INFLUENCE, INFORMATION TECHNOLOGY & GROUP POLARIZATION: A FIELD STUDY OF A VIRTUAL TEAM

Completed Research Paper

Chih-Hung Peng
Georgia Institute of Technology
800 West Peachtree NW, Atlanta GA 30308
chih-hung.peng@mgt.gatech.edu

Sandra A. Slaughter
Georgia Institute of Technology
800 West Peachtree NW, Atlanta GA 30308
sandra.slaughter@mgt.gatech.edu

Abstract

This study examines influence and IT in group polarization. Group polarization is the tendency of group members to shift their initial positions to a more extreme direction following discussion. We hypothesize that informational influence is relatively more important than normative influence in causing group members to shift their positions and that IT can be used to enhance the effects of informational influence. Our investigation of group processes, influence and IT use by a virtual team responsible for forecasting ozone levels reveals several important findings. First, we find the heterogeneity of pre-discussion individual decisions and greater task uncertainty increase group polarization through a greater relative use of informational influence. Second, surprisingly, we find that the relative use of informational influence and the use of IT for persuasion are substitutive not complementary in their effects on group polarization. These findings have significant theoretical and practical implications for decision making in virtual teams.

Keywords: Virtual teams, group polarization, information technology, influence, persuasion

Introduction

Does group discussion really help group members reach an unbiased consensus? During a discussion, group members can exchange factual information and share individual preferences to reconcile their differences. In addition, a group can combine information from multiple perspectives to avoid making a risky group decision. However, contrary to people's expectations, group members have a tendency to shift their initial positions/decisions in an extreme direction following a group discussion (Isenberg 1986). Such a tendency is called "group polarization." For example, jurors who initially favor a harsh penalty are more likely to decide on a harsher penalty after discussion, while jurors who initially favor a short sentence tend to decide on a shorter sentence after discussion (Sunstein, 2002).

In the academic field, group polarization has been considered an important and significant group phenomenon. Researchers from many disciplines, including jury decision making (MacCoun 1989), organizational behavior (Heath and Gonzalez 1995), information systems (Sia et al. 2002), marketing (Chandrashekaran et al. 1996), finance (Barber et al. 2003), political science (Stroud 2010), public policy (Paluck 2010), communication (Lee 2007), and economic decision making (Cason and Mui 1997), have taken an interest in group polarization. To enhance understanding of why group polarization occurs, researchers have identified several group processes and antecedents. Prior studies have proposed that either one of two underlying mechanisms/processes can be used to explain group polarization: normative influence and informational influence (Isenberg 1986). In the first, group polarization takes place when individuals are motivated to present themselves in a socially favorable light. In the second, group polarization occurs when group members exchange persuasive arguments during their discussion. In addition to group processes, researchers have identified many antecedents of group polarization such as pre-discussion individual decisions (Butler and Crino 1992; Vinokur and Burnstein 1978a), risk level (Shupp and Williams 2008), group composition (Farrar et al. 2009), culture (El-Shinnawy and Vinze 1997), and media use (Lea and Spears 1991; Siegel et al. 1986).

Why do group members polarize their group decisions? Two points motivate our approach to this question. The first is the perspective of influence. Group members can make a group decision by using a single influence process (e.g., normative influence), but recent studies have underscored the importance of the interplay among various influences. The second is the perspective of technology. Information technologies are not only communication or decision making tools but are also persuasive tools that can be used to change one's opinions (Fogg 2003). These two motivations are linked to research on group polarization.

Past studies have focused on the investigation of antecedents. To date, however, we know little about the process of group polarization. Most of the past studies on group polarization have treated a group process as a "black box," but in this study, we attempt to open up this black box. The first goal of this study is to explore the interplay between informational influence and normative influence. Many researchers have investigated the effect of these influences on group polarization separately. That is, while some researchers have argued that informational influence is a sufficient and necessary process to explain group polarization, other researchers have reasoned that normative influence is a major process for judgmental tasks. However, to our knowledge, group polarization researchers have not studied the relative use of informational versus normative influence. Specifically, relative use is the ratio of the use of informational influence arguments to normative influence arguments. An investigation into relative use is very critical because the magnitude of group polarization may differ according to influence usage. In other words, a group with higher relative use during its discussion may experience a different magnitude of group polarization than a group with lower relative use.

Moreover, past studies have often considered technologies as either communication tools (e.g., Daft et al. 1987), or decision support tools (e.g., Todd and Benbasat 1999), or both (e.g., Zigurs et al. 1988). We know little about whether information technology can be used to persuade group members during a group discussion. Thus, the second goal of this study is to investigate the new role of information technology for persuasion in group polarization. Group members are more likely to shift or polarize their positions when receiving credible and persuasive information (Barber et al. 2003; Burnstein and Vinokur 1977; Isenberg 1986). Research on credibility has suggested that the credibility of information can increase because of source citations or references. For example, people are more likely to believe a tornado warning supported/cited by weather information technologies than they are a warning that is not supported/cited by such technologies. That is, a high intensity of informational references is associated with a high level of persuasiveness. Therefore, the intensity of information technology references and relative use may interact in their effect on the magnitude of group polarization. Another important factor that has not been analyzed in past studies is reference to information technology.

The third goal of this study is to examine when group members may adjust their relative use of informational influence versus normative influence. Since past studies have examined links between group polarization and its antecedents directly, our study complements these studies by exploring the relationships between antecedents and group processes. Two antecedents that may affect the relative use of informational influence versus normative influence are (1) the heterogeneity of pre-discussion individual decisions and (2) the uncertainty of the task. The goals of this study are consistent with a call by Sia et al. (2002) for research focusing on the group discussion process at a greater level of detail and a call by El-Shinnawy and Vinze (1998) for research investigating the relative importance of informational influence versus normative influence in virtual team settings.

In addition, we can further enhance knowledge about group polarization by including a field study. Most past studies have used controlled experiments to investigate group polarization. Because of experimental constraints, these experiments have focused on a single-shot task. Our study can complement these experiments by conducting a field study. Our field study allows us to investigate whether group polarization still takes place in a repeated task and time-constrained environment.

More knowledge about group polarization may be beneficial to group leaders or decision makers. Group polarization is a double-edged sword. On the one hand, group polarization can be favorable. For example, if a community, a city, or a country is seriously destroyed by a natural disaster (e.g., a tsunami, an earthquake, or a hurricane), individuals may be more generous when helping the victims after a social discussion (Muehleman et al. 1976). Thus, we could have expected group polarization to be very useful in fundraising activities for the March 11, 2011 earthquake in Japan, the fourth largest in the world, and for the May 12, 2008 earthquake in China, which caused over 69,000 fatalities and 18,000 missing. On the other hand, group polarization can be very harmful. For example, a weather forecasting group may initially issue a hurricane warning, but the group may then decide not to issue a warning after discussion. Such a decision might lead to enormous public health consequences if a warning was needed. Another example relates to an airline crash. According to the National Transportation Safety Board report, the reason that American Airlines Flight 1420 crashed on June 1, 1999, was that both pilots made a risky landing decision following a discussion. Therefore, exploring group polarization in more detail may encourage a group to make a favorable decision or discourage a group from making an unfavorable one.

Our research setting is well-suited for conducting a field study on group polarization. We investigated the group processes and information technology use of a virtual team responsible for forecasting ozone levels for the 5-million person Atlanta region in the United States. This natural research setting provides a rich context for examining the relative use of informational influence versus normative influence in an expert virtual team. The group's forecasting task is relatively constant but the level of uncertainty varies from day to day. Over a two-year period, we observed individual predictions before discussion, the intensity of information technology references used to support forecasters' arguments, and the magnitude of group polarization.

Our results reveal several interesting findings. First, we find that the relative use of informational influence versus normative influence is an important group process. The heterogeneity of pre-discussion individual decisions and task uncertainty cause group polarization through relative use. Surprisingly, we also find that relative use and the intensity of information technology references have a substitutive rather than complementary effect on group polarization.

Literature Review

Group Polarization

Before Stoner's (1961) classic study, the conventional wisdom had been that the members of a group would make riskier individual decisions than the group did. The supporting argument was that a group can combine information from different perspectives and prevent its members from making a risky decision. However, Stoner (1961) found the opposite. That is, a group is more likely to make a risky decision following a discussion than its typical or average group member. Researchers have called this phenomenon a risky shift. In addition, some researchers have found that, in some cases, a group decision moves toward a more cautious direction after discussion. Therefore, such movement has been called a cautious shift.

