604	66
		Uniform	4.474	1.2559	78
		Total	4.431	1.2098	144
	Total	Majority	4.625	1.2730	144

		Uniform	4.568	1.2455	162
		Total	4.595	1.2568	306
Leader	Chat	Majority	3.808	1.1173	78
		Uniform	4.083	1.4743	84
		Total	3.951	1.3178	162
	Both	Majority	3.924	1.1808	66
		Uniform	3.513	1.1367	78
		Total	3.701	1.1712	144
	Total	Majority	3.861	1.1442	144
		Uniform	3.809	1.3492	162
		Total	3.833	1.2552	306
Able to influence	Chat	Majority	4.551	1.1914	78
		Uniform	4.440	1.3112	84
		Total	4.494	1.2523	162
	Both	Majority	4.167	1.1036	66
		Uniform	4.077	1.1927	78
		Total	4.118	1.1496	144
	Total	Majority	4.375	1.1640	144
		Uniform	4.265	1.2649	162
		Total	4.317	1.2177	306
Enough info	Chat	Majority	4.359	1.2058	78
		Uniform	4.262	1.0656	84
		Total	4.309	1.1327	162
	Both	Majority	4.136	1.1078	66
		Uniform	4.000	1.1166	78
		Total	4.063	1.1108	144
	Total	Majority	4.257	1.1632	144
		Uniform	4.136	1.0949	162
		Total	4.193	1.1273	306
Too much info	Chat	Majority	4.526	1.2865	78
		Uniform	4.417	1.1741	84
		Total	4.469	1.2269	162
	Both	Majority	4.182	1.1219	66
		Uniform	4.449	1.3353	78
		Total	4.326	1.2450	144
	Total	Majority	4.368	1.2219	144
		Uniform	4.432	1.2505	162
		Total	4.402	1.2355	306
System had all tools	Chat	Majority	4.269	1.1128	78
		Uniform	4.333	1.1122	84
		Total	4.302	1.1095	162
	Both	Majority	4.485	.9322	66
		Uniform	4.218	1.1241	78
		Total	4.340	1.0456	144
	Total	Majority	4.368	1.0360	144
		Uniform	4.278	1.1159	162

		Total	4.320	1.0783	306
System distracting	Chat	Majority	5.359	1.2585	78
		Uniform	5.024	1.3261	84
		Total	5.185	1.3008	162
	Both	Majority	4.561	1.2169	66
		Uniform	4.590	1.2425	78
		Total	4.576	1.2266	144
	Total	Majority	4.993	1.2982	144
		Uniform	4.815	1.3008	162
		Total	4.899	1.3005	306
Constrained	Chat	Majority	4.936	1.1548	78
		Uniform	4.536	1.3394	84
		Total	4.728	1.2660	162
	Both	Majority	4.576	1.0086	66
		Uniform	4.462	1.0530	78
		Total	4.514	1.0309	144
	Total	Majority	4.771	1.1013	144
		Uniform	4.500	1.2069	162
		Total	4.627	1.1644	306
Information overload	Chat	Majority	4.705	1.4152	78
		Uniform	4.833	1.2785	84
		Total	4.772	1.3434	162
	Both	Majority	4.803	1.2306	66
		Uniform	4.513	1.2968	78
		Total	4.646	1.2708	144
	Total	Majority	4.750	1.3301	144
		Uniform	4.679	1.2933	162
		Total	4.712	1.3091	306
Frequency of expression	Chat	Majority	4.974	1.2481	78
		Uniform	4.619	1.5122	84
		Total	4.790	1.3985	162
	Both	Majority	4.515	1.4909	66
		Uniform	4.449	1.2551	78
		Total	4.479	1.3637	144
	Total	Majority	4.764	1.3791	144
		Uniform	4.537	1.3927	162
