Expertise, Extraversion and Group Interaction Styles as Performance Indicators in Virtual Teams

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Abstract

This study investigates how a personality trait and expertise affect virtual teams interaction, and how that interaction leads to different levels of performance (e.g., solution quality, solution acceptance, cohesion). Teams have been shown to exhibit constructive, aggressive/defensive, or passive/defensive interaction styles that affect communication and thus team performance by facilitating or hindering the exchange of information among group members. These styles reflect an aggregation of the behaviors exhibited by individual team members, which are rooted in their individual personalities. The effects of interaction style on team performance have been well established in face-to-face and virtual teams. Generally, constructive interaction styles produce positive outcomes whereas passive/defensive styles beget negative ones. Aggressive/defensive teams produce solutions that are correlated with the expertise of those that have wrested control of the group –but there is often little support for those solutions. The current work explores how different constellations of extraversion and expertise manifest themselves into group interaction styles and, ultimately, outcomes. The study involves 248 professional managers from executive MBA and professional development programs in 63 virtual teams that performed an intellective task. Results show that expertise and extraversion to be curvilinearly related to group interactions and performance, and high levels of extraversion and higher variations in extraversion between team members lead to less constructive and more passive/defensive interaction styles within teams. Results show that although expertise is the best predictor of task performance, it is primarily group interaction styles that predict contextual outcomes (e.g., solution acceptance, cohesion, effectiveness) in virtual teams.

ACM Categories: H.4.1, H.4.3, H.5.3

Keywords: Group Interaction Styles, Expertise, Extraversion, “Big Five” Personality Model, Virtual Teams, Contextual Performance, Task Performance.

Introduction

More and more organizations are realizing the benefits of using virtual teams. Team members can bring their differing expertise to bear on pressing problems from any geographic location, collaborating via network-supported groupware of various types. While travel and its associated expense and inconvenience can be reduced, it is not yet clear that virtual teams perform as well as their face-to-face (FTF) counterparts. One approach to improving virtual team performance is to identify characteristics that differentiate low performing FTF teams from high performing FTF teams and then determine if virtual teams also have these characteristics. If they do, and if those characteristics can be properly managed, virtual teams may enjoy increases in performance similar to those realized with FTF teams.

Interaction style has been shown to have a great effect on conventional work teams' ability to achieve solution quality and solution acceptance (Hirokawa, 1985; Hirokawa & Gouran, 1989; Cooke & Szumal, 1993; Watson & Michaelsen, 1988). Group interaction styles affect communication and thus team performance by facilitating or hindering the exchange of information among group members. These styles reflect an aggregation of communication traits of individual team members, rooted in their individual personalities. The effects of interaction style on team decision performance outcomes have been well established (as noted above) in face-to-face teams. Recent research by Potter et al. (2000) revealed that interaction styles produced similar results in virtual teams. Among the issues requiring further study is how different constellations of personality types and levels of expertise manifest into team interaction styles. The practical implication of this research is that it may be possible to predict virtual team interaction style from an assessment of the personalities of its individual members. Once the interaction style can be predicted, the effectiveness of the team's performance on certain types of tasks can also be predicted, and managed proactively, if necessary. Below we elaborate on interaction styles, expertise, and extraversion and their manifestations and effects in the FTF and virtual team environments. After this background we present a study that examines the relationship between one of the personality factors (extraversion) that a group's members possess and the interaction style that the group exhibits. The study used 63 virtual teams of professional managers who participated in an intellective decision making task using a Web-based conferencing tool.

Background

Interaction Styles, Expertise, and Virtual Team Performance

Communication is a fundamental behavior of conventional (FTF) teams (McIntyre et al., 1989; Morgan et al., 1986). However, members of problem-solving teams face two types of pressures in achieving quality solutions and high solution acceptance (Maier, 1963, 1967). On the one hand, there is pressure on each member to contribute unique, and possibly controversial, information to maximize the team's resources. On the other hand, members of teams tend to believe that closure to team problem solving and strong solution acceptance are best achieved through conformity of opinions (e.g., Festinger, 1950; Hoffman, 1979; McGrath, 1984). The way in which a team deals with the conflicting "task" and "maintenance" pressures is reflected in the team's *interaction style.* Watson and Michaelsen (1988) showed that a team's interaction style affects performance. They identified positive and negative behaviors as components of group interaction style. Three groups of behaviors (expectations of performance and integration, leadership, and cohesiveness) contributed to team performance on an intellective task while one group of negative behaviors (e.g., noninvolvement, withholding of information) detracted.

Building on Maslow's (1954) classic work on motivation and personality, the Watson and Michaelsen typology, and others (e.g., Maier, 1967; Hoffman, 1979), Cooke & Szumal (1994) showed that group interaction, aggregated from stable personality factors of the individual group members, can be categorized as constructive, passive/defensive, and aggressive/defensive styles. The *constructive style* is characterized by a balanced concern for personal and group outcomes, cooperation, creativity, free exchange of information, and respect for others' perspectives. The *constructive style* enables group members to fulfill both needs for personal achievement as well as needs for affiliation. The *passive/defensive style* places greater emphasis on fulfillment of affiliation goals only, maintaining harmony in the group, and limiting information sharing, questioning and impartiality. The *aggressive/defensive style* places greater emphasis on personal achievement needs, with personal ambitions placed above concern for group outcome. Aggressive/defensive groups are characterized by competition, criticism, interruptions, and overt impatience.

Group interaction style is theorized to affect performance because it can impede or enhance team members' ability to bring their unique knowledge and skills to bear on the task, and the extent to which they develop and consider alternative strategies for approaching the task (Hackman & Morris, 1975). This is particularly critical for groups with heterogeneous levels of expertise, as communication by most expert group members is positively correlated with group performance. Zalesny (1990) found that the most accurate member in interacting groups did not influence performance unless he or she was assertive and confident. Bottger (1984) also found that amount of communication time and expertise are positively correlated with performance, though only with high-performing groups. In their study of estimation methods for individual-team performance differences, Cooke and Kernaghan (1987) found that average individual scores explain an average of 57% of the variance in team scores. They also noted that the expertise of the best member contributes significantly to the team score, above and beyond the average individual score, with both factors together explaining an average 69% of the variance in team score performance. That study also documented significant variances in relative performance, with some groups composed of less able individuals showing significant group process gains, and instances of high-potential groups (i.e., with high average individual performance scores) showing minimal gains or even losses due to group processes. Group performance has usually been found to be inferior to that of the best individual, and typically, groups perform better than the average of their individual members and worse than their best individual member (Burleson et al., 1984; Hill, 1982; Libby et al., 1987; Yetton & Bottger, 1982). In sum, this research demonstrates that while expertise is positively related to team performance, it will be so only if the team exhibits an interaction style that permits the expertise to be heard, considered, and when possible, improved upon.

The parallel processing characteristic of text-based virtual environments should allow individual expertise to be expressed. That is, knowledge will not be suppressed due to domination of dialogue as in FTF environments. However, systems cannot control the tone of the written dialogue, so if the team has an aggressive/defensive interaction style (which often engenders sharp criticism) input from experts may be withheld for fear of criticism. A passive/defensive interaction style connotes a lack of willingness to contribute as well.

Intuitively, low amounts of expertise (i.e., a team with few or no experts) lead to large amounts of errors (minimizing performance) and high levels of expertise should maximize performance. Thus, teams with more expertise have the potential for better quality information sharing among several participants (even those with limited or poor group dynamics), providing those teams with a greater potential to create a better solution. Counter-intuitively, it is probable that large amounts of expertise will result in a less-than-constructive interaction style because, without appropriate training, members will not naturally attempt to share their expertise or seek to improve upon their own knowledge. In addition, if the opinions of the experts differ, conflict is likely and could be disruptive unless the team has a constructive interaction style. Alternatively, lower amounts of expertise may lead to better interactions since participants may attempt to seek knowledge they lack (though the lack of knowledge will ultimately limit the potential of the group).