Researchers have considered either a cautious shift or a risky shift as group polarization. Group polarization has been defined as the inclination of making an extreme decision (risky or cautious) following group discussion (Isenberg 1986; Myers and Lamm 1976). However, an extreme decision does not indicate that group decisions have to move to one polar side. Researchers have suggested that an extreme decision is a within-group movement, not toward the middle of initial group members' preferences, but toward the initial tendency of those preferences (Butler and Crino 1992; Sunstein 2002).

Such a group's tendency can be explained by social comparison theory and persuasive argument theory. Social comparison theory posits that people are motivated to present themselves in a socially favorable light during group discussion (Baron and Roper 1976; Brown 1986). This motivation may lead to either a pluralistic balance behavior or a one-upmanship behavior (Isenberg 1986). A pluralistic balance behavior refers to a compromising behavior in which individuals present their positions between what they prefer and what their group prefers. A one-upmanship behavior is that individuals want to be distinct from as well as better than other people in a desirable direction. Therefore, group polarization results when most members of a group exhibit such behaviors, which are considered as normative influence.

In contrast, proponents of persuasive argument theory have suggested that only informational influence, not normative influence, is necessary and sufficient to cause group polarization (Burnstein 1982; Vinokur and Burnstein 1978b). The theory has argued that an individual's position is influenced by the number and persuasiveness of available arguments during group discussion. Persuasiveness can be determined by two components of an argument: novelty and validity (Isenberg 1986). Novelty of an argument is the level to which an argument can shed new insights. Validity is the level to which an argument is sound. Thus, group polarization is likely to occur when group members are exposed to more valid and/or novel arguments during a discussion. Such exposure of arguments is considered as informational influence.

Previous studies have debated whether group polarization can be better explained by two theories together. Some researchers have argued that persuasive argument theory alone is enough for the explanation of group polarization (Burnstein and Vinokur 1977; El-Shinnawy and Vinze 1998). These researchers also have argued that persuasive argumentation mediates the relationship between social comparison and group polarization. That is, social comparison is neither a necessary nor a sufficient condition. However, other scholars have suggested that social comparison theory and persuasive argument theory together are able to provide a better explanation for group polarization than either one alone (Isenberg 1986; Sia et al. 2002). For instance, a meta-analysis by Isenberg (1986) has suggested that both social comparison and persuasive argumentation co-occur during group discussion to produce group polarization, though the effect of persuasive argumentation is stronger than the effect of social comparison. Moreover, many scholars have proposed that both influences should be explored at the same time to effectively investigate group discussion (Butler and Crino 1992; Huang and Wei 2000; Kaplan and Miller 1987). Therefore, informational influence and normative influence could be considered important mechanisms which link group polarization and its antecedents.

Information Technology & Credibility

Past studies have investigated the different roles of information technologies. Most of the studies have considered information technologies as decision support and/or communication support tools. To effectively make a decision, people can use information technologies to facilitate information processing (e.g., Todd and Benbasat 1999). In addition, to clearly express their opinions, people can select technologies/media to convey different messages (e.g., Daft et al. 1987). Relatively few studies have examined the persuasive role of information technologies. Fogg and his colleagues have defined persuasive technologies as tools which are used to change one's attitude and behavior (Fogg 2003; Tseng and Fogg 1999). The tendency of the change is determined by the credibility level of information. That is, people are more likely to shift their decisions when receiving credible information.

Generally, credibility has been defined as believability (Tseng and Fogg 1999). Credible people are believable people; a credible message is a believable message. Moreover, Webster's dictionary defines credibility as "the quality or power of inspiring belief."

Credibility has been investigated in many academic disciplines such as communication (Metzger et al. 2003), information science (Hilligoss and Rieh 2008), marketing (Erdem and Swait 2004), and management information systems (Bhattacherjee and Sanford 2006; Poston and Speier 2005). Researchers from diverse disciplines together have enhanced our understanding of the concept of credibility. However, because these disciplines have their own goals, preferred methodologies, and backgrounds, such inconsistencies not only cause field-specific definitions of credibility but also lead to different focused dimensions of credibility (Rieh and Daniels 2007). Some disciplines (e.g., communication) have paid significant attention to source and media credibility, whereas others (e.g., information science) have focused on message credibility (Flanagin and Metzger 2007). That is, whether information is credible can be judged from either a source perspective or a message perspective. Although credibility can be examined from different perspectives, most researchers have considered credibility as a perceived characteristic of information (Wathen and Burkell 2002).

One stream of credibility research has suggested that source credibility is positively related to the perception of credible information. That is, sources with high credibility are more likely to create information that is perceived to be more credible than are sources with low credibility. Source credibility is determined by two key dimensions (Fogg et al. 2001; Self 1996). The trustworthiness dimension is defined as the extent to which a source is perceived to be well-intentioned, truthful, and unbiased. The expertise dimension, on the other hand, refers to the extent to which a source is perceived to be knowledgeable, experienced and competent.

In addition to these two dimensions, researchers have recognized that identifying the types of source credibility can enhance our understanding of how a source gains and loses its credibility. Tseng & Fogg (1999) have identified four types of source credibility. First, reputed credibility results from source labels. For instance, the source labeled *Consumer Reports* is perceived as more credible than the source labeled *National Enquirer*. Second, presumed credibility is based on the general assumptions of a perceiver. For example, people often have negative views of car salesmen and assume the salesmen are dishonest with low credibility. By contrast, people assume their friends are generally honest, so they consider such friends as credible sources. Third, surface credibility indicates the extent to which a perceiver believes a source by simply inspecting. For example, users judge a book by its cover. Finally, experienced credibility refers to the extent to which a perceiver believes a source by using first-hand experience. For instance, interacting with sources over time can help people evaluate sources' credibility.

Another stream of credibility research tends to focus on the message rather than the source. This stream has discussed the relationship between three message attributes and users' perception of credibility (Flanagin and Metzger 2007; Hong 2006; Metzger et al. 2003). The first attribute is message content. Research on message content has attempted to identify which aspects of message content are related to credibility assessment. For instance, quality of a message, currency of a message, and the use of citations in a message are three possible aspects (Rieh and Belkin 1998; Slater and Rouner 1996; Sundar 1998). The second attribute is message organization. Organization-related research has found that the structure of a message can influence credibility assessment. For example, a well written message is more likely to be perceived from credible source than is a poorly written message (Slater and Rouner 1996). Furthermore,

message delivery has been related to credibility (Hong 2006). For example, the speed of loading is used to evaluate the credibility of information in a website (Rieh and Belkin 1998).

Although they assess credibility in different ways, credibility researchers have admitted that assessment from either a source or a message perspective is not complete (Wathen and Burkell 2002). It is hard to differentiate the impact of source from the impact of message on the perception of credibility. In other words, credible sources are assumed to create more credible messages; credible messages are assumed to be originated from credible sources (Fragale and Heath 2004). Therefore, source-oriented and message-oriented credibility may have many overlaps. For instance, the notion of reputed credibility in source-oriented studies is similar to the use of citations in message-oriented studies.

Information technology increases the credibility of an argument. One way to increase the reputed credibility of an argument is the use of a source reference. In other words, referring to a reference is similar to increasing the reputed credibility of an argument. Therefore, referring to information technologies can enhance the perception of the credibility of an argument. This implies that information technologies could play a role for persuasion in group decision making setting.

Hypotheses

Past studies have suggested that two group processes, persuasive argumentation and social comparison, can be used to explain why group polarization occurs (Isenberg 1986). Persuasive argument theory has argued that exchanging factual information and data causes people to shift their initial decisions in an extreme direction, whereas social comparison theory has claimed that sharing individual preferences and values leads people to change their original choices. Therefore, persuasive argumentation and social comparison are named as informational influence and normative influence, respectively.

The amount of the use of different types of influence is determined by the nature of the task (El-Shinnawy and Vinze 1998; Kaplan and Miller 1987). Laughlin and his colleagues have proposed that tasks vary along an intellective-judgmental continuum (Laughlin 1980; Laughlin and Earley 1982). That is, for example, if a task is relatively closer to the intellective end of the continuum, its intellective component would predominate over its judgmental component. A task with a predominant intellective component can be completed by focusing on exchanging factual information. This implies that informational influence arguments would be used relatively more than normative influence arguments for intellective tasks. Conversely, a task with a predominant judgmental component can be fulfilled by focusing on sharing individual preferences. This implies that normative influence arguments would be used more, relative to informational influence arguments for judgmental tasks. Thus, to effectively complete a task, group members have to consider the relative use of informational influence arguments versus normative influence arguments because a task involves these two components.

In our study, we did not attempt to compare the effect of informational influence to that of normative influence since past research has demonstrated the result (e.g., Isenberg, 1986). We also did not examine whether the combination of informational influence and normative influence would lead to greater group polarization. However, unlike past studies, our study has focused on how the relative use of informational influence versus normative influence is affected by antecedents and leads to group polarization.