		Total	4.644	1.3887	306
Perception of intimacy	Chat	Majority	4.167	1.3620	78
		Uniform	4.083	1.3815	84
		Total	4.123	1.3685	162
	Both	Majority	3.727	1.0458	66
		Uniform	3.615	1.2192	78
		Total	3.667	1.1405	144
	Total	Majority	3.965	1.2427	144
		Uniform	3.858	1.3228	162

		Total	3.908	1.2848	306
Factor1 (IS Quality)	Chat	Majority	31.1026	5.67883	78
		Uniform	30.0952	5.61113	84
		Total	30.5802	5.64886	162
	Both	Majority	29.3636	5.19359	66
		Uniform	30.3333	5.28823	78
		Total	29.8889	5.24919	144
	Total	Majority	30.3056	5.51194	144
		Uniform	30.2099	5.44245	162
		Total	30.2549	5.46648	306
Factor2 (Groupthink)	Chat	Majority	37.1410	6.44200	78
		Uniform	37.0952	7.41802	84
		Total	37.1173	6.94377	162
	Both	Majority	35.0455	5.73097	66
		Uniform	34.0000	6.51870	78
		Total	34.4792	6.17118	144
	Total	Majority	36.1806	6.19458	144
		Uniform	35.6049	7.14826	162
		Total	35.8758	6.71169	306
Factor3 (Individual Analysis)	Chat	Majority	19.0256	2.95408	78
		Uniform	18.9643	3.53109	84
		Total	18.9938	3.25614	162
	Both	Majority	18.3939	3.52083	66
		Uniform	18.4872	3.33320	78
		Total	18.4444	3.40870	144
	Total	Majority	18.7361	3.23007	144
		Uniform	18.7346	3.43492	162
		Total	18.7353	3.33465	306
Factor4 (Enjoyability)	Chat	Majority	29.8462	4.57286	78
		Uniform	29.4286	4.36935	84
		Total	29.6296	4.45946	162
	Both	Majority	29.1515	3.85603	66
		Uniform	29.9615	4.47632	78
		Total	29.5903	4.20857	144
	Total	Majority	29.5278	4.25900	144
		Uniform	29.6852	4.41549	162
		Total	29.6111	4.33617	306
Factor5 (Group Awareness)	Chat	Majority	24.8333	3.69772	78
		Uniform	24.1310	4.22779	84
		Total	24.4691	3.98471	162
	Both	Majority	22.6667	3.40286	66
		Uniform	22.4872	3.23031	78
		Total	22.5694	3.30004	144
	Total	Majority	23.8403	3.71477	144

		Uniform	23.3395	3.85798	162
		Total	23.5752	3.79334	306
Factor6 (Case Complexity)	Chat	Majority	12.2436	3.12587	78
		Uniform	12.6071	2.68426	84
		Total	12.4321	2.90187	162
	Both	Majority	12.0303	2.43670	66
		Uniform	12.5128	2.99672	78
		Total	12.2917	2.75548	144
	Total	Majority	12.1458	2.82340	144
		Uniform	12.5617	2.83049	162
		Total	12.3660	2.83017	306

Test

```
       306 cases accepted.
         0 cases rejected because of out-of-range factor values.
         0 cases rejected because of missing data.
        51 non-empty cells.

         1 design will be processed.
```

Group

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 EFFECT .. SESSION2 WITHIN CONDITION2 BY MAJUNI2 (ERROR 1) (Cont.)
 Univariate F-tests with (47,255) D. F.