Groups whose interactions are characterized by a dominant style typically achieve a particular level of task performance (in the present study, an intellective task with one best solution) and exhibit a certain level of positive contextual outcomes, such as satisfaction with the group solution, group cohesion, and satisfaction with participation. Specifically, predominantly constructive groups produce solutions that are superior in quality (i.e., closer to the ideal solution) to those produced by passive/defensive groups and superior in solution acceptance to those produced by either passive/defensive or aggressive/ defensive groups. Predominantly passive/defensive teams produce solutions that are inferior in quality to those of constructive (and sometimes aggressive/ defensive) groups and inferior in acceptance to those of constructive groups. Similarly, groups with predominantly aggressive/defensive styles produce solutions that are not as consistently of high quality as those generated by constructive groups but not as consistently of low quality as those produced by passive/defensive groups. The solutions produced by aggressive/defensive groups generate less overall acceptance than those developed by constructive groups and about the same level of acceptance as those generated by passive/defensive groups (Cooke & Szumal, 1994).

Communication quality is also emerging as a key determinant of virtual team performance. Recent studies show that communication characteristics including high frequency, initiation of contact, positive tone, and appropriate feedback style are key to establishing “swift” trust, and that swift trust has a significant positive effect on team performance (Jarvenpaa et al., 1998; Iacono & Weisband, 1997). Maznevski & Chudoba (2000) found that successful distributed teams developed a rhythm in media choice, using both FTF and computer-mediated collaboration (CMC) meetings when each was deemed appropriate. The successful teams’ communication was characterized by higher message frequency, positive tone, and appropriate feedback. Ocker et al. (1998) also found that teams that used FTF along with synchronous and asynchronous CMC media produced higher quality work and were more satisfied with their solutions. Building on research that examined information exchange in FTF teams (e.g., Stasser & Titus, 1985), Hightower and Sayeed (1996) found information exchange to be positively linked to distributed team performance on an intellective decision task. Tan et al. (2000) found information exchange positively related to distributed team performance on a preference task. Warkentin et al. (1997) found that perceptions of shared norms and expectations of task process were types of relational links positively related to a higher level of team cohesion and information exchange in computer-supported distributed teams. Mennecke and Valacich (1998) also found information sharing to be positively related to decision quality for GSS-supported groups whose members had unique information.

Cooke and Szumal (1993) developed an instrument that can reliably assess interaction styles of FTF groups. It is a self-report survey that solicits post task feedback from team members on their perceptions of team interaction (we give a more complete description later). Potter et al. (2000) validated a Web-based version of the Cooke and Szumals' (1994) interaction style assessment tool. In that validation study, a series of experiments with distributed teams showed that team interaction via CMC did not significantly interfere with the expression and perception of individual interaction characteristics. The computer-supported communication medium (described below) did not interfere with team members' ability to accurately assess their team's interaction style. The virtual teams used in those studies all exhibited interaction styles, and the effects of those styles on team decision performance and contextual outcomes were directionally consistent with those commonly found with FTF teams.

Extraversion and Virtual Team Performance

Prior to the late 1980's, it was generally assumed that the link between personality and job performance was tenuous at best. Research findings were inconsistent. However, in the last decade there have been a series of advances which unequivocally demonstrate that personality, as assessed through standardized instruments, has a predictive relationship with job performance approaching, and in some cases exceeding, that of cognitive ability (Goffin et al., 1996; Nowack, 1997). The greatest single advance in personality research has been the emergence and broad acceptance of the Five Factor model of personality, commonly referred to as the "Big Five" (Digman, 1990; Hogan et al., 1996). The Big Five are bipolar dimensions of personality that have been found to form the taxonomic (and factorial) core of personality models and also capture lay-persons descriptions of personality as found in everyday language (Fiske, 1949; Hogan, 1991; McCrae & John, 1992; Barry & Stewart, 1997). These dimensions/factors are extraversion (surgency), agreeableness, conscientiousness, openness and neuroticism. McCrae and John (1992) investigated the history and evolution of the model and concluded that all five factors were shown to have convergent and discriminant validity across instruments and observers.

There are several reasons why personality should be considered when examining virtual teams. Individuals working in teams each bring something to the team that affects the way the team interacts. This "something" consists of expertise, cognitive ability, and the personalities exhibited by each team member. Hoyle and Crawford (1994) asserts that the analysis of a group or work team should include what the group member brings to the group. Research indicates that there is a complex and profound relationship between personality and job performance (Barrick & Mount, 1991; Barrick et al., 1998). Also, many companies use personality assessment tools (e.g., Myers-Briggs Type Indicator — MBTI) to assist in hiring decisions and work assignments of their employees.

There is also an extensive history of research examining the link between personality characteristics and effective leadership. Personality characteristics have been shown to predict overall leader effectiveness in terms of outcomes, the ability of the leader to build an effective team, subordinate ratings of leader effectiveness, and executive derailment (Barry & Stewart, 1997). Furthermore, personality is also predictive of emergent leadership - that is, early identification of leadership potential (Hogan et al., 1994). Many virtual teams are largely self-managed. In these particular work arrangements, management and leadership roles may not be the same as those in traditional teams. Barry and Stewart (1997) note:

> "…personality may be particularly important in self-managed teams…the role of personality within self-managed teams must be examined from a perspective that allows roles to evolve through interpersonal interactions. One method of determining this effect is to examine how group processes and performance vary with the number or proportion of group members with relatively high scores on personality traits that are theoretically related to group process and performance." (p. 65)

The predictive utility of personality assessment is enhanced when job type and personality constructs are matched, either based on the findings of previous research, rational analysis, or a thorough personality oriented job analysis (Raymark et al., 1997). This is to say, different tasks demand different personality profiles (Hogan, 1996). Extraversion, widely agreed to be the first "Big Five" personality factor, appears to be a valid predictor for tasks involving social interaction (McCrae & Costa, 1987). As such, it is the most appropriate initial factor to examine as we deal with interaction styles and performance in virtual teams in this study. In essence, will extraversion influence the process of a work team that is geographically and/or temporally dispersed and where all communication is mediated by technology?

Extraversion refers to the degree to which individuals are gregarious, friendly, compliant, cooperative, nurturing, caring and sympathetic in contrast to introversion, which is characterized by those who are shy, unassertive, and withdrawn. Extraversion affects interpersonal relations through the quality of social interactions (Barry & Stewart, 1997; McCrae & John, 1992). Extraverts are usually active participants in group interactions and often have high intragroup popularity (Barry & Stewart, 1997; Mann, 1959). Barrick and Mount (1991) also found that extraversion was a personality factor that consistently related to success in the work place. They concluded that extraversion correlates positively with individual performance in jobs involving social interaction. Barry and Stewart (1997) found that at the individual level, extraversion was the "key" personality correlate with individual impact on group performance. At the group level the proportion of high extraversion members in a group was found to be curvilinearly related to group processes and performance (Barry & Stewart, 1997).