Pre-discussion Individual Decisions and Relative Influence Use

One of the purposes of using teams, rather than individuals, is to bring multiple perspectives to bear on important decisions (Hackman and Morris 1975). Virtual teams further enhance the range of perspectives by bringing together individuals from different organizations and locations (Martins et al. 2004). In some cases, these different perspectives lead to similar conclusions; in others, differences in the ways in which individuals interpret and combine data can lead to very different predictions (Priem and Harrison 1995). That is, the heterogeneity of pre-discussion individual decisions may be quite different.

A level of heterogeneity could determine how group members complete their tasks. A higher level of heterogeneity indicates that the range of group members' opinions is wider. To complete a task with high heterogeneity, group members are more likely to follow a collective decision. Such following behaviors can intensify, protect, or rebuild their self-esteem (Cialdini and Goldstein 2004) and also can share the risk of making an erroneous decision. Moreover, an increase in heterogeneity makes a task's judgmental

component salient, especially during time-constrained discussion. The salience leads group members to pay more attention to social comparison than persuasive argumentation since a group decision will be determined by the consensus of preference (El-Shinnawy and Vinze 1998; Kaplan and Miller 1987). Therefore, the increased likelihood of following behaviors and increased attention to social comparison cause group members to focus on a group process which can facilitate consensus development (i.e., normative influence), rather than a process which can help increase understanding of a task (i.e., informational influence). That is, we can expect that when heterogeneity is higher, group members will use more normative influence relative to informational influence. This suggests that:

> *HYPOTHESIS 1 (H1): Higher heterogeneity of pre-discussion individual decisions is associated with lower relative use of informational influence versus normative influence.*

Task Uncertainty and Relative Influence Use

Research on interpersonal communications (Carlson and Zmud 1999; Daft and Lengel 1984) suggests that uncertainty reduction is one important objective. Uncertainty refers to the gap between the amount of information required to perform a task and the amount of information the performer has (Daft et al. 1987). A high level of uncertainty indicates a large information gap. To effectively accomplish a highly uncertain task, group members tend to focus on a group process which enhances information sharing (i.e., informational influence) rather than a group process which facilitates consensus building (i.e., normative influence). That is, uncertainty could be reduced by gathering more factual information. Thus, it is reasonable to expect that when the level of uncertainty is higher, group members will increase informational influence relative to normative influence.

> *HYPOTHESIS 2 (H2): Higher task uncertainty is associated with higher relative use of informational influence versus normative influence.*

Relative Influence Use and Group Polarization

Group polarization can be explained by informational influence and normative influence. Proponents of persuasive argument theory have argued that group members' positions can be affected by the number and persuasiveness of available arguments during a group discussion. Supporters of social comparison theory, on the other hand, have claimed that group members are motivated to act in a socially desirable direction. To thoroughly investigate group polarization, researchers have suggested that considering two influences simultaneously is more appropriate (Isenberg 1986; Sia et al. 2002).

The relative use of informational influence versus normative influence can determine the extent to which group members polarize the group's decision. As discussed earlier, a meta-analysis has found that the impact of informational influence on group polarization is larger than that of normative influence (Isenberg 1986). This finding suggests that a higher level of relative use will lead to a greater magnitude of group polarization; a lower level of relative use will cause a smaller magnitude of group polarization. A higher level of relative use indicates that, during a group discussion, group members are exposed to relatively more persuasive argumentation than social comparison. Thus, the relative use of informational influence versus normative influence is likely to be positively associated with the magnitude of group polarization.

> *HYPOTHESIS 3 (H3): The greater the group's relative use of informational influence versus normative influence, the greater the magnitude of group polarization.*

Information Technology Reference and Group Polarization

Information technologies can be tools for persuasion (Fogg 2003; Tseng and Fogg 1999). Such tools are used to change people's attitudes and behaviors by increasing the credibility of information received. Fogg and his colleagues have identified four types of credibility. One of those is reputed credibility. Reputed credibility can be increased by using citations, references, or labels. Hence, information with a reference is more believable and persuasive than information without any reference. For instance, referring to a technology such as "NAM" model may increase the persuasiveness of an argument about the patterns of sea level pressure.

The intensity of references determines the persuasiveness of arguments and information. During a time-constrained discussion, group members have to make a group decision as soon as possible. Thus, group members are less likely to exchange messages with many references. That is, the low intensity of references in messages can be expected. In our setting, the members of a virtual team can choose whether they want to cite an information technology to support their arguments. Citing fewer information technologies equals the lower intensity of information technology references. However, the lower the intensity of information technology references, the weaker the persuasiveness of messages. Conversely, the higher the intensity of information technology references, the greater the persuasiveness of messages.

Group members' positions are affected by the persuasiveness of available arguments and messages. The magnitude of group polarization should be even greater when both the relative use of informational influence versus normative influence and the intensity of information technology references are high. When group members are exposed to relatively more informational influence than normative influence, group members are more likely to change their positions in a larger magnitude. This likelihood is amplified in a persuasive environment. During group discussion, persuasiveness can be increased by citing more information technologies.

> *HYPOTHESIS 4 (H4): The relative use of informational influence versus normative influence and the intensity of information technology reference interact positively in their effect on the magnitude of group polarization, such that the positive effect of the relative use on the magnitude of group polarization is stronger with a higher intensity of information technology reference.*

Method

To evaluate our hypotheses on the relative use of informational influence versus normative influence, we conducted a field study. The field study involved collecting daily data on group discussion content from a virtual smog forecasting team during ground-level ozone season (May 1 to September 30) in Atlanta, Georgia, in 2007 and 2008. The following describes the setting of the data collection and our measures of key variables.

Research Setting

The setting for our study is a ten-person virtual team responsible for forecasting air quality for the Atlanta region. The team is made up of research scientists at a major research university and the state's environmental protection division (EPD). Team members include meteorologists, atmospheric scientists, a geochemist, and an expert in statistics, and are located in various parts of the region.

The primary task of the team each day is to forecast the air quality (i.e., the level of ozone pollutant concentrations measured as parts-per-billion (PPB) in the air) for the subsequent day in the Atlanta metropolitan area and surrounding cities during the ground-level ozone season (May 1 to September 30). The U.S. Environmental Protection Agency (EPA) classifies different levels of air quality into six color zones, based on ozone concentration values. A value between 0-59 (green) is considered "good"; 60-75 (yellow) is "moderate"; 76-95 (orange) means "unhealthy for sensitive groups"; 96-115 (red) is "unhealthy for everyone"; 116-374 (purple) is "very unhealthy for everyone"; and over 374 (brown) is considered "dangerous for everyone," but conditions in this range have never occurred in Georgia. In Atlanta, smog alerts are issued in three color zones: orange, red, and purple. Air quality forecasting is a difficult task, and is particularly challenging in the Atlanta area. For example, thunderstorms can unexpectedly develop and clear out air pollutants, or accidents can trigger major traffic congestion that increases air pollutants. In addition, the smog forecasting team makes predictions for surrounding cities, and a city northwest of Atlanta can experience very different conditions than a city southeast of Atlanta.

This field setting is especially well suited to study the relative use of informational influence versus normative influence by virtual teams. The virtual smog forecasting team consists of an experienced group of experts whose task, predicting the next day's peak ozone concentration, remains constant; however, the heterogeneity of pre-discussion individual decisions and the uncertainty of a task can vary considerably from day to day. In addition, the forecasters use a website to assess information technologies used to make forecasts, to post individual predicted value, and to store team's discussion content. The website

allows us to measure team's relative use of informational influence versus normative influence, the intensity of information technology references and predicted air quality level on each day. In sum, studying how an experienced virtual team makes high-uncertainty decisions in a dynamic environment in the same task over time offers a strong test of the extent to which variations in the decision context affect relative use. Moreover, studying such team allows us to investigate how the intensity of information technology references moderates the effect of the relative use on the magnitude of group polarization.

Dependent Variables

Relative Use of Informational Influence versus Normative Influence (*RELATIVE USE*): We selected Sia et al.'s (2002) coding scheme to classify group processes. Past studies provided many coding schemes (El-Shinnawy and Vinze 1998; Huang and Wei 2000; Kaplan and Miller 1987; Sia et al. 2002; Zigurs et al. 1988), but some of these coding schemes have been used in different contexts or for one specific process (e.g., only informational influence process). This study chose Sia et al.'s coding scheme because (1) it was specifically designed to classify group processes as normative influence or informational influence and (2) it can be used to investigate group polarization. Based on Sia et al.'s coding scheme, group discussion was coded into five categories (novel argument, valid argument, pluralistic balance statement, one-upmanship statement, and other statement). The first two types reflected informational influence and the third and fourth types were considered normative influence. The unit of analysis was a sentence which group members uttered during group discussion. Appendix A provides a sample coding.