 Variable   Hypoth. SS   Error SS Hypoth. MS   Error MS    F  Sig. of F

 IS Quality 1673.44089 7360.33333   35.60513   28.86405   1.23355  .157
 Groupthink 3180.80952 9676.66667   67.67680   37.94771   1.78342  .003
 Individual
 Analysis    466.38961 2880.83333    9.92318   11.29739    .87836  .697
 Enjoy-
 ability     740.23576 4937.50000   15.74970   19.36275    .81340  .801
 Group
 Awareness   904.90276 3102.00000   19.25325   12.16471   1.58271  .014
 Case
 Complexity  426.59807 1989.66667    9.07655    7.80261   1.16327  .231
 q12          80.33225  377.66667    1.70920    1.48105   1.15405  .242
 q17          61.77689  294.66667    1.31440    1.15556   1.13746  .264
 q18         206.89469  546.33333    4.40201    2.14248   2.05463  .000
 q19         101.80078  565.83333    2.16597    2.21895    .97612  .522
 q20         140.90210  566.00000    2.99792    2.21961   1.35065  .076
 q22          47.69789  249.33333    1.01485     .97778   1.03791  .414
 q29         118.67433  557.50000    2.52499    2.18627   1.15493  .241
 q32         100.67399  379.00000    2.14200    1.48627   1.44119  .041
 q36          65.85206  399.16667    1.40111    1.56536    .89507  .668
 q37          50.49476  392.50000    1.07436    1.53922    .69799  .931
 q40          91.07126  287.50000    1.93769    1.12745   1.71864  .005
 q41          83.45813  381.83333    1.77570    1.49739   1.18587  .205
 q42          68.40418  284.66667    1.45541    1.11634   1.30373  .103
 q46          71.30861  419.83333    1.51720    1.64641    .92153  .621
```

q47	65.52048	338.33333	1.39405	1.32680	1.05069	.393
q48	71.30162	446.66667	1.51706	1.75163	.86608	.718
q49	84.57900	493.16667	1.79955	1.93399	.93049	.605
q50	64.94764	425.00000	1.38186	1.66667	.82912	.777
q2	56.20979	310.50000	1.19595	1.21765	.98218	.511

Group Effect Size

Variable	Partial ETA Square
IS Quality	.18524
Groupthink	.24739
Individual Analysis	.13934
Enjoyability	.13038
Group Awareness	.22584
Case Complexity	.17655
q12	.17540
q17	.17331
q18	.27468
q19	.15248
q20	.19932
q22	.16058
q29	.17551
q32	.20988
q36	.14161
q37	.11398
q40	.24057
q41	.17937
q42	.19374
q46	.14519
q47	.16224
q48	.13766
q49	.14639
q50	.13256
q2	.15328

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Interaction

EFFECT .. CONDITION2 BY MAJUNI2 (Cont.)
Univariate F-tests with (1,47) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
IS Quality	60.47732	1673.44089	60.47732	35.60513	1.69856	.199
Groupthink	.26894	3180.80952	.26894	67.67680	.00397	.950
Individual Analysis	1.42701	466.38961	1.42701	9.92318	.14381	.706
Enjoyability	42.14869	740.23576	42.14869	15.74970	2.67616	.109
Group Awareness	15.68864	904.90276	15.68864	19.25325	.81486	.371
Case						

Complexity	.96587	426.59807	.96587	9.07655	.10641	.746
q12	.02073	80.33225	.02073	1.70920	.01213	.913
q17	.01762	61.77689	.01762	1.31440	.01340	.908
q18	8.31846	206.89469	8.31846	4.40201	1.88969	.176
q19	.35071	101.80078	.35071	2.16597	.16192	.689
q20	.00064	140.90210	.00064	2.99792	.00021	.988
q22	.00815	47.69789	.00815	1.01485	.00803	.929
q29	3.77842	118.67433	3.77842	2.52499	1.49641	.227
q32	.13469	100.67399	.13469	2.14200	.06288	.803
q36	6.60923	65.85206	6.60923	1.40111	4.71715	.035
q37	.03249	50.49476	.03249	1.07436	.03024	.863
q40	.06298	91.07126	.06298	1.93769	.03250	.858
q41	.13125	83.45813	.13125	1.77570	.07392	.787
q42	.71706	68.40418	.71706	1.45541	.49269	.486
q46	1.11753	71.30861	1.11753	1.51720	.73657	.395
q47	1.29505	65.52048	1.29505	1.39405	.92898	.340
q48	2.08223	71.30162	2.08223	1.51706	1.37255	.247
q49	.27233	84.57900	.27233	1.79955	.15133	.699
q50	.09170	64.94764	.09170	1.38186	.06636	.798
q2	.34686	56.20979	.34686	1.19595	.29003	.593

Interaction Effect Size

Variable	Partial ETA Square
IS Quality	.03488
Groupthink	.00008
Individual Analysis	.00305
Enjoyability	.05387
Group Awareness	.01704
Case Complexity	.00226
q12	.00026
q17	.00029
q18	.03865
q19	.00343
q20	.00000
q22	.00017
q29	.03086
q32	.00134
q36	.09121
q37	.00064
q40	.00069
q41	.00157
q42	.01037
q46	.01543
q47	.01938
q48	.02837
q49	.00321
q50	.00141
q2	.00613

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Information Aggregation

EFFECT .. MAJUNI2 (Cont.)