Straus investigated the relationship between individual participation in discussions and extraversion to determine if electronic communication promotes participation equalization by reducing member inhibitions (Straus, 1996). The findings revealed that individuals exhibiting extraversion personality characteristics dominated in both FTF and CMC groups. These results supported previous findings that members of CMC groups participate more equally in discussions than do FTF groups, which may be due to the ability of individuals to participate simultaneously in the CMC groups. Similarly, in a study involving extraverts and introverts in traditional FTF meetings and a virtual environment, all participants contributed more original solutions in the virtual environment, compared to the FTF. Although there were more comments in the FTF setting, overall, the extraverts had more comments in both environments (Yellen et al., 1995). Therefore, though CMC promotes equality of participation, and introverts may experience a greater impact in the virtual world than in the traditional team setting, extraverts will typically exert their influence in both settings.

Two ways in which extraversion could be linked to group interaction are based on the nature of extraverted individuals and their behavior characteristics. Extraverted persons have strong tendencies to be articulate, expressive, and may be able to persuade and influence others (Goldberg, 1990; Watson & Clark, 1997). An important behavioral characteristic of extraversion is dominance (Trapnell & Wiggins, 1990). House and Howell (1992) describes dominance as a tendency to "take initiative in social settings, to introduce people to each other, and to be socially engaging by being humorous, introducing topics of discussion, and stimulating social interaction" (House & Howell, 1992, p. 85).

The proportion of group members that are high in extraversion may be related to the groups' interaction style, which in turn, affects both the objective group performance (i.e., task solution quality) and subjective contextual outcomes such as acceptance of the group solution. Too few extraverts can result in low performance whereas too many extraverts can lead to a decrease in group performance due to the group's lessened ability to remain focused on task completion (McCrae & Costa, 1992, 1996). Two possible reasons are: 1) extraverts may be more concerned with pleasurable social interactions than task completion (Barry & Stewart, 1997) and, 2) too many extraverts may result in intra-team conflict. Recalling that one of the characteristics of extraverts is dominance, conflict can occur when there are too many dominant individuals (Mazur, 1973).

To summarize, previous research shows that, while expertise is positively related to team performance, it will be only so long as the team exhibits an interaction style that permits the expertise to be heard, considered, and when possible, improved upon. The presence of extraverted team members is conducive to this process only if those members place high value on social rather than task-related processes. As extraverts commonly display dominance both in the FTF and virtual settings, expertise held by non-extraverts is likely to be suppressed, yielding lower information sharing, lower performance, and lower satisfaction with process. Even if extraverts hold the expertise, dominated introverts will likely feel less free to contribute and improve upon the knowledge, yielding lower performance as well as lower satisfaction with the team process. The model below captures the essence of these relationships. A rationale for each hypothesis is provided.

Model And Hypotheses

H1 Levels of group extraversion and variation in extraversion between virtual team members will influence the development of group interaction styles and outcomes.

- **H1(a)** Extraversion will be positively related to aggressive/defensive and constructive interaction styles.
- **H1(b)** Extraversion will be positively related to contextual measures of performance (cohesion, solution acceptance, and effectiveness).
- **H1(c)** Variation in extraversion between virtual team members will be positively related to the passive/defensive interaction style and negatively related to constructive interaction style.

H1(d) Variation in extraversion between virtual team members will be negatively related to contextual measures of performance.

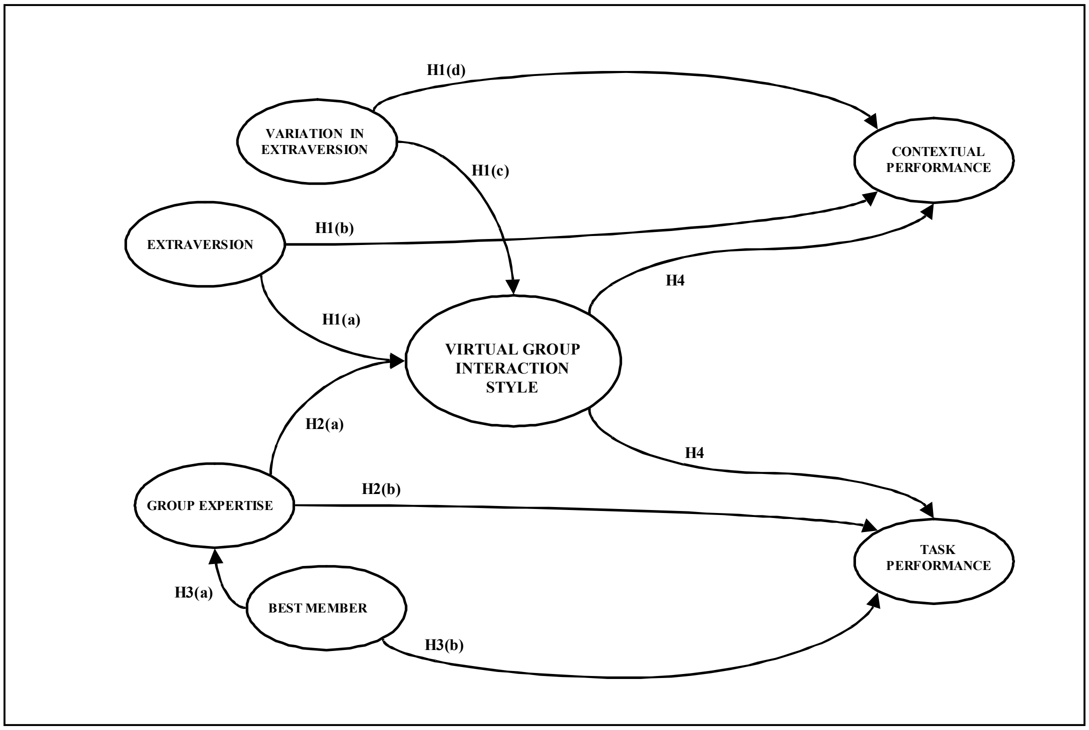

Figure 1. Research model testing the importance of expertise, extraversion, and group interaction style in virtual teams.

Rationale. Group deliberations with gregarious, friendly, cooperative, and nurturing individuals suggest that there will be active participation in the virtual setting. However, extraversion does not necessarily balance both needs for personal achievement and group outcomes. Extraverts with needs for affiliation will create an atmosphere suited for a constructive interaction style. Those extraverts without concern for the group outcome might be perceived as less constructive by their peers. However, these two behavioral extremes of extraverts, at the individual level, suggest that there might not be a clear linear relationship, at the group level, between average extraversion measures and group interaction styles.

A significant difference in extraversion within one experimental virtual team (for instance, teams having a standard deviation score for group extraversion beyond one standard deviation of the mean standard deviation score for all teams) might indicate that only one member of the team is a true extravert or that the team is truly bipolar — suggesting friction between the personalities. Since aggressive/defensive behaviors beget a passive/defensive response and that small number of extraverts cannot produce constructive interactions by themselves, we postulate that a passive/defensive interaction style will prevail with a significantly lower incidence of constructive interactions.

Introverts will not produce the type of interactions that team members would find effective. Consequently, "buying in" the solution would be equally difficult. Groups with many extraverts will produce a fulfilling discussion that, although might not produce an optimum solution, would produce "buy in" and be evaluated as effective by the membership. The behavioral friction of a bipolar team suggests that, even though the solution might be of high quality, there will not be much solution acceptance or perceived effectiveness in those teams.

H2 Levels of expertise in a virtual team will influence the development of group interaction styles and task performance.

H2(a) Expertise will be negatively related to the constructive interaction style.

H2(b) Expertise will be positively related to task performance.

Rationale. Intuitively, low amounts of expertise lead to large amounts of team errors and high levels of expertise will minimize team errors. Knowledgeable teams have better quality information shared among several participants. Thus, through straightforward information exchanges (even those with limited or poor group dynamics), those virtual teams have a greater potential to create a better solution. However, the greater the knowledge in the group, the more difficult it will be to produce a "synergistic" outcome -- one with significantly less errors than the solution proposed by the best individual in the group.