In order to establish coding reliability, the study included two coders. Coder 1 was one of the authors and Coder 2 was a graduate student who did not know any hypothesis in the study. Before coding forecasting discussions, Coder 1 studied basic meteorology and weather forecasting for a year and frequently discussed coding content with a principle forecaster. We randomly selected 20 of 300 daily discussions for Coder 2: five discussions for 4 conditions (high vs. low heterogeneity and high vs. low task uncertainty). Since weather forecasters used many forecasting jargons (e.g., BL: boundary layer depth; COT: cloud optical thickness) and technology abbreviations (e.g., vis sat: visible satellite imagery), Coder 1 had to interpret such jargons and technology abbreviations to Coder 2 when Coder 2 was coding the discussion content. However, Coder 1 was not allowed to help Coder 2 make any coding decision. Following Kaplan and Miller (1987), we computed the coefficient of agreement for each of the 4 conditions: .84, .89, .90, .96. Overall, the coefficient is .89. Therefore, coding reliability was considered acceptable. Both coders discussed with each other to reconcile their coding differences. After that, Coder 1 independently coded the rest of the discussions.

We measured *RELATIVE USE* by the team on a particular day as the number of informational influence sentences used during the team's chat room discussion that day divided by the number of normative influence sentences used. This ratio controls for potential differences in the number of influence sentences used on a given day. For example, during group discussion, if the team utilizes 10 informational influence sentences and 20 normative influence sentences, the relative use of informational influence versus normative influence on that day is 0.5.

Group Polarization (*POLARIZATION*): Group polarization has been widely considered as a choice shift (Zuber et al. 1992). The choice shift is measured by taking the absolute difference between the final group decision and the average of pre-discussion individual decisions (Sia et al. 2002; Sunstein 2002). The difference refers to the magnitude of group polarization. In other words, a higher value indicates a larger degree of group polarization.

Moderator

Intensity of Information Technology Reference (*INTENSITY*): We measured the intensity of information technology references by dividing the number of information technology references by the number of informational influence sentences used during team discussion. For instance, if the discussion content includes two technology references and ten informational influence sentences, the intensity of information technology reference is 0.2.

Independent Variables

Heterogeneity of Pre-discussion Individual Decisions (*HETERO*): Heterogeneity measures the distribution of group members' pre-discussion decisions (Butler and Crino 1992). Such distribution can be computed by the variance in the initial individual forecasts on a given day. For example, if forecasters made three individual predictions: 75, 80, and 80, the heterogeneity of pre-discussion individual decisions would be 8.33.

Task Uncertainty (*UNCERTAINTY*): Background interviews and discussions after observing the team forecasting process revealed that team members perceived two borders as the most uncertain. The first is the yellow-orange border. A yellow color zone does not involve issuing a smog alert; an orange color zone involves issuing a smog alert for sensitive groups (e.g., children, elders, and individuals with heart or lung disorders.) If the team finds that any air pollutant (e.g., carbon dioxide emission) will impact at least one sensitive group, the team will forecast an orange color zone. Conversely, if the team finds that no air pollutant will affect any sensitive group, the team will forecast a yellow color zone. Thus, the yellow-orange border is seen as uncertain since the team has to obtain additional environmental information to choose between a yellow zone and an orange zone. The second is the orange-red border. A red color zone involves issuing a smog alert for everyone. If the team finds that air pollutants will affect not only all sensitive groups but also everyone else, the team will forecast a red color zone. Otherwise, the team will only forecast an orange color zone if the team finds that at least one group will not be influenced by air pollutants (e.g., young adults with good health conditions.) Thus, the orange-red border is seen as even more uncertain since more information is needed for the team to decide between an orange zone and a red zone. The team did not express similar concerns about predictions at the green-yellow border as this border does not involve a smog alert, so the team did not attempt to identify which color zone is most likely. Accordingly, we used one binary variable to represent uncertainty and coded *UNCERTAINTY* as "1" if the initial team perception was within 5 parts-per-billion (PPB) of the yellow-orange border or the orange-red border; "0" otherwise.

Control Variables

In our analysis, we controlled for other factors likely to affect group processes and group polarization. Prior research has suggested that group size (*GROUP SIZE*) can affect both group processes and group polarization (Butler and Crino 1992; Smith et al. 1994; Teger and Pruitt 1967); thus, we include group size as a covariate. We measured group size for each day by counting the number of forecasters who participated by posting an initial forecast.

In addition, virtual teams can be composed of members from different locations and different expertise. Such differences may make in- and out-group characteristics salient, which would affect group processes (e.g., group cohesion) (Martins et al. 2004). We controlled two basic diversities in virtual teams: expertise and location. First, the virtual smog members' expertise was coded based on their academic training. We classified group members into six categories: "Meteorologist", "Atmospheric Scientist", "Geochemist", "Statistician", "Monitoring Expert", and "Other". Second, the group members were located at either a major research university in Georgia or the state's environmental protection division (EPD). Following past research on team diversity (Knight et al. 1999), expertise diversity as well as location diversity were computed using Blau's (1977) heterogeneity index: $(1- \Sigma p_i^2)$, where p_i is the proportion of the group in the i th category.

Furthermore, to control for differences in ground-level ozone concentrations on weekdays versus weekends (U.S. Environmental Protection Agency 2003), we coded *WEEKDAY* as "1" for Monday to Friday and "0" otherwise. Because ground-level ozone concentrations vary by month and year (e.g., due to the use of reformulated fuel or shifts in population (U.S. Environmental Protection Agency 2003)), we used four binary variables, *JUNE*, *JULY*, *AUGUST*, and *SEPTEMBER*, to distinguish these months from the base month of May.

Analysis and Results

The data on heterogeneity of pre-discussion individual decisions, task uncertainty, intensity of information technology reference, and the magnitude of group polarization yielded a total of 300 daily

observations from 2007-2008. Table 1 reports the means, standard deviations, and correlations of the variables in the analysis. As shown in Table 1, pair-wise correlations between the variables in our analysis are modest with almost all well below 0.50.

We conducted a number of specification checks. We examined our model for multicollinearity by calculating a condition index for the whole model and variance inflation factors (VIF) for each of the independent variables. As a rule of thumb (Kennedy 2008), a condition index should be lower than 30 and each independent variable should have a VIF < 10 . The condition index and the VIFs were all well below the recommended cutoff value, thus suggesting multicollinearity may not be a potential data analysis problem.

In addition, we conducted Durbin-Watson's test for autocorrelation and White's test for heteroskedasticity (Greene 2003; Kennedy 2008). As for autocorrelation, Durbin-Watson's d-statistic demonstrated that the result of autocorrelation existence was inconclusive. Thus, we conducted a further analysis (see our robustness analysis section). The results showed the autocorrelation was not an issue in our data. As for heteroskedasticity, White's test revealed no diagnostic problem.

Relative Use of Informational Influence vs. Normative Influence

The first two hypotheses investigated the relationships between the antecedents of group polarization and the relative use of informational influence versus normative influence. Using hierarchical regression analysis, we estimated the effect of the heterogeneity of pre-discussion individual decisions and the effect of task uncertainty on relative use.

$$\text{RELATIVE USE} = \beta_0 + \beta_1\text{WEEKDAY} + \beta_2\text{JUNE} + \beta_3\text{JULY} + \beta_4\text{AUGUST} + \beta_5\text{SEPTEMBER} + \beta_6\text{YEAR2008} + \beta_7\text{GROUP SIZE} + \beta_8\text{EXPERTISE} + \beta_9\text{LOCATION} + \beta_{10}\text{HETERO} + \beta_{11}\text{UNCERTAINTY} + \varepsilon \quad \textbf{(1)}$$

Table 2 displays the results of these estimates. In the first step of our estimation, we entered all control variables into the model. In the second step, adding HETERO and UNCERTAINTY resulted in a significant increase in variance explained ($\Delta R2 = 0.12$, $F = 22.67$, $p < 0.001$), suggesting that these antecedent variables explain significant variation in the relative use of informational influence versus normative influence.

Hypothesis 1 posited that higher levels of heterogeneity of pre-discussion individual decisions were associated with lower relative use of informational influence versus normative influence. We found that the effect of heterogeneity on relative use was significant, but the sign of the coefficient was in a direction opposite from our expectation ($\beta_{10} = 0.01$, $p < 0.01$).

Hypothesis 2 postulated that higher levels of task uncertainty were associated with greater relative use of informational influence versus normative influence. The effect of task uncertainty on relative use was positive and significant ($\beta_{11} = 0.38$, $p < 0.001$). Therefore, Hypothesis 2 was supported.