Univariate F-tests with (1,47) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
IS Quality	6.67978	1673.44089	6.67978	35.60513	.18761	.667
Groupthink	.81583	3180.80952	.81583	67.67680	.01205	.913
Individual Analysis	1.94572	466.38961	1.94572	9.92318	.19608	.660
Enjoyability	7.89873	740.23576	7.89873	15.74970	.50152	.482
Group Awareness	9.82526	904.90276	9.82526	19.25325	.51032	.479
Case Complexity	20.15211	426.59807	20.15211	9.07655	2.22024	.143
q12	.80057	80.33225	.80057	1.70920	.46839	.497
q17	.97633	61.77689	.97633	1.31440	.74279	.393
q18	13.98130	206.89469	13.98130	4.40201	3.17611	.081
q19	1.86085	101.80078	1.86085	2.16597	.85913	.359
q20	8.98615	140.90210	8.98615	2.99792	2.99746	.090
q22	.02158	47.69789	.02158	1.01485	.02127	.885
q29	.16376	118.67433	.16376	2.52499	.06486	.800
q32	1.65968	100.67399	1.65968	2.14200	.77483	.383
q36	.00475	65.85206	.00475	1.40111	.00339	.954
q37	1.25594	50.49476	1.25594	1.07436	1.16901	.285
q40	.28243	91.07126	.28243	1.93769	.14575	.704
q41	.00861	83.45813	.00861	1.77570	.00485	.945
q42	.81009	68.40418	.81009	1.45541	.55661	.459
q46	3.22510	71.30861	3.22510	1.51720	2.12569	.151
q47	4.87274	65.52048	4.87274	1.39405	3.49538	.068
q48	.22032	71.30162	.22032	1.51706	.14523	.705
q49	8.91949	84.57900	8.91949	1.79955	4.95650	.031
q50	1.73150	64.94764	1.73150	1.38186	1.25302	.269
q2	.01125	56.20979	.01125	1.19595	.00941	.923

Information Aggregation Effect Size

Variable	Partial ETA Square
IS Quality	.00398
Groupthink	.00026
Individual Analysis	.00415
Enjoyability	.01056
Group Awareness	.01074
Case Complexity	.04511
q12	.00987
q17	.01556
q18	.06330
q19	.01795
q20	.05995
q22	.00045
q29	.00138
q32	.01622
q36	.00007
q37	.02427

q40	.00309
q41	.00010
q42	.01170
q46	.04327
q47	.06922
q48	.00308
q49	.09540
q50	.02597
q2	.00020

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Technological Support

EFFECT .. CONDITION2 (Cont.)
Univariate F-tests with (1,47) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
IS Quality	13.18632	1673.44089	13.18632	35.60513	.37035	.546
Groupthink	880.72009	3180.80952	880.72009	67.67680	13.01362	.001
Individual Analysis	40.96314	466.38961	40.96314	9.92318	4.12802	.048
Enjoyability	6.93904	740.23576	6.93904	15.74970	.44058	.510
Group Awareness	356.35458	904.90276	356.35458	19.25325	18.50880	.000
Case Complexity	5.62382	426.59807	5.62382	9.07655	.61960	.435
q12	47.87259	80.33225	47.87259	1.70920	28.00882	.000
q17	2.68015	61.77689	2.68015	1.31440	2.03906	.160
q18	8.70752	206.89469	8.70752	4.40201	1.97808	.166
q19	6.01380	101.80078	6.01380	2.16597	2.77649	.102
q20	2.88235	140.90210	2.88235	2.99792	.96145	.332
q22	13.88022	47.69789	13.88022	1.01485	13.67713	.001
q29	1.39002	118.67433	1.39002	2.52499	.55051	.462
q32	.28327	100.67399	.28327	2.14200	.13225	.718
q36	8.86728	65.85206	8.86728	1.40111	6.32877	.015
q37	7.96845	50.49476	7.96845	1.07436	7.41696	.009
q40	8.70752	91.07126	8.70752	1.93769	4.49377	.039
q41	.12750	83.45813	.12750	1.77570	.07180	.790