We postulate that large amounts of expertise will result in a less-than-constructive interaction style because, without appropriate training, members will not naturally attempt to improve their own knowledge. Alternatively, lower amounts of expertise will lead to better interactions since participants will seek knowledge but the lack of knowledge will ultimately limit the potential of the group. However, teams with limited expertise will also find it difficult to outperform its best member since the knowledge does not exist in the team to do so.

H3 Expertise from the best member on a virtual team will influence group expertise and task performance.

H3(a) The expertise of the best member will be positively related to group expertise.

H3(b) The expertise of the best member will be positively related to task performance.

Rationale. These hypotheses are self-evident but are offered to examine the contribution of, arguably, the most important individual within the group. (It is important to note that individuals do not know if they are the "best" member, although they might have an indication of their expertise level). The knowledge of the best member in a virtual group is, by extension, a component of the group knowledge. Higher levels of knowledge should improve the potential for producing a good solution. However, the greater the score of the best individual in the group, the more difficult it will be for the group to outperform him/her. We do not expect a relationship between knowledgeable individuals and an extraverted personality. Since group interaction style is more a function of personality traits than knowledge and the virtual setting attenuates the personality of the individuals, we do not expect the best member to substantially influence the development of a predominant group interaction style. We use the same argument with respect to the influence of the best member on contextual performance measures -- it is not a function of knowledge.

H4 Group interaction styles are a significantly more important predictor of task and contextual performance than specific estimates of expertise and/or extraversion.

Rationale. Like individuals, virtual teams have distinct "personalities" (styles of interaction) and potential (available expertise). These group interaction styles are a reflection of a complex interaction between participant characteristics at the individual level and process and personality synergies and losses at the group level. Like people's personalities, group styles can be positive and effective, leading to high-quality solutions to which members are committed. Or they can be negative and defeating, leading to solutions of marginal quality and acceptance.

We postulate that constructive interaction styles within the virtual team will be positively related to task and contextual performance and defensive styles (passive/defensive and aggressive/defensive) will have the opposite relationship.

Method

Participants

Extraversion, group interaction style, task and contextual performance data were collected from 248 members of 63 groups who had completed the Internet version of the "Ethical Decision Challenge" (Balthazard, 2000; Cooke, 1994), a structured problem-solving exercise used for management development and team building in classroom and corporate settings. Subjects were four executive MBA cohorts and several groups of mid-level managers. The groups completed the exercise for course or professional credit. The median number of participants per team was four with 14 three-member teams, 39 four-member teams, and 10 five-member teams. Given their background and/or prior coursework that used Web-based communications and software, all subjects were assumed to be highly computer literate, especially with respect to the technologies in use within the exercise (Windows, Internet browser, e-mail, chat room).

The terms "team" and "group" have been used interchangeably in this paper, although they are not strictly synonymous. Hollenbeck et al. (1997) consider groups to be configurations of two or more interdependent individuals who interact over time, and teams to be special cases of groups, whose members incorporate skill differentiation and share a common fate (i.e., similar consequences for all members depending on success or failure at the team level). Brannick and Prince (1997) also distinguish teams from groups by their members having distinct and non-interchangeable functions. Our subjects met some of these definitional requirements of teams, but not others. Consistent with Hollenbeck et al. (1997) our group members were interdependent, had differing levels of skill, and shared a common fate. However, their roles were not distinct and they were interchangeable. They interacted very briefly compared to most real world virtual teams (e.g., Maznevski & Chudoba, 2000) *on* *this particular task*, but they had interacted with each other previously (and would for the remainder of their coursework). In sum, although our student "teams" are in reality more like groups these definitions provide some justification in using the term "team" to describe our groups.

Task and Technology

The Internet version of the "Ethical Decision Challenge" requires participants to rank ten biomedical and behavioral research practices—all of which involve human subjects— in terms of their relative permissibility and acceptability (Balthazard, 2000; Cooke, 1994). It provides participants with an opportunity to practice their skills in both ethical analysis and group decision-making in a virtual setting. Solutions to the "Ethical Decision Challenge" were developed and posted via an active server page (ASP) input form, first on an individual basis and then as a group. Individual and team solutions were then compared to experts' solution based on the decisions of over 800 Institutional Review Board (IRB) members who are responsible for reviewing proposals for research involving human subjects. Comparisons between individual solutions and the experts' solution indicate how well participants are exercising their knowledge, experience, and skills with respect to ethical analysis and complex problem solving in a distributed environment. Comparisons between participants' individual performance and their team's performance indicate whether they were able to achieve team synergy by fully using and building on their collective knowledge and skills (see Cooke & Kernaghan, 1997). In other words, the team's performance should be better than any individual score if team synergy were achieved.

Participants were introduced to the "Challenge" during a regular 90-minute class meeting. At first, each randomly selected team was asked to provide a team name and select a team secretary (a member with a clerical responsibility for providing the group consensus solution with no implied leadership role). The participants were provided with the URL of the home page for the exercise and directed to the problem statement. Each participant was given a first 10-minute block to read the situation and a second 10-minute block to rank 10 items (e.g., permissibility and acceptability of 10 behaviors). Groups were then given up to 45 minutes to discuss the problem (exclusively on the Internet) and provide the best possible consensus ranking of the items —a ranking with which <u>all</u> group members could "live with." Team members were segregated among several dispersed computer laboratories within the large urban campus and were closely observed to eliminate verbal communication and non-verbal cues (with anyone regardless of team membership). Participants were told that any type of communication would disqualify their participation and cause their team members to forfeit credit for the exercise. All of their discussion was to take place in writing within the "conference" and "chat" features of FirstClass®, a Web-based communication tool and course management software used extensively by the participants in other work. Each team was provided with its own password-protected work area.

It is not clear that the majority of laboratory studies on computer-based group support systems (e.g., electronic brainstorming tools) have given sufficient attention to the issue of trial length (Fjermestad & Hiltz, 1999). If the trial is too long, benefits of a particular treatment or intervention may be exaggerated. If it is too short, the groups may miss out on producing more high quality ideas that generate a better outcome. Although this was not a brainstorming task, we sought to give sufficient time to allow our teams to do their work (which involves surfacing of perspectives on the problem as well as alternative schemes for its resolution, inherent in many brainstorming tasks). We allotted 45 minutes to the test but all teams completed the task within 34 minutes. Thus it seems that all teams completed the task without excessive time pressure and without generating participant fatigue or disinterest.

Upon achieving a consensus solution, the team's secretary registered the ranking by submitting a Web form. Lastly, each member independently completed two questionnaires: (1) The *Group Style Inventory*™[1] (Balthazard, 1999), a normed and validated commercial instrument that assesses interaction behaviors within a group, was answered immediately by all participants. (2) A group process questionnaire (that required some comprehensive essay answers) that assesses satisfaction with the process and "buy-in" into the consensus solution was answered after the session but within 48 hours of the completion of the session. Both questionnaires were answered after ranking the items as a group but before receiving feedback on the "experts' rank" or the quality of their own or team solution.

Measures

Expertise

The "Average (Individual) Expertise" measure represents the average of the absolute difference between individual solutions and the expert's solution and is scored out of 50 points. That is, maximum error would receive a score of 0 and absolute consistency

[1] Group Styles Inventory™and GSI™ are Trademarks owned and licensed by Human Synergistics, Inc.

with the expert's ranking would receive a score of 50. Participants with high initial expertise values were most likely to have considered the implications of their decisions on all the stakeholders within the simulation problem. More generally, individuals with well-honed task skills — such as extensive knowledge, experience, or skills in ethical analysis (our task here) and/or complex problem solving — will have the best (higher) expertise values. At the group level of analysis, higher values indicate teams with better *potential* for performance.