Impact on Group Polarization

Following a standard practice for analyzing models with interaction effects (Aiken and West 1991; Cohen and Cohen 1983), We used hierarchical OLS regression analysis to estimate the effects of the relative use of informational influence versus normative influence as well as the intensity of information technology references on the magnitude of group polarization as shown in Equation 2 below. This approach allows us to evaluate whether the variables add significant explanatory power to the model incrementally over all other variables. As can be seen in the Table 3, we first added only the control variables. We then added relative use and the intensity of information technology references into the regression model, which increased the explanatory power of the regression model ($\Delta R2 = 0.03$, $F = 4.35$, $p < 0.05$), suggesting that relative use and intensity help explain significant variance in the magnitude of group polarization. Finally, we entered the interaction effect between relative use and the intensity of information technology references into the model, which further increased the predictive power of the regression model ($\Delta R2 = 0.01$, $F = 3.88$, $p < 0.05$), suggesting that the interaction variable explains significant variation in the magnitude of group polarization over that explained by the other variables.

$$\text{GROUP POLARIZATION} = \beta_0 + \beta_1\text{WEEKDAY} + \beta_2\text{JUNE} + \beta_3\text{JULY} + \beta_4\text{AUGUST} + \beta_5\text{SEPTEMBER} + \beta_6\text{YEAR2008} + \beta_7\text{GROUP SIZE} + \beta_8\text{EXPERTISE} + \beta_9\text{LOCATION} + \beta_{10}\text{HETERO} + \beta_{11}\text{UNCERTAINTY} + \beta_{12}\text{RELATIVE USE} + \beta_{13}\text{INTENSITY} + \beta_{14}\text{RELATIVE USE*INTENSITY} + \varepsilon \quad \textbf{(2)}$$

To evaluate our third hypothesis, we followed the standard statistical procedure (e.g., Greene (2003)) to test main effects in the full model. This requires differentiating Equation 2 with respect to the particular effect and then substituting the mean value of the interacting effect. To test Hypothesis 3, that the relative use of informational influence versus normative influence is associated with the magnitude of group polarization, this is GROUP POLARIZATION = ∂GROUP POLARIZATION / ∂RELATIVE USE = $\beta_{12} + \beta_{14}$ * INTENSITY = 0.36 + (−0.72)*0.05 = 0.32. Following Greene (2003) the standard error for the coefficient is 0.08, yielding a t value of 4.00, $p < 0.001$. Thus, we find a significant positive relationship between relative use and the magnitude of group polarization, and Hypothesis 3 was supported.

Hypothesis 4 posited a moderating relationship between relative use and the intensity of information technology references on the magnitude of group polarization, such that at higher levels of relative use, the higher intensity of information technology references would be associated with an even greater magnitude of group polarization. As can be seen in Table 3, the interaction effect was significant, but the sign of the coefficient was contrary to our expectations ($\beta_{14} = -0.72$, $p < 0.05$). Our results from hypothesis testing are summarized in Table 4.

Robustness Analyses

We conducted a number of analyses to verify the robustness of our results. Given the time series nature of the data, we evaluated whether serial correlation was an issue. Using the Cochrane-Orchutt procedure to correct for potential serial correlation, we re-estimated equations [1] and [2]; these results (shown in Tables 2 and 3) produce estimates that are consistent with those we obtained from ordinary least squares regression, leading us to conclude the serial correlation is not an issue in our data.

Past research has proposed that experience can affect how groups interact and perform (Boh et al. 2007; Martins et al. 2004). Similar to past research, we measured group experience as the number of forecasts the virtual team had made until that day in that year. After experience was taken into account, the estimates were still consistent with those without considering experience. Therefore, experience may not be an issue in our data.

Following Baron and Kenny (1986), we conducted a mediation test to confirm that relative use mediates the relationships between group polarization and its antecedents. A mediator must meet the following conditions. (1) *HETERO* ($\beta = 0.01$, $p < 0.01$) and *UNCERTAINTY* ($\beta = 0.38$, $p < 0.001$) were positively associated with *RELATIVE USE*. Thus, heterogeneity and task uncertainty met the first condition; (2) *HETERO* ($\beta = 0.01$, $p < 0.01$) and *UNCERTAINTY* ($\beta = 0.42$, $p < 0.001$) were significantly related to *POLARIZATION* and, thus, support the second condition; (3) *RELATIVE USE* ($\beta = 0.24$, $p < 0.01$) was positively related to *POLARIZATION* and, thus, support the third condition. Further, results show that, after considering *RELATIVE USE*, the effect of *HETERO* ($\beta = 0.01$, $p < 0.05$) and *UNCERTAINTY* ($\beta = 0.33$, $p < 0.01$) became weaker, although still significant, which suggests partial mediation.

We applied a Sobel test to further confirm the significance of the mediation. Results show that the intervening effects of relative use for heterogeneity ($p < 0.01$) and task uncertainty ($p < 0.01$) were all significant. Therefore, the mediation effects of relative use were supported.

Table 1. Means, Standard Deviations, and Correlations

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. POLARIZATION	0.26	0.85	1.00													
2. RELATIVE USE	0.54	0.63	0.27	1.00												
3. INTENSITY	0.05	0.14	0.09	0.35	1.00											
4. HETERO	31.49	33.07	0.22	0.26	0.15	1.00										
5. UNCERTAINTY	0.31	0.46	0.19	0.27	0.13	-0.12	1.00									
6. EXPERTISE	0.56	0.15	-0.09	-0.01	0.07	-0.02	0.00	1.00								
7. LOCATION	0.46	0.09	0.04	0.02	0.06	0.07	-0.06	0.23	1.00							
8. WEEKDAY	0.72	0.45	0.00	-0.01	0.06	-0.01	0.02	-0.16	0.15	1.00						
9. JUNE	0.20	0.40	0.00	0.17	0.08	0.18	0.03	-0.40	-0.09	-0.01	1.00					
10. JULY	0.20	0.40	0.01	-0.10	0.12	-0.02	-0.01	0.13	0.02	0.02	-0.25	1.00				
11. AUGUST	0.20	0.40	0.08	0.13	-0.03	-0.06	0.23	0.08	0.07	-0.02	-0.25	-0.25	1.00			
12. SEP	0.20	0.40	-0.07	-0.11	-0.08	-0.04	-0.22	0.09	-0.03	-0.01	-0.24	-0.25	-0.25	1.00		
13. YEAR2008	0.50	0.50	-0.03	-0.14	-0.03	-0.05	0.02	-0.08	0.05	0.00	0.01	-0.02	0.01	0.01	1.00	
14. GROUP SIZE	4.71	1.20	-0.05	-0.07	0.11	-0.03	0.07	0.23	0.41	0.20	-0.13	0.10	0.08	-0.11	0.03	1.00

Table 2. Relative Use of Informational Influence versus Normative Influence

	Control Variables Only		+ Main Effects		Cochrane-Orcutt Procedure	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
β0 INTERCEPT	0.41	2.82**	0.22	1.46	0.23	1.52
β1 WEEKDAY	0.02	0.22	0.01	0.11	-0.01	-0.10
β2 JUNE	0.34	3.25**	0.22	2.36*	0.22	2.55*
β3 JULY	-0.03	-0.41	-0.05	-0.75	-0.05	-0.91
β4 AUGUST	0.27	1.99*	0.18	1.28	0.18	1.38
β5 SEP	-0.05	-0.76	0.01	0.09	0.01	0.24
β6 YEAR2008	-0.17	-2.40*	-0.16	-2.57*	-0.17	-3.00**
β7 GROUP SIZE	-0.04	-1.21	-0.05	-1.47	-0.04	-1.26
β8 EXPERT	0.26	1.28	0.16	0.81	0.17	0.80
β9 LOCATION	0.35	1.13	0.40	1.46	0.35	1.29
β10 HETERO			0.01	3.18**	0.01	3.22**
β11 UNCERTAINTY			0.38	4.61**	0.40	5.31**
R^2	0.09		0.21		0.24	
R^2 Change	0.09		0.12			
F Change	2.27*		22.67**		47.22**	

N = 300. ** p < 0.01; * p < 0.05; + p < 0.10.