q42	.01639	68.40418	.01639	1.45541	.01126	.916
q46	20.37491	71.30861	20.37491	1.51720	13.42924	.001
q47	3.50781	65.52048	3.50781	1.39405	2.51627	.119
q48	2.42198	71.30162	2.42198	1.51706	1.59650	.213
q49	1.23570	84.57900	1.23570	1.79955	.68667	.411
q50	11.66708	64.94764	11.66708	1.38186	8.44299	.006
q2	2.79158	56.20979	2.79158	1.19595	2.33419	.133

Technological Support Effect Size

Variable	Partial ETA Square
IS Quality	.00782
Groupthink	.21684
Individual Analysis	.08074
Enjoyability	.00929
Group	

Awareness	.28254
Case Complexity	.01301
q12	.37341
q17	.04158
q18	.04039
q19	.05578
q20	.02005
q22	.22541
q29	.01158
q32	.00281
q36	.11867
q37	.13630
q40	.08727
q41	.00153
q42	.00024
q46	.22223
q47	.05082
q48	.03285
q49	.01440
q50	.15228
q2	.04731

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Appendix H – Statistics
Consensus Results

ANOVA – Group Consensus – Max

Descriptive Statistics

Dependent Variable: Max # agreeing

Technology Condition	Information Aggregation Condition	Mean	Std. Deviation	N
Chat	Majority	4.6923	1.10940	13
	Uniform	4.2857	.91387	14
	Total	4.4815	1.01414	27
Both	Majority	3.9091	1.13618	11
	Uniform	3.6154	1.12090	13
	Total	3.7500	1.11316	24
Total	Majority	4.3333	1.16718	24
	Uniform	3.9630	1.05544	27
	Total	4.1373	1.11390	51

Tests of Between-Subjects Effects

Dependent Variable: Max # agreeing

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8.427(a)	3	2.809	2.462	.074
Intercept	861.310	1	861.310	755.079	.000
condition	6.682	1	6.682	5.858	.019
majuni	1.551	1	1.551	1.360	.249
condition * majuni	.040	1	.040	.035	.852
Error	53.612	47	1.141		
Total	935.000	51			
Corrected Total	62.039	50			

a R Squared = .136 (Adjusted R Squared = .081)

ANOVA – Group Consensus – Entropy

Descriptive Statistics

Dependent Variable: entropy

Technology Condition	Information Aggregation Condition	Mean	Std. Deviation	N
Chat	Majority	.210313	.1647506	13
	Uniform	.247094	.1099358	14
	Total	.229385	.1375540	27
Both	Majority	.281480	.1227400	11
	Uniform	.327016	.1355316	13
	Total	.306145	.1291160	24
Total	Majority	.242931	.1484033	24
	Uniform	.285575	.1271883	27
	Total	.265507	.1378583	51

Tests of Between-Subjects Effects

Dependent Variable: entropy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.096(a)	3	.032	1.768	.166
Intercept	3.593	1	3.593	197.781	.000
condition	.072	1	.072	3.974	.052
majuni	.021	1	.021	1.180	.283
condition * majuni	.000	1	.000	.013	.909
Error	.854	47	.018		
Total	4.545	51			
Corrected Total	.950	50			

a R Squared = .101 (Adjusted R Squared = .044)

Appendix I – Statistics
Pre-meeting Questionnaire Results

ANOVA – Pre-meeting Questionnaire

Descriptive Statistics

	Technology Condition	Information Aggregation Condition	Mean	Std. Deviation	N
Confidence Level	Chat	Majority	4.372	1.0333	78
		Uniform	4.524	1.1870	84
		Total	4.451	1.1148	162
	Both	Majority	4.667	1.1140	66
		Uniform	4.654	.9373	78
		Total	4.660	1.0185	144