From individual expertise we derive the "Best Member Expertise" group-level measure by selecting the highest individual performance score within a team (prior to interaction). This measure provides another standard or benchmark for analyzing the team's performance. Ideally the team should develop a solution that is of higher quality than the solution developed by the best member working alone.

Task Measures of Performance

Two measures of task performance were derived for each team. The first, "Team Performance," represents the absolute difference between the team's consensus solution and the expert solution. As per the individual recipe, a score of 50 represents absolute consistency with the expert ranking. Groups with relatively few errors in their solutions are more likely to have considered the implications of their decisions on all the stakeholders within the simulation problem. A solid team performance value can be the result of high-quality group interaction, but it can also be achieved when members have significant task skills and knowledge (as reflected by the individual expertise measure discussed above).

Second, "Team Synergy," is computed by subtracting the team (consensus) performance measure from the best member's performance. If the team's performance measure is *higher* than the best member's performance measure, the difference represents a gain in quality over the best member's initial solution; if the team's performance is *lower* than the best members', the difference represents a loss in quality.

Process loss is indicated when better solutions are developed by members working alone rather than as a group. It occurs when the group interacts and approaches problems in ways that either prevents members from sharing relevant knowledge and information or from recognizing and using relevant knowledge and information when it is offered.

In contrast, when groups outperform even their best-scoring members, they have achieved synergy. A team measure that is better than the initial measure of any of its members cannot be explained by initial task ability or knowledge; rather, such performance is due solely to the quality of interaction, communication, and learning within the group.

Group-level Extraversion

At the beginning of the course in which they were enrolled, and several weeks prior to the exercise, individuals participating in the study completed a 50-statement "Big Five" factor instrument. Respondents judged the accuracy of each sentence as a description of self on a 5-point response scale; scale endpoints were (1) *Very Inaccurate* and (5) *Very Accurate*. Within the instrument, 10 items are intended to represent each of the five personality dimensions that comprise the model --extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience (see Goldberg, 1990; Barry & Stewart, 1997; McCrae & Costa, 1989). The answers to the 10 extraversion items were summed to form a single individual measure (see Table 1 for inter-rater reliability and average variance extracted measures). Sample items include:

(1) Feel comfortable about people.
(2) Am skilled in handling social situations.
(3) Keep in the background (reverse coded).
(4) Know how to captivate people.

We then determined the overall levels of extraversion within each team by averaging the scale scores of individual members. Following Barry and Stewart (1997), a second group level extraversion measure captured the variance in the extraversion measures for each member (operationalized as the standard deviation of extraversion in each team).

Group Interaction Styles

To assess group interaction styles, participants answered the Group Styles Inventory™ (GSI) from Human Synergistics International of Plymouth, Michigan. The instrument contains 72 questions that focus on the ways in which members of a group might interact with one another and approach their task during a meeting or specific problem-solving session (see Cooke & Szumal, 1994 for complete list of items and description of the commercial instrument). Specifically, following prior research (see Cooke & Rousseau, 1988; Cooke & Szumal, 1994), constructive, passive/defensive and aggressive/defensive interaction styles were treated as first-order constructs that reflected underlying group behaviors. A constructive interaction style was measured by four subscales (i.e., second-order constructs) composed of six items each, labeled as follows: "self-actualizing, "humanistic/encouraging," "achievement," and "affiliative" constructive behaviors (coded as "Constructive *n*" in Table 1). Similarly, a passive/defensive interaction style was measured by four subscales comprised of six items each, assessing "approval," "conventional," "dependent," and "avoidance" passive interaction styles (coded as "Defensive P*n*" in Table 1), whereas an aggressive/defensive interaction style was measured by four subscales composed of six items each, assessing "oppositional," "power," "competitive," and "perfectionistic" aggressive interaction styles (coded as "Defensive A*n*" in Table 1) (Cooke & Szumal, 1994).

After completing the "Ethical Decision Challenge," participants answered the questionnaire by indicating the extent to which each item described the style of their group using a five-point response scale ranging from (1) *not at all* to (5) *a very great extent*. Responses to the relevant items for each of the four constructive and eight defensive group interaction subscales were summed, and an average score was computed for the respective teams on each subscale. Sample aggressive/defensive items include:

To what extent…

(1) …did some members seem more interested in "winning the point" than in solving the problem;
(2) …did the discussion seem to turn into a contest;
(3) …did the group get "hung up" on details.

Sample Constructive items include:

To what extent…

(1) …did the group set goals and work toward them;
(2) …were conflicts and differences used constructively (to generate better ideas);
(3) …did members actively look to each other for ideas, insights, and opinions.

Sample passive/defensive items include:

To what extent…

(1) …did some members seem to expect others to run the meeting;
(2) …were members evasive when decisiveness was needed;
(3) …did people stay detached (and never fully come together as a team).

The overall levels of aggressive/defensive, constructive, and passive/defensive interaction styles within each team were then computed by averaging the scale scores of individual members. Justification for aggregation of these measures is discussed in the "Level of Analysis" section below.

Factor scores were used instead of scale scores for the group interaction styles in all our analyses to ensure statistical independence of those scores. Because of the complementary nature of the 12 behaviors (second-order constructs) that make up the 3 styles measured by the instrument (first-order constructs), they are all related to some degree to one another; thus, the "raw" scale scores for the three styles that are aggregates of the 12 behaviors are likely to be correlated as well, presenting multicollinearity problems in statistical analyses where group interaction styles are present. Providing independence (at the individual level of analysis) between the constructive, passive/defensive, and aggressive/defensive factor scores is consistent with the varimax rotation used to identify orthogonal group-level measures used in our analyses.

Contextual Measures of Team Performance

Three contextual measures of performance were derived for each team: "Cohesion," "Process Effectiveness" and "Solution Acceptance." Cohesion was measured by asking participants on the post-task questionnaire to rate nine items that dealt with group atmosphere and satisfaction with the group. Respondents were asked to indicate their level of agreement with:

(1) members appeared to feel that they were really part of the group;
(2) people offering new ideas were likely to get "clobbered" (reverse);
(3) the group members really helped each other out on this task;
(4) some people showed no respect for the others (reverse);
(5) members of the group really stuck together;
(6) there were feelings in the group which tended to pull the group apart (reverse);
(7) group really got along well with one another;
(8) there was constant bickering (reverse);
(9) it appeared that members of the group would look forward to working with one another again.

Items 1, 2, 4, 6, 8, and 9 were taken from the work of Cook (1981); items 3, 5, and 7 came from the work of O'Reilly et al. (1989). Responses to each of these items were rated on a 5-point Likert scale ranging from 1 = *strongly disagree* to 5 = *strongly agree.* However, we ultimately retained only items 1, 3, 5, 7, and 9 for two reasons. First, as described further below, the reverse coded items loaded on their own dimension and overlapped with either the group interaction styles measure or other contextual measures, weakening the discriminant validity of the cohesion measure in this context. Thus, only the five remaining items for group cohesion were averaged for each team.

Process effectiveness was measured by asking participants on the post-task questionnaire to rate two sentences that dealt with behaviors consistent with conscientious groups (specifically completing the EDC). Respondents were asked to indicate to what extent…

(1) …were the potential risks to research subjects fully considered by the group?
(2) …was the importance of the research procedures (to investigators, the hospital, and to scientific knowledge) fully considered by the group?