Table 3. Impact on Group Polarization								
	Control Variables Only		+ Main Effects		+ Interactions		Cochrane-Orcutt Procedure	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
β0 INTERCEPT	0.31	0.84	0.25	0.68	0.21	0.55	0.13	0.35
β1 WEEKDAY	-0.04	-0.40	-0.04	-0.42	-0.03	-0.31	-0.03	-0.39
β2 JUNE	-0.21	-1.55	-0.26	-1.98*	-0.27	-2.04*	-0.25	-1.86+
β3 JULY	0.04	0.33	0.06	0.45	0.06	0.46	-0.01	-0.09
β4 AUGUST	0.07	0.53	0.02	0.19	0.02	0.20	0.02	0.14
β5 SEP	-0.04	-0.41	-0.04	-0.42	-0.03	-0.30	-0.05	-0.47
β6 YEAR2008	-0.06	-0.61	-0.02	-0.19	-0.01	-0.09	-0.03	-0.37
β7 GROUP SIZE	-0.06	-1.20	-0.05	-0.94	-0.05	-1.05	-0.03	-0.68
β8 EXPERT	-0.78	-1.38	-0.82	-1.45	-0.80	-1.42	-0.74	-1.31
β9 LOCATION	0.90	1.88+	0.80	1.69+	0.81	1.70+	0.80	1.66+
β10 HETERO	0.01	2.98**	0.01	2.31**	0.01	2.35*	0.00	2.10*
β11 UNCERTAINTY	0.42	3.54**	0.33	3.1**	0.32	3.05**	0.34	3.22**
β12 RELATIVE USE			0.25	3.6**	0.36	4.13**	0.34	4.13**
β13 INTENSITY			-0.05	-0.23	0.47	1.57	0.50	1.62
β14 RELATIVE * USEINTENSITY					-0.72	-1.97*	-0.65	-1.84+
R^2	0.13		0.15		0.16		0.16	
R^2 Change	0.13		0.03		0.01			
F Change	2.82**		4.35*		3.88*		4.30**	

N = 300. ** p < 0.01; * p < 0.05; + p < 0.10.

Table 4. Hypothesis Summary		
No.	Prediction	Result
1 HETEROGENEITY, RELATIVE USE	–	Opposite
2 UNCERTAINTY, RELATIVE USE	+	Supported
3 RELATIVE USE, GROUP POLARIZATION	+	Supported
4 RELATIVE USE * INTENSITY, GROUP POLARIZATION	+	Opposite

Discussion and Conclusion

Group polarization is an important aspect of group decision making. Our study attempts to understand group polarization from an influence perspective and a technology perspective. This is important because little is known about how the relative use of informational influence versus normative influence is affected by antecedents and affects the magnitude of group polarization in virtual team settings. In addition, we do not know much about whether virtual teams refer to information technology for persuasion and influence.

An influence perspective is supported by our study. We found that the level of task uncertainty was positively associated with the relative use of informational influence versus normative influence. The finding suggests that when the gap between the amount of information required and the amount of information group members possessed becomes larger, group members increase their use of persuasive argumentation relative to the use of social comparison. Contrary to our expectations, we found that heterogeneity of pre-discussion individual decisions was positively associated with the relative use of informational influence versus normative influence. One possible explanation is that an established team

mental model can increase factual information sharing. Members with a history of working together are likely to have their team mental model. Such a model allows team members to predict the resource and information needs of their teammates and facilitates team decision making (Cannon-Bowers et al. 1993; Mathieu et al. 2000). Therefore, when members have very different initial views, they may know which information their teammates may ignore. This suggests that when a range of group members' opinions becomes wider, group members who are in a virtual team and know each other well prefer to use relatively more persuasive argumentation than social comparison during a group discussion. Our research setting was a virtual team whose members had worked together for over 10 years.

Furthermore, we found that relative use had a positive effect on the magnitude of group polarization. This finding suggests that group members can either boost or alleviate group polarization when they know how to strategically use different influences. For example, group members can move their group decision to a more extreme direction by providing more objective facts and less social norm information. In contrast, group members can use more social norm statements than objective facts to reduce the group's tendency to make an extreme decision. Overall, consistent with prior experimental studies (El-Shinnawy and Vinze 1998; Sia et al. 2002), our field study confirmed that virtual team members had a tendency to polarize a team decision following discussion.

Our study also demonstrates the importance of the technology perspective. Contrary to our expectations, we found that the intensity of technology references and the relative use of informational influence versus normative influence are substitutive, not complementary in their effects on group polarization. As Figure 1 illustrates, when relative use is lower, the effect of intensity is stronger. Conversely, when relative use is higher, the effect of intensity becomes smaller. Therefore, the figure suggests that the two factors are somewhat substitutable. One possible explanation for this result is that people may not focus on both relative use and intensity simultaneously. Higher levels of relative use provide group members enough factual information to decide the magnitude of group polarization. The facts provided will lead group members to focus on informational influence rather than the intensity of information technology references. Conversely, higher levels of the intensity of information technology references assist group members to invoke more factual information from identified sources. This recall will lead group members to consider more information by themselves, thus leading group members to pay less attention to informational influence.

Motivation is another possible explanation. A level of motivation determines which one of two routes in elaboration likelihood model (ELM) people use more to process messages (Petty and Cacioppo 1986). A high level of motivation leads people to use a central route rather than a peripheral route. The central route indicates that people change their beliefs by carefully scrutinizing communication messages. In contrast, the peripheral route indicates that people do not elaborate messages, but depend on external characteristics of messages (e.g., perceived credibility of the source) to alter their attitudes. However, people may use a mixture of a central route and a peripheral route to process different messages. That is, they use a central route to process some messages and a peripheral route to process other messages. In addition, without strong motivation, some members of a group are likely to have social loafing behaviors (Chidambaram and Tung 2005; Karau and Williams 1993). For example, group members may only process a small portion of messages. Both ELM and social loafing behaviors suggest that people may not put all their effort to process information when making a decision. Therefore, the effect of relative use can be substitutive with the intensity of information technology references.

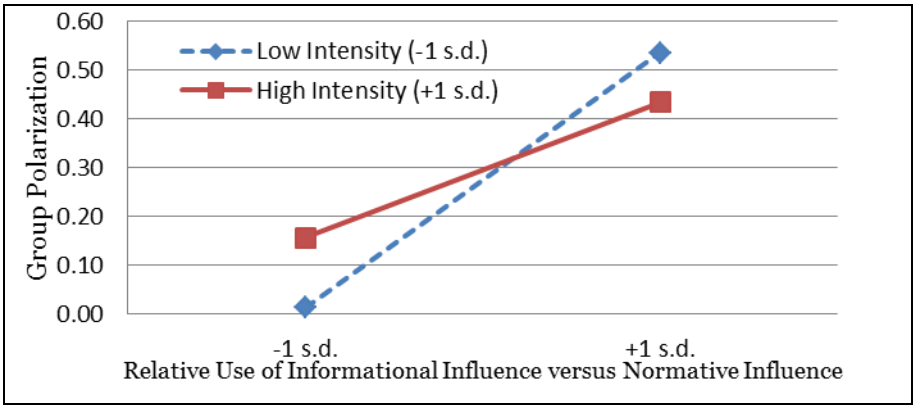

Figure 1. Relative Use X Intensity

Our study makes two important contributions. First, our study extends the literature on group polarization by hypothesizing and testing an input-process-output framework. Previous studies have investigated the relationships between antecedents and group polarization without including group processes. Moreover, most researchers have argued that applying either an informational influence process or a normative influence process is sufficient to explain group polarization and have treated these underlying processes as a "black box." Our study opens up this black box and also contributes to the limited number of studies examining both processes together. We introduced the notion of the relative use of informational influence versus normative influence. We found that two important antecedents (i.e., heterogeneity and task uncertainty) determined the magnitude of group polarization through the relative use of informational influence versus normative influence. Such findings validate the argument that relative use is an important process during group discussion.

Our study provides insights into the relative use of informational influence versus normative influence. This relative use is important because decision makers need to know how to increase the magnitude of beneficial group polarization and how to prevent harmful group polarization from becoming worse. As for an increase in benign group polarization (e.g., making more donations to a community that was hit by a natural disaster), our study suggests that decision makers can encourage their group members to use more informational influence relative to normative influence during group discussion. As for prohibition of hurtful group polarization (e.g., keep investing in the failing Enron Corporation), our suggestion is to use less informational influence relative to normative influence.

Second, our study contributes to group polarization research and IS research by theorizing the persuasive role of information technology as a credible source of information. Credibility is believability. The credibility of information can be increased by using labels or references. We introduced the notion of the intensity of information technology references. We found the surprising interaction effect of relative use and intensity on group polarization. The finding suggests that the benefits of these variables are substitutive and that their joint effects experience diminishing effects as both variables increase. Thus, our study reveals the importance of understanding whether decision makers should increase the intensity of information technology references during a discussion. Decision makers who want to increase the magnitude of group polarization even more should use a lower intensity of technology references when the relative use of informational influence versus normative influence is already high. In addition, this finding represents an important contribution to the literature on information technology usage. Recent research has focused on two roles of information technology: a communication tool (e.g., Daft et al. 1987) and a decision making tool (e.g., Todd and Benbasat 1999). However, our findings suggest that information technology can be a powerful persuasion tool. Especially, information technology can be used to persuade group members when informational influence statements are shared less than normative influence statements during group discussion. Such a persuasive role of information technology should provide GDSS system designers with new ideas about how to design a new GDSS. For instance, GDSS can include one feature which allows group members to cite information and sources easily. Further studies need to be conducted to better understand the role of information technology for persuasion. For instance, technology characteristics (e.g., information amount) may moderate the effect of the relative use of informational influence versus normative influence on group polarization.