	Total	Majority	4.507	1.0774	144
		Uniform	4.586	1.0728	162
		Total	4.549	1.0739	306
$ on John	Chat	Majority	33.7949	23.78604	78
		Uniform	29.9286	21.52879	84
		Total	31.7901	22.65579	162
	Both	Majority	30.2121	24.19887	66
		Uniform	31.5769	26.32589	78
		Total	30.9514	25.29472	144
	Total	Majority	32.1528	23.95897	144
		Uniform	30.7222	23.89736	162
		Total	31.3954	23.89781	306
$ on Alex	Chat	Majority	37.8718	24.22479	78
		Uniform	42.1310	24.67660	84
		Total	40.0802	24.47739	162
	Both	Majority	43.1667	24.58679	66
		Uniform	41.3077	28.12787	78
		Total	42.1597	26.48886	144
	Total	Majority	40.2986	24.44949	144
		Uniform	41.7346	26.31505	162
		Total	41.0588	25.42291	306
$ on Nali	Chat	Majority	28.3333	20.68230	78
		Uniform	27.9405	21.06808	84
		Total	28.1296	20.81929	162
	Both	Majority	26.6212	20.70137	66
		Uniform	27.1154	23.91597	78
		Total	26.8889	22.42411	144
	Total	Majority	27.5486	20.63632	144
		Uniform	27.5432	22.41758	162

		Total	27.5458	21.56256	306
How much effort	Chat	Majority	4.846	1.0075	78
		Uniform	4.702	1.2299	84
		Total	4.772	1.1272	162
	Both	Majority	4.652	1.0741	66
		Uniform	4.577	.9469	78
		Total	4.611	1.0043	144
	Total	Majority	4.757	1.0394	144
		Uniform	4.642	1.1012	162
		Total	4.696	1.0724	306
Interesting	Chat	Majority	4.705	1.0458	78
		Uniform	4.667	1.3473	84
		Total	4.685	1.2080	162
	Both	Majority	4.455	1.0551	66
		Uniform	4.615	1.0349	78
		Total	4.542	1.0436	144
	Total	Majority	4.590	1.0539	144
		Uniform	4.642	1.2036	162
		Total	4.618	1.1341	306
Important	Chat	Majority	4.282	1.4041	78
		Uniform	4.310	1.2985	84
		Total	4.296	1.3462	162
	Both	Majority	4.364	1.3771	66
		Uniform	4.359	1.2058	78
		Total	4.361	1.2825	144
	Total	Majority	4.319	1.3875	144
		Uniform	4.333	1.2511	162
		Total	4.327	1.3149	306
Difficult	Chat	Majority	4.718	.9656	78
		Uniform	4.333	.9980	84
		Total	4.519	.9983	162
	Both	Majority	4.439	.9943	66
		Uniform	4.282	1.0051	78
		Total	4.354	.9998	144
	Total	Majority	4.590	.9853	144
		Uniform	4.309	.9987	162
		Total	4.441	1.0007	306
Enjoyable	Chat	Majority	4.551	1.2022	78
		Uniform	4.583	1.0889	84
		Total	4.568	1.1414	162
	Both	Majority	4.439	1.1249	66
		Uniform	4.628	1.2599	78
		Total	4.542	1.1995	144
	Total	Majority	4.500	1.1648	144
		Uniform	4.605	1.1709	162
		Total	4.556	1.1673	306
Clear	Chat	Majority	4.308	1.3799	78

		Uniform	4.512	1.3398	84
		Total	4.414	1.3589	162
	Both	Majority	4.258	1.3957	66
		Uniform	4.410	1.4364	78
		Total	4.340	1.4150	144
	Total	Majority	4.285	1.3825	144
		Uniform	4.463	1.3838	162
		Total	4.379	1.3838	306
Enough Info	Chat	Majority	4.359	1.2271	78
		Uniform	4.036	1.4095	84
		Total	4.191	1.3306	162
	Both	Majority	4.045	1.3636	66
		Uniform	4.077	1.3748	78
		Total	4.063	1.3650	144
	Total	Majority	4.215	1.2964	144
		Uniform	4.056	1.3887	162
		Total	4.131	1.3462	306

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Whos Guilty	.674(a)	3	.225	.404	.750
	Confidence Level	4.274(b)	3	1.425	1.238	.296
	$ on John	724.795(a)	3	241.598	.421	.738