Similar (but more generic) items have been used in the work of Cook (1981), O'Reilly et al. (1989), and Human Synergistics (1993). Responses to each of these items, which ranged from (1) *not at all* to (5) *to a very great extent,* were summed and averaged for each team member. High scores on the two items thus represent a high degree of process effectiveness. The overall level of process effectiveness within each team then was computed by averaging the scale scores of individual members.

Solution Acceptance was measured by five supplementary questions included in the group interaction questionnaire. Respondents were asked to report the extent to which they…

(1) …were personally committed to the course of action proposed by the team?
(2) …thought the solution generated by the group was better than the one developed personally?
(3) …thought the group came up with the best solution possible – given the time available to solve
the problem?
(4) …had reservations about any of the decisions reached by the group?
(5) …would feel comfortable defending the group's decisions?

The questions were adapted from the work of Cooke and Lafferty (1988). Responses to each of these items, which ranged from (1) *not at all* to (5) *to a very great extent,* were averaged for each team member. High scores on this scale therefore represent a high degree of solution acceptance in the group. Solution Acceptance within each team then was computed by averaging the scale scores of individual members.

Level of Analysis

The level of analysis in the present study is the group. To justify the aggregation of the items measuring the various scales to the group level, inter-rater reliability and agreement was assessed for the measures by means of the eta-squared statistic (η^2), a series of one-way analyses of variance (ANOVAs with group membership as the independent variable and the measure to be aggregated as the dependent variable), and tests based on the multiple-item estimator $r_{wg(j)}$ for scales with moderately skewed distributions (see James et al., 1984, 1993; Lindell & Brandt, 1999; Lindell et al., 1999). The multiple-item estimator $r_{wg(j)}$ was used to assess inter-rater consensus or the interchangeability among different members' responses within each group to the items associated with each scale. As a measure of convergence among a group of raters, this estimator is particularly relevant to instruments designed to measure group- or organizational-level variables on the basis of individual members' reports (Kozlowski & Hattrup, 1992). As depicted at the bottom of Table 1, results of the r_{wg} analyses indicate a minimum average IRC of .71, for all appropriate scales. That is, 71% of the teams on average achieved a r_{wg} value above .70. An inter-rater consensus coefficient (IRC) of .70 for the *majority* of cases is considered sufficient agreement (George, 1990, p.110). In this study, $r_{WG(j)}$ statistics are not appropriate for the process effectiveness or extraversion measures. The effectiveness scale has only 2 items (which can lead to unpredictable results with the r statistic) and the average extraversion measure is an aggregate of self-assessed items with only one rater (self) per individual.
The η^2 statistics indicate that group membership explained 44% of the variance in individual responses to the defensive items, 43% of the variance for the constructive measure, 51% of the variance for the cohesion measure, 32% of the variance for the effective measure and 44% of the variance for the solution acceptance measure. Similarly, the *F* ratios in Table 1 suggest that the variance in responses between groups is significant in relation to the total variance for each measure, except effectiveness (which despite its small number of items produced an adequate eta-squared statistic). The η^2 and most *F* ratios therefore support the proportional consistency of variance (Kozlowski & Hattrup, 1992) among the responses of members within the same group as compared to the responses of members across groups (i.e., inter-rater reliability). Thus, team members' assessments of the team's interaction styles, and team members' assessments of cohesion, solution acceptance, and process effectiveness were aggregated to the group level for each scale.

Analysis

The foregoing hypotheses address the mechanisms through which personal characteristics of individuals are aggregated via group-level dynamics to produce group-level outcomes. Although we believe that the examination of the contribution of each individual to the group outcome is a worthwhile exercise, we limit our work here to group-level analyses. Actually, combinations of group member dispositional characteristics have been presumed conceptually to be associated with group processes since the early days of group dynamics research (e.g., Haythorn, 1953). We believe that there is no conceptual reason to dispute this assumption in the virtual setting.

The hypotheses were tested three ways: correlation analysis, regression analysis, and a series of *post hoc* *t*-tests examining outcomes for specific levels of expertise and/or extraversion. First, correlations were computed among the different measures. The correlations provide an indication of the direction and magnitude of the relationship between the expertise, extraversion, interaction styles, and task and contextual outcome measures.

Second, two sets of multiple regression analyses were performed to define the relative importance of each measure as a predictor of outcomes. A forward (stepwise) selection procedure was first performed followed by a backward elimination procedure. Forward selection is traditionally the most widely used but least reliable in reaching valid results in multivariate datasets. The backward elimination procedure is more accurate. Therefore, agreement between these two stepwise regression procedures would be enough to provide reliable and valid estimates of the standardized regression coefficients. Unlike the correlations, the standardized betas from a multiple regression equation with independent variables entered simultaneously provide an indication of the unique effects of average expertise, extraversion, variation in extraversion, and group interaction styles when taken together. We excluded best member expertise in this set of independent variables since our model depicts its role in the development of a group interaction style as included within group expertise.

Collinearity diagnostics, including variance inflation factors (VIF), are provided with the regression analyses. The VIF are inversely related to tolerance values (amount of variability of a selected independent variable not explained by other independent variables) and indicate the degree of collinearity or multicollinearity among the independent variables. Tolerance values below .10 and corresponding VIF values above 10 are considered large and indicative of significant multicollinearity issues. Finally, the resulting R^2 from a multiple regression equation provides an estimate of the total variance explained in the dependent variable by the set of independent variables (i.e., the seven measures entered together). Five sets of regression equations were computed, one set for each outcome measure. The direction of the standardized regression coefficients and their corresponding level of significance (as estimated by the *t* statistic) were used to further determine whether the hypotheses were supported.

Finally, a series of ANOVAs and *post hoc* *t*-tests examined the significance of outcomes at different levels of extraversion, expertise, and group interaction styles. Graphical representations provide evidence of curvilinear relationships between levels of knowledge, behavior, and performance.

Results

Test of the Measurement Model

We tested the measurement model by examining individual item reliability, internal consistency, convergent validity, and discriminant validity. We assessed individual item reliability of the scales used to measure the constructs in the model by examining the factor loadings of items on constructs (see Table 1).

As explained earlier, initial examination of the measurement model revealed that four cohesion items had cross-factor loadings on the interaction style and solution acceptance measures. Close examination of these items revealed that they measured specific behaviors (e.g., “new ideas were likely to get clobbered” – reverse coded) rather than the “togetherness” of the team (“…group really got along well”). One item (“I look forward to working with this group again”) erroneously loaded on the solution acceptance factor, although it measures group commitment. Accordingly, these four items were dropped from the scale, and five items remained to measure cohesion. We also dropped one item from the extraversion scale (“I would describe my experiences as somewhat dull” – reverse coded) that cross-loaded on the defensive interaction scale. No other change to our scales was required.

Table 1(a) shows the factor and cross-factor loadings of the measures of the constructs and the scale reliabilities. With few exceptions, items loaded at the .60 level or higher on their respective constructs, as recommended by Barclay et al. (1995), and did not cross-load significantly (over .40) on other factors. One of five cohesion items cross-loaded on the constructive factor and one of five solution acceptance items cross-loaded on the cohesion factor.