Appendix: Sample Coding of Forecasting Discussion

Categories	Sia et al.'s (2002) Coding Scheme	Examples
Novel Argument (*Informational Influence*)	A novel argument was one that contained facts in support of the collective position and yielded fresh insights (i.e., it was not related to arguments presented earlier).	Forecaster A: With skies clearing again, lighter winds and restricted boundary layer depth, I saw us climbing again for O3. Note: "climbing" was a new insight.
Valid Argument (*Informational Influence*)	A valid argument was one that contained facts in support of the collective position and reinforced other arguments (i.e., it was related to arguments presented earlier).	Forecaster B: Agree with light downslope (NW flow) Note: One forecaster had mentioned NW flow before Forecaster B.
Pluralistic Balance Statement (*Normative Influence*)	A person was considered to have engaged in pluralistic balance behavior if he or she moved in the direction of the collective position provided no facts in support of the collective position (e.g., simply stated personal preference).	Forecaster C: I'll go with 68/19 then and update with yellow for both. Note: Forecaster C moved his/her forecast to 68 from 70.
One-upmanship Statement (*Normative Influence*)	A person was considered to have engaged in one-upmanship behavior if he or she moved in the direction of the collective position beyond the average collective position in the previous round, regardless of the arguments given.	Forecaster D: OK then 85/42 ok with me. Note: Forecaster D moved his/her forecast from 81 to 85. The collective consensus was 84.
Other	Otherwise	Forecaster E: Need to vote2-my numbers went away again.

References

U.S. Environmental Protection Agency 2003. "Guidelines for Developing an Air Quality (Ozone and Pm2.5) Forecasting Program," EPA-456/R-03-002, (available at http://www.epa.gov/aqi/aq_forecasting_guidance-1016.pdf).

Aiken, L., and West, S. 1991. *Multiple Regression: Testing and Interpreting Interactions*. Newbury Park, CA.: Sage.

Barber, B.M., Heath, C., and Odean, T. 2003. "Good Reasons Sell: Reason-Based Choice among Group and Individual Investors in the Stock Market," *Management Science* (49:12), pp. 1636-1652.

Baron, R.M., and Kenny, D.A. 1986. "The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations," *Journal of Personality and Social Psychology* (51:6), pp. 1173-1182.

Baron, R.S., and Roper, G. 1976. "Reaffirmation of Social Comparison Views of Choice Shifts: Averaging and Extremity Effects in an Autokinetic Situation," *Journal of Personality and Social Psychology* (33:5), pp. 521-530.

Bhattacherjee, A., and Sanford, C. 2006. "Influence Processes for Information Technology Acceptance: An Elaboration Likelihood Model," *MIS Quarterly* (30:4), pp. 805-825.

Blau, P.M. 1977. *Inequality and Heterogeneity: A Primitive Theory of Social Structure*. New York: Free Press.

Boh, W.F., Slaughter, S.A., and Espinosa, J.A. 2007. "Learning from Experience in Software Development: A Multilevel Analysis," *Management Science* (53:8), pp. 1315-1331.

Brown, R. 1986. *Social Psychology*. New York: Free Press.

Burnstein, E. 1982. "Persuasion as Argument Processing," in *Contemporary Problems in Group Decision-Making*, H. Brandstatter, J.H. Davis and G. Stocker-Kreichgauer (eds.). New York: Academic Press, pp. 103-124.

Burnstein, E., and Vinokur, A. 1977. "Persuasive Argumentation and Social-Comparison as Determinants of Attitude Polarization," *Journal of Experimental Social Psychology* (13:4), pp. 315-332.

Butler, J.K., and Crino, M.D. 1992. "Effects of Initial Tendency and Real Risk on Choice Shift," *Organizational Behavior and Human Decision Processes* (53:1), pp. 14-34.

Cannon-Bowers, J.A., Salas, E., and Converse, S.A. 1993. "Shared Mental Models in Expert Team Decision Making," in *Individual and Group Decision Making: Current Issues*, N.J. Castellan (ed.). Hillsdale, New Jersey: Lawrence Erlbaum, pp. 221-246.

Carlson, J.R., and Zmud, R.W. 1999. "Channel Expansion Theory and the Experiential Nature of Media Richness Perceptions," *Academy of Management Journal* (42:2), pp. 153-170.

Cason, T.N., and Mui, V.L. 1997. "A Laboratory Study of Group Polarisation in the Team Dictator Game," *Economic Journal* (107:444), pp. 1465-1483.

Chandrashekaran, M., Walker, B.A., Ward, J.C., and Reingen, P.H. 1996. "Modeling Individual Preference Evolution and Choice in a Dynamic Group Setting," *Journal of Marketing Research (JMR)* (33:2), pp. 211-223.

Chidambaram, L., and Tung, L.L. 2005. "Is out of Sight, out of Mind? An Empirical Study of Social Loafing in Technology-Supported Groups," *Information Systems Research* (16:2), pp. 149-168.

Cialdini, R.B., and Goldstein, N.J. 2004. "Social Influence: Compliance and Conformity," *Annual Review Of Psychology* (55:1), pp. 591-621.

Cohen, J., and Cohen, P. 1983. *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*. Hillsdale, NJ.: Lawrence Erlbaum Associates.

Daft, R.L., and Lengel, R.H. 1984. "Information Richness: A New Approach to Managerial Information Processing and Organizational Design," in *Research in Organizational Behavior*, B. Staw; and L. Cummings (eds.). Greenwich, Connecticut: JAI Press, pp. pp. 191-233.

Daft, R.L., Lengel, R.H., and Trevino, L.K. 1987. "Message Equivocality, Media Selection, and Manager Performance - Implications for Information-Systems," *MIS Quarterly* (11:3), pp. 355-366.

El-Shinnawy, M., and Vinze, A.S. 1997. "Technology, Culture and Persuasiveness: A Study of Choice-Shifts in Group Settings," *International Journal of Human-Computer Studies* (47:3), pp. 473-496.

El-Shinnawy, M., and Vinze, A.S. 1998. "Polarization and Persuasive Argumentation: A Study of Decision Making in Group Settings," *MIS Quarterly* (22:2), pp. 165-198.

Erdem, T., and Swait, J. 2004. "Brand Credibility, Brand Consideration, and Choice," *The Journal of Consumer Research* (31:1), pp. 191-198.

Farrar, C., Green, D.P., Green, J.E., Nickerson, D.W., and Shewfelt, S. 2009. "Does Discussion Group Composition Affect Policy Preferences? Results from Three Randomized Experiments," *Political Psychology* (30:4), pp. 615-647.

Flanagin, A.J., and Metzger, M.J. 2007. "Digital Media and Youth: Unparalleled Opportunity and Unprecedented Responsibility," in *Digital Media, Youth, and Credibility*, M.J. Metzger and A.J. Flanagin (eds.). Cambridge, MA: The MIT Press, pp. 5-28.

Fogg, B.J. 2003. *Persuasive Technology: Using Computers to Change What We Think and Do*. San Francisco: Morgan Kaufmann.

Fogg, B.J., Marshall, J., Laraki, O., Osipovich, A., Varma, C., Fang, N., Paul, J., Rangnekar, A., Shon, J., Swani, P., and Treinen, M. 2001. "What Makes Web Sites Credible?: A Report on a Large Quantitative Study," in: *Proceedings of the SIGCHI conference on Human factors in computing systems*. Seattle, Washington, United States: ACM, pp. 61-68.

Fragale, A.R., and Heath, C. 2004. "Evolving Informational Credentials: The (Mis)Attribution of Believable Facts to Credible Sources," *Personality and Social Psychology Bulletin* (30:2), pp. 225-236.

Greene, W.H. 2003. *Econometric Analysis*. Upper Saddle River, NJ: Prentice Hall.

Hackman, J.R., and Morris, C.G. 1975. "Group Tasks, Group Interaction Process, and Group Performance Effectiveness: A Review and Proposed Integration.," in *Advances in Experimental Social Psychology*, L. Berkowitz (ed.). New York: Academic Press, pp. 45-99.

Heath, C., and Gonzalez, R. 1995. "Interaction with Others Increases Decision Confidence but Not Decision Quality: Evidence against Information Collection Views of Interactive Decision Making," *Organizational Behavior and Human Decision Processes* (61:3), pp. 305-326.