	$ on Alex	1186.882(c)	3	395.627	.610	.609
	$ on Nali	132.332(d)	3	44.111	.094	.963
	How much effort	2.999(e)	3	1.000	.868	.458
	Interesting	2.555(f)	3	.852	.660	.577
	Important	.352(d)	3	.117	.067	.977
	Difficult	8.927(g)	3	2.976	3.031	.030
	Enjoyable	1.368(h)	3	.456	.333	.802
	Clear	2.930(i)	3	.977	.508	.677
	Enough Info	5.528(j)	3	1.843	1.017	.385
Intercept	Whos Guilty	1134.457	1	1134.457	2039.095	.000
	Confidence Level	6296.848	1	6296.848	5472.513	.000
	$ on John	298941.003	1	298941.003	520.460	.000
	$ on Alex	513360.591	1	513360.591	791.228	.000
	$ on Nali	229656.716	1	229656.716	489.543	.000
	How much effort	6690.565	1	6690.565	5810.576	.000
	Interesting	6453.788	1	6453.788	5001.270	.000
	Important	5688.736	1	5688.736	3260.152	.000
	Difficult	5994.042	1	5994.042	6104.942	.000
	Enjoyable	6287.240	1	6287.240	4584.273	.000
	Clear	5803.147	1	5803.147	3015.937	.000

	Enough Info	5176.991	1	5176.991	2856.957	.000
condition	Whos Guilty	.003	1	.003	.005	.946
	Confidence Level	3.426	1	3.426	2.978	.085
	$ on John	71.007	1	71.007	.124	.725
	$ on Alex	379.437	1	379.437	.585	.445
	$ on Nali	122.159	1	122.159	.260	.610
	How much effort	1.944	1	1.944	1.689	.195
	Interesting	1.729	1	1.729	1.340	.248
	Important	.326	1	.326	.187	.666
	Difficult	2.064	1	2.064	2.103	.148
	Enjoyable	.085	1	.085	.062	.803
	Clear	.437	1	.437	.227	.634
	Enough Info	1.407	1	1.407	.777	.379
majuni	Whos Guilty	.371	1	.371	.667	.415
	Confidence Level	.368	1	.368	.320	.572
	$ on John	118.744	1	118.744	.207	.650
	$ on Alex	109.320	1	109.320	.168	.682
	$ on Nali	.195	1	.195	.000	.984
	How much effort	.905	1	.905	.786	.376
	Interesting	.284	1	.284	.220	.639
	Important	.010	1	.010	.006	.940
	Difficult	5.574	1	5.574	5.677	.018
	Enjoyable	.926	1	.926	.675	.412
	Clear	2.417	1	2.417	1.256	.263
	Enough Info	1.616	1	1.616	.892	.346
condition * majuni	Whos Guilty	.258	1	.258	.463	.497
	Confidence Level	.516	1	.516	.448	.504
	$ on John	519.276	1	519.276	.904	.342
	$ on Alex	710.312	1	710.312	1.095	.296
	$ on Nali	14.931	1	14.931	.032	.859
	How much effort	.091	1	.091	.079	.779
	Interesting	.754	1	.754	.584	.445
	Important	.020	1	.020	.011	.916
	Difficult	.980	1	.980	.998	.319
	Enjoyable	.466	1	.466	.340	.560
	Clear	.050	1	.050	.026	.872
	Enough Info	2.388	1	2.388	1.318	.252
Error	Whos Guilty	168.019	302	.556		
	Confidence Level	347.491	302	1.151		
	$ on John	173462.358	302	574.379		
	$ on Alex	195942.060	302	648.815		
	$ on Nali	141675.528	302	469.124		
	How much effort	347.737	302	1.151		
	Interesting	389.710	302	1.290		
	Important	526.969	302	1.745		
	Difficult	296.514	302	.982		

	Enjoyable	414.187	302	1.371		
	Clear	581.096	302	1.924		
	Enough Info	547.244	302	1.812		
Total	Whos Guilty	1314.000	306			
	Confidence Level	6684.000	306			
	$ on John	475803.000	306			
	$ on Alex	712992.000	306			
	$ on Nali	373991.000	306			
	How much effort	7099.000	306			
	Interesting	6917.000	306			
	Important	6256.000	306			
	Difficult	6341.000	306			