A. Factor and Cross-Factor Loadings[A]

	Extraversion (negative)	Extraversion (positive)	Constructive	Defensive	Cohesion	Solution Acceptance	Process Effectiveness
extraversion N1	***0.79***	0.22	-0.12	0.02	0.00	-0.02	-0.01
extraversion N2	***0.78***	0.29	-0.10	0.00	-0.03	-0.05	0.04
extraversion N3	***0.77***	0.22	-0.05	0.03	-0.05	0.06	0.03
extraversion N4	***0.64***	0.12	0.04	0.08	0.01	-0.04	-0.26
extraversion P1	***0.51***	***0.46***	0.08	0.06	-0.05	-0.14	-0.02
extraversion P2	0.20	***0.79***	-0.19	-0.01	0.06	0.03	0.03
extraversion P3	0.22	***0.76***	0.03	-0.09	-0.07	0.01	-0.12
extraversion P4	0.25	***0.75***	0.08	0.01	-0.06	-0.03	-0.05
extraversion P5	0.22	***0.67***	-0.08	0.02	-0.01	-0.06	0.23
constructive 1	-0.05	-0.03	***0.86***	-0.12	0.23	0.24	0.13
constructive 2	-0.09	0.00	***0.85***	-0.01	0.31	0.11	0.14
constructive 3	0.00	-0.04	***0.82***	-0.06	0.33	0.25	0.02
constructive 4	-0.08	-0.07	***0.75***	0.04	0.20	0.30	0.29
Defensive A1	-0.01	-0.04	-0.12	***0.88***	-0.14	-0.16	0.01
Defensive A2	-0.02	-0.03	-0.17	***0.87***	-0.07	-0.17	0.09
Defensive A3	0.05	-0.05	-0.02	***0.81***	0.04	-0.11	0.12
Defensive A4	0.01	-0.03	0.00	***0.78***	-0.02	-0.18	0.16
Defensive P1	0.04	-0.05	-0.05	***0.84***	-0.11	-0.09	-0.19
Defensive P2	0.06	0.06	-0.14	***0.80***	-0.17	-0.01	-0.24
Defensive P3	0.01	-0.03	0.13	***0.79***	0.00	-0.01	-0.15
Defensive P4	-0.05	-0.03	-0.01	***0.77***	-0.28	0.00	-0.21
Cohesion 1	-0.10	0.02	0.29	-0.11	***0.75***	0.20	-0.01
Cohesion 2	-0.05	0.01	0.12	-0.12	***0.71***	-0.04	0.35
Cohesion 3	0.07	-0.05	0.22	-0.07	***0.70***	0.27	-0.15
Cohesion 4	-0.03	-0.07	**0.40**	-0.30	***0.58***	0.11	-0.04
Cohesion 5	0.03	-0.10	0.39	-0.14	***0.56***	0.22	0.20
Sol. Accept. 1	0.03	-0.08	0.20	-0.13	0.19	***0.78***	0.14
Sol. Accept. 2	0.10	-0.08	0.22	-0.08	0.08	***0.69***	0.25
Sol. Accept. 3	-0.13	-0.02	0.37	-0.21	0.04	***0.62***	0.20
Sol. Accept. 4	-0.16	0.08	0.05	-0.31	0.17	***0.59***	-0.23
Sol. Accept. 5	-0.13	0.02	0.31	-0.13	**0.40**	***0.56***	0.09
Effectiveness 1	-0.12	0.08	0.33	-0.18	0.18	0.21	***0.64***
Effectiveness 2	-0.10	0.02	0.33	-0.08	0.03	0.27	***0.64***

[A] Obtained via principal components analysis with Varimax rotaition and Kaiser normalization.
The KMO measure of sampling adequacy was 0.89.

B. Consistency, Reliability, and Aggregation Assessments

	Extraversion	Constructive	Defensive	Cohesion	Solution Acceptance	Process Effectiveness
ICC(3,k)	0.86	0.93	0.94	0.81	0.80	0.70
AVE	0.62	0.81	0.74	0.64	0.63	0.63
η^2	n/a	0.43	0.44	0.51	0.44	0.32
Anova	n/a	1.88**	1.93**	2.63**	1.99**	1.21
Mean $r_{WG(j)}$ IRC	n/a	0.78	0.84	0.71	0.83	n/a

** p < .01

Table 1. Test of the Measurement Model

Another peculiarity of the factor analysis was the behavior of the extraversion items. Positively worded items and negatively worded items (reverse coded) loaded on two distinct factors, except for one positively worded item than loaded equally on both. Positive items cross-loaded on only one factor: the negative items; and negative items also cross-loaded on only one factor: the positive items. We decided to keep the nine extraversion items within the same intact scale. Thus, the distribution of factor loadings indicated six independent factors.

Table 1(b) shows measures of consistency, reliability, and aggregation. Scale reliability was evaluated using Fornell and Larcker's (1981) internal consistency measure, denoted ICC(3,k), a two-way mixed effects model average reliability measure. Internal consistency is interpreted in the same way as Cronbach's alpha, but it takes into account individual item weightings (whereas Cronbach's alpha is based on the assumption that each item contributes equally to the construct). Internal consistency reliabilities for the constructs examined in this study ranged from .70 to .94 which exceed Nunnally's (1978) guideline of .70. Convergent validity was evaluated by calculating the average variance extracted (AVE) for each construct. When the AVE exceeds .50, the interpretation is that the variance shared between the construct and its measures is greater than unexplained error (Fornell and Larcker, 1981). The AVE ranged from .62 to .81 for all constructs (see Table 1).

The loading of the passive/defensive (people and security oriented) and aggressive/defensive (task and security oriented) constructs on a single "defensive" factor is to be expected in a discriminant analysis. The task-people distinction is definitely secondary in magnitude and importance to the security-satisfaction distinction and, when other variables are considered in the same analysis, the two constructs converge. That is, they are distinct but become relatively similar when analyzed along with outcomes like solution acceptance and cohesion. However, consistent with prior research (e.g., Cooke & Lafferty, 1988; Cooke & Szumal, 1994), analysis in a downward hierarchical manner produced distinct sub-factors corresponding to the constructive, passive/defensive, and aggressive/defensive styles. Since we postulate that passive and aggressive styles differentially impact outcomes (consistent with prior research), the distinct factor scores of the sub-analysis were retained and used in our analyses.

The intercorrelations presented in Table 2 provide further evidence to support the convergent and discriminant validity of the measures examined in the current study. In all cases, the average correlation among the measures of each construct, as shown by the boldfaced elements on the diagonal of the correlation matrix (where appropriate), was greater than that construct's relationship with any other construct tested in the network of constructs. Yet, there was also some overlap in the constructs being measured, as expected based on our discussion of prior literature. In particular, the cohesion measure is strongly related to the constructive and aggressive (defensive) measures.

However, examination of Table 2 indicates that the cohesion items have much higher loadings on this construct than on any other construct, thereby providing further support for the discriminant validity of this measure.

Correlation Analysis

The results of the correlation analysis are presented in Table 2. There is only partial support for hypothesis H1. Contrary to H1(a), the level of extraversion is negatively and significantly correlated with the constructive interaction styles in virtual teams (as estimated by the Pearson coefficient $r = -.27$, $p < .05$). The relationship is also in the negative direction with aggressive/defensive styles. Further, refuting H1(b), the level of extraversion does not have a significant relationship with contextual performance measures. However, there is strong support for H1(c) that postulates that variation in extraversion is positively and significantly related to the passive/defensive style ($r = .25$, $p < .05$), and negatively and significantly related to the constructive style ($r = -.22$, $p < .05$). In support of H1(d), variation in extraversion is also strongly and negatively correlated to contextual measures of performance.