Hilligoss, B., and Rieh, S.Y. 2008. "Developing a Unifying Framework of Credibility Assessment: Construct, Heuristics, and Interaction in Context," *Information Processing & Management* (44:4), pp. 1467-1484.

Hong, T. 2006. "The Influence of Structural and Message Features on Web Site Credibility," *Journal of the American Society for Information Science and Technology* (57:1), pp. 114-127.

Huang, W.W., and Wei, K.K. 2000. "An Empirical Investigation of the Effects of Group Support Systems (GSS) and Task Type on Group Interactions from an Influence Perspective," *Journal of Management Information Systems* (17:2), pp. 181-206.

Isenberg, D.J. 1986. "Group Polarization: A Critical Review and Meta-Analysis," *Journal of Personality and Social Psychology* (50:6), pp. 1141-1151.

Kaplan, M.F., and Miller, C.E. 1987. "Group Decision Making and Normative Versus Informational Influence: Effects of Type of Issue and Assigned Decision Rule," *Journal of Personality and Social Psychology* (53:2), pp. 306-313.

Karau, S.J., and Williams, K.D. 1993. "Social Loafing: A Meta-Analytic Review and Theoretical Integration," *Journal of Personality and Social Psychology* (65:4), pp. 681-706.

Kennedy, P. 2008. *A Guide to Econometrics*, (6th ed.). Malden, MA: Blackwell Publishing.

Knight, D., Pearce, C.L., Smith, K.G., Olian, J.D., Sims, H.P., Smith, K.A., and Flood, P. 1999. "Top Management Team Diversity, Group Process, and Strategic Consensus," *Strategic Management Journal* (20:5), p 445.

Laughlin, P.R. 1980. "Social Combination Processes of Cooperative, Problem-Solving Groups on Verbal Intellective Tasks," in *Progress in Social Psychology*, M. Fishbein (ed.). Hillsdale, NJ: Erlbaum, pp. 127-155.

Laughlin, P.R., and Earley, P.C. 1982. "Social Combination Models, Persuasive Arguments Theory, Social Comparison Theory, and Choice Shift," *Journal of Personality and Social Psychology* (42:2), pp. 273-280.

Lea, M., and Spears, R. 1991. "Computer-Mediated Communication, De-Individuation and Group Decision-Making," *International Journal of Man-Machine Studies* (34:2), pp. 283-301.

Lee, E.-J. 2007. "Deindividuation Effects on Group Polarization in Computer-Mediated Communication: The Role of Group Identification, Public-Self-Awareness, and Perceived Argument Quality," *Journal of Communication* (57:2), pp. 385-403.

MacCoun, R.J. 1989. "Experimental Research on Jury Decision-Making," *Science* (244:4908), pp. 1046-1050.

Martins, L.L., Gilson, L.L., and Maynard, M.T. 2004. "Virtual Teams: What Do We Know and Where Do We Go from Here?," *Journal of Management* (30:6), pp. 805-835.

Mathieu, J.E., Heffner, T.S., Goodwin, G.F., Salas, E., and Cannon-Bowers, J.A. 2000. "The Influence of Shared Mental Models on Team Process and Performance," *Journal of Applied Psychology* (85:2), pp. 273-283.

Metzger, M.J., Flanagin, A.J., Eyal, K., Lemus, D.R., and McCann, R.M. 2003. "Credibility in the 21st Century: Integrating Perspectives on Source, Message, and Media Credibility in the Contemporary Media Environment.," in *Communication Yearbook*, P. Kalbfleisch (ed.). Newbury Park, Ca: Sage Publications, pp. 293-335.

Muehleman, J.T., Bruker, C., and Ingram, C.M. 1976. "The Generosity Shift," *Journal of Personality and Social Psychology* (34:3), pp. 344-351.

Myers, D.G., and Lamm, H. 1976. "The Group Polarization Phenomenon," *Psychological Bulletin* (83:4), pp. 602-627.

Paluck, E.L. 2010. "Is It Better Not to Talk? Group Polarization, Extended Contact, and Perspective Taking in Eastern Democratic Republic of Congo," *Personality and Social Psychology Bulletin* (36:9), pp. 1170-1185.

Petty, R.E., and Cacioppo, J.T. 1986. "The Elaboration Likelihood Model of Persuasion," in *Advances in Experimental Social Psychology*, L. Berkowitz (ed.). San Diego, CA: Academic Press.

Poston, R.S., and Speier, C. 2005. "Effective Use of Knowledge Management Systems: A Process Model of Content Ratings and Credibility Indicators," *MIS Quarterly* (29:2), pp. 221-244.

Priem, R.L., and Harrison, D.A. 1995. "Structured Conflict and Consensus Outcomes in Group Decision Making," *Journal of Management* (21:4), pp. 691-710.

Rieh, S.Y., and Belkin, N.J. 1998. "Understanding Judgment of Information Quality and Cognitive Authority in the Www," in: *Proceedings of the 61st ASIS Annual Meeting* C.M. Preston (ed.). Silver Spring, MD: American Society for Information Science, pp. 279-289.

Rieh, S.Y., and Daniels, D.R. 2007. "Credibility: A Multidisciplinary Framework," in *Annual Review of Information Science and Technology*, B. Cronin (ed.). Medford, NJ: Information Today, pp. 307-364.

Self, C.S. 1996. "Credibility," in *An Integrated Approach to Communication Theory and Research*, M. Salwen and D. Stacks (eds.). Mahwah, NJ: Lawrence Erlbaum Associates, pp. 421-441.

Shupp, R.S., and Williams, A.W. 2008. "Risk Preference Differentials of Small Groups and Individuals," *Economic Journal* (118:525), pp. 258-283.

Sia, C.-L., Tan, B.C.Y., and Wei, K.-K. 2002. "Group Polarization and Computer-Mediated Communication: Effects of Communication Cues, Social Presence, and Anonymity," *Information Systems Research* (13:1), pp. 70-90.

Siegel, J., Dubrovsky, V., Kiesler, S., and McGuire, T.W. 1986. "Group Processes in Computer-Mediated Communication," *Organizational Behavior and Human Decision Processes* (37:2), pp. 157-187.

Slater, M.D., and Rouner, D. 1996. "How Message Evaluation and Source Attributes May Influence Credibility Assessment and Belief Change," *Journalism & Mass Communication Quarterly* (73:4), pp. 974-991.

Smith, K.G., Smith, K.A., Sims Jr, H.P., O'Bannon, D.P., Scully, J.A., and Olian, J.D. 1994. "Top Management Team Demography and Process: The Role of Social Integration and Communication," *Administrative Science Quarterly* (39:3), pp. 412-438.

Stoner, J.A.F. 1961. "A Comparisoonf Individual and Group Decisions Involving Risk." Cambridge, MA: MIT.

Stroud, N.J. 2010. "Polarization and Partisan Selective Exposure," *Journal of Communication* (60:3), pp. 556-576.

Sundar, S.S. 1998. "Effect of Source Attribution on Perception of Online News Stories," *Journalism and Mass Communication Quarterly* (75:1), pp. 55-68.

Sunstein, C.R. 2002. "The Law of Group Polarization," *Journal of Political Philosophy* (10:2), pp. 175-195.

Teger, A.I., and Pruitt, D.G. 1967. "Components of Group Risk Taking," *Journal of Experimental Social Psychology* (3:2), pp. 189-205.

Todd, P., and Benbasat, I. 1999. "Evaluating the Impact of DSS, Cognitive Effort, and Incentives on Strategy Selection," *Information Systems Research* (10:4), pp. 356-374.

Tseng, S., and Fogg, B.J. 1999. "Credibility and Computing Technology," *Communications of the ACM* (42:5), pp. 39-44.

Vinokur, A., and Burnstein, E. 1978a. "Depolarization of Attitudes in Groups," *Journal of Personality and Social Psychology* (36:8), pp. 872-885.

Vinokur, A., and Burnstein, E. 1978b. "Novel Argumentation and Attitude Change: The Case of Polarization Following Group Discussion," *European Journal of Social Psychology* (8:3), pp. 335-348.

Wathen, C.N., and Burkell, J. 2002. "Believe It or Not: Factors Influencing Credibility on the Web," *Journal of the American Society for Information Science & Technology* (53:2), pp. 134-144.

Zigurs, I., Poole, M.S., and DeSanctis, G.L. 1988. "A Study of Influence in Computer-Mediated Group Decision Making," *MIS Quarterly* (12:4), pp. 625-644.

Zuber, J.A., Crott, H.W., and Werner, J. 1992. "Choice Shift and Group Polarization: An Analysis of the Status of Arguments and Social Decision Schemes," *Journal of Personality and Social Psychology* (62:1), pp. 50-61.