	Enjoyable	6766.000	306			
	Clear	6452.000	306			
	Enough Info	5774.000	306			
Corrected Total	Whos Guilty	168.693	305			
	Confidence Level	351.765	305			
	$ on John	174187.154	305			
	$ on Alex	197128.941	305			
	$ on Nali	141807.859	305			
	How much effort	350.735	305			
	Interesting	392.265	305			
	Important	527.320	305			
	Difficult	305.441	305			
	Enjoyable	415.556	305			
	Clear	584.026	305			
	Enough Info	552.771	305			

a R Squared = .004 (Adjusted R Squared = -.006)
b R Squared = .012 (Adjusted R Squared = .002)
c R Squared = .006 (Adjusted R Squared = -.004)
d R Squared = .001 (Adjusted R Squared = -.009)
e R Squared = .009 (Adjusted R Squared = -.001)
f R Squared = .007 (Adjusted R Squared = -.003)
g R Squared = .029 (Adjusted R Squared = .020)
h R Squared = .003 (Adjusted R Squared = -.007)
i R Squared = .005 (Adjusted R Squared = -.005)
j R Squared = .010 (Adjusted R Squared = .000)

Appendix J – Statistics
Chat Comment Count Results

Per User Overall

Descriptive Statistics

	N	Mean	Std. Deviation
count	306	26.43	22.221

Per Session Overall

Descriptive Statistics

Dependent Variable: count

session	Mean	Std. Deviation	N
1	38.83	17.982	6
11	25.00	3.406	6
12	38.00	12.490	6
14	16.83	12.828	6
15	13.83	8.612	6
16	64.67	44.554	6
17	53.67	56.202	6
18	29.67	12.801	6
19	25.83	12.156	6
2	42.17	23.362	6
20	33.33	19.128	6
21	29.17	12.750	6
22	31.17	19.854	6
23	64.83	44.038	6
25	36.00	12.806	6
26	30.33	23.830	6
27	43.00	18.450	6
28	25.83	13.393	6
29	16.83	9.786	6
3	31.00	18.698	6
30	24.17	13.212	6
31	46.83	38.050	6
32	23.17	12.937	6
33	4.17	2.563	6
35	26.67	20.265	6
36	9.83	8.841	6
37	46.83	29.896	6
38	29.00	16.137	6
4	21.83	12.875	6
40	16.83	12.416	6

41	23.17	14.757	6
42	23.67	18.096	6
43	17.00	9.798	6
44	12.50	9.607	6
45	27.83	17.566	6
47	31.50	33.780	6
48	14.67	12.832	6
49	22.17	9.704	6
5	31.00	7.694	6
50	13.17	7.782	6
51	10.83	8.256	6
52	25.00	20.669	6
53	20.83	9.174	6
54	20.17	11.839	6
55	2.17	1.835	6
56	5.50	6.348	6
57	14.33	9.709	6
58	13.67	14.236	6
59	16.17	7.757	6
6	32.50	6.863	6
7	30.83	14.162	6
Total	26.43	22.221	306

Per Experimental Conditions

Modified HANOVA – opinion factors and variable

Descriptive Statistics

Dependent Variable: count

Technology Condition	Information Aggregation Condition	Mean	Std. Deviation	N
Chat	Majority	30.76	21.207	78
	Uniform	38.98	26.330	84
	Total	35.02	24.279	162
Both	Majority	15.35	12.897	66
	Uniform	17.97	15.815	78
	Total	16.77	14.561	144
Total	Majority	23.69	19.420	144
	Uniform	28.86	24.245	162
	Total	26.43	22.221	306

Tests

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	94894.67	255	372.14		
SESSION2					
WITHIN COND	27346.59	47	581.84	1.56	.016 - **Grp**
ITION2 BY MAJUNI2 (ERROR 1)					
Error 1	27346.59	47	581.84		
CONDITION2	25384.68	1	25384.68	43.63	.000 - **Tech**
MAJUNI2	2385.32	1	2385.32	4.10	.049 - **Info**
CONDITION2 BY MAJUNI2	593.80	1	593.80	1.02	.318 - **Inter**

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