	Mean[A]	S.D.	1	2	3	4	5	6	7	8	9	10	11	12
1. Average Expertise	26.72	3.61	*n/a*											
2. Best Member Expertise	33.94	4.42	.64**	*n/a*										
3. Extraversion	2.53	0.36	-.02	-.01	**.79**[B]									
4. Variation in Extraversion	0.64	0.25	.03	-.01	.20*	*n/a*								
5. Aggressive Style (factor)[C]	-0.01	0.68	-.04	-.01	-.19	.01	**.87**							
6. Constructive Style (factor)	-0.02	0.61	-.21*	-.09	-.27*	-.22*	-.01	**.90**						
7. Passive Style (factor)	-0.02	0.58	-.09	.04	.02	.25*	-.11	-.06	**.85**					
8. Team Performance	29.87	5.29	.48**	.52**	.13	-.05	-.03	-.03	-.14	*n/a*				
9. Team Synergy	-4.07	4.82	-.06	-.35**	.15	-.05	-.02	.05	-.19*	.62**	*n/a*			
10. Cohesion	3.80	0.60	-.15	.04	-.08	-.34**	-.17+	.60**	-.30**	.24*	.23*	**.80**		
11. Solution Acceptance	3.42	0.51	-.14	-.04	-.13	-.33**	-.24*	.54**	-.30**	.13	.19*	.62**	**.79**	
12. Process Effectiveness	3.16	0.65	.06	.02	-.03	-.20*	-.13	.47**	-.23*	.19*	.19*	.45**	.54**	**.79**

A. N = 63 teams.

B. Where appropriate, diagonal elements in boldface represent the square root of the average of variance extracted. For adequate discriminant validity, the diagonal elements should be greater than the corresponding off-diagonal correlations.

C. Factor scores used for interaction styles (for independence of measures).

* p<.05; ** p < .01; + p<.10

Table 2. Group-Level Means, Standard Deviations, and Correlations

In support of hypotheses H2 and H3, the correlation analysis also demonstrates that expertise is negatively and significantly correlated (r = -.21, $p < .05$) to the constructive interaction style (H2(a)) and positively correlated (r = .48, $p < .01$) to team performance (H2(b)). The team's level of expertise also correlates highly and positively (r = .64, $p < .01$) with the best member's expertise (H3(a)). This is not surprising since the best member's expertise is a component of the group's expertise. The analysis also shows that the best member's expertise is positively associated with team performance (r = .52, $p < .01$) but negatively associated with team synergy (r = -.35, $p < .01$) in the virtual setting (H3(b)). A careful examination of the correlation columns representing team expertise and the expertise of its most expert member demonstrates that the special abilities of a single individual do not translate into any predominant interaction style although they contribute to the team solution – there are other factors at play.

In addition, the correlation analysis provides information about the group interaction styles (H4). First, the styles inter-correlations are negligible at the group level of analysis and provide further support for the use of aggregated factor scores in our analyses. Second, each interaction style provides a different pattern of relationship with task and contextual performance measures. A passive/defensive style marginally correlates (negatively) with team performance (r = -.14, ns) and significantly (negatively) with team synergy (r = -.19, $p < .05$) whereas constructive and aggressive/defensive styles do not seem to relate to task outcomes in the virtual setting.

However, pertaining to contextual outcomes in virtual teams the relationships are clear. Constructive styles promote healthy group outcomes whereas passive/defensive styles do not. Although negative, the relationships between contextual performance measures and aggressive/defensive interaction styles are not as strongly defined. For instance, where the negative relationship between process effectiveness and the passive/defensive group style is significant (r = -.23, $p<.05$), it is not significant in relation to the aggressive/defensive style (r = -.13, ns). A similar situation exists for the relationship with cohesion. The correlation is negative and significant between it and the passive/defensive style (r = -.30, $p<.01$) but it is not significant (at the $p<.05$ level) between it and the aggressive/defensive style.

Multiple Regressions

Prior to conducting the stepwise multiple-regression analysis, we tested the *a priori* assumptions of linearity and normality. Linearity was ascertained by the inspection of bivariate scatterplots of the target measures and normality by the review of histograms for the residuals as well as normal probability plots, examining the distribution of the residual values. The regression results, pertaining to hypothesis H4, are shown in Table 3. The values have been confirmed by replicating the analysis using a backward elimination procedure without significant changes in the standardized coefficients reported here. We ran five sets of equations, one for each task and contextual performance measure. In all models, we included team size as a control variable, expertise, two measures of extraversion, and the three group interaction styles. The variance inflation factors, all relatively close to 1.0, support the factor and cross-factor loadings of Table 1 and our management of the multicollinearity issue.

Not surprisingly, we find that expertise is the most powerful predictor of team performance (β = .52, $p < .01$). That is, in "content full" tasks like the Ethical Decision Challenge, the quality of the team solution is related to the amount of expertise available in the team (e.g., greater expertise will decrease team errors). The significant F value (e.g., F = 3.47, $p < .01$) and the adjusted R^2 indicates that our model is adequate to explain a significant amount of variance in the team performance measure.

Outcome[A]	(Control) Team Size	Expertise	Extraversion	Variation in Extraversion	Group Interaction Style[B] Aggressive	Constructive	Passive	F (7,56)	Adjusted R^2
Team Performance	.09[C]	.52**	.19	-.07	.01	.12	-.08	3.47**	.20
Team Synergy	-.01	-.06	.18	-.02	.01	.07	.18	0.64	.04
Cohesion	.17+	-.03	.07	-.17+	-.19*	.57**	-.27**	9.54**	.47
Solution Acceptance	.13	-.06	-.03	-.15	-.27**	.48**	-.28**	7.70**	.42
Process Effectiveness	.11	.16	.10	-.07	-.13	.51**	-.21*	4.84**	.24
VIF =	1.05	1.09	1.19	1.15	1.09	1.19	1.11		

A. N = 63 teams. Results confirmed with backward elimination procedure.

B. Interaction Styles are aggregated factor scores (for independence of style measures).

C. Standardized regression coefficients.

* p < .05; ** p < .01; + p < .10

Table 3. Contribution to Outcomes: Stepwise Regression and Collinearity Diagnostics

Our models also explain a significant amount of variance in the cohesion, solution acceptance, and process effectiveness measures. In contrast, in the absence of other measures our model cannot adequately explain team synergy.

Surprisingly, we find that the importance of extraversion and variation in extraversion is limited in our models. It may be that extraversion and variation in extraversion may contribute to outcomes only through their effect on interaction style. In other words, the effect of extraversion and variation in extraversion on outcomes tends to dissipate (e.g., mediated) when interaction type is taken into account. In fact, when interaction styles are included in the model, effects from other variables are greatly reduced or disappear, except with team performance—which is best predicted by expertise in the group— and team synergy which cannot be explained by our model.

The constructive style promotes cohesion (β = .57, p < .01), which is inhibited by aggressive/defensive (β = -.19, p < .05) and passive/defensive behaviors (β = -.27, p < .01). It also promotes solution acceptance (β = .48, p < .01), again inhibited by aggressive/defensive acceptance (β = -.27, p < .01) and passive/defensive behaviors (β = -.28, p < .01). Finally, constructive behaviors promote process effectiveness (β = .51, p <. 01) and passive behaviors inhibit process effective-ness (β = -.21, p < .05). As expected, we find no role for team size (a control variable) and conclude that team size did not have a significant effect on our task or contextual measures.

Overall, the regression analysis provides only partial support for H4, particularly with respect to the impact of interaction styles on contextual performance. It also indicated that team performance is best predicted by the available expertise in the group and that team synergy cannot be explained by the set of variables in our models.

Discussion

Our results offer a number of important insights into virtual teams. First, individual communication behavior — rooted in stable personality characteristics — can be expressed and perceived via some modern forms of computer-supported media. In addition, as with more traditional face-to-face teams, virtual teams exhibit constellations of these behaviors that can constitute an interaction style. In this study, we have shown that cognitive indicators such as expertise and personality factors such as extraversion contribute to these styles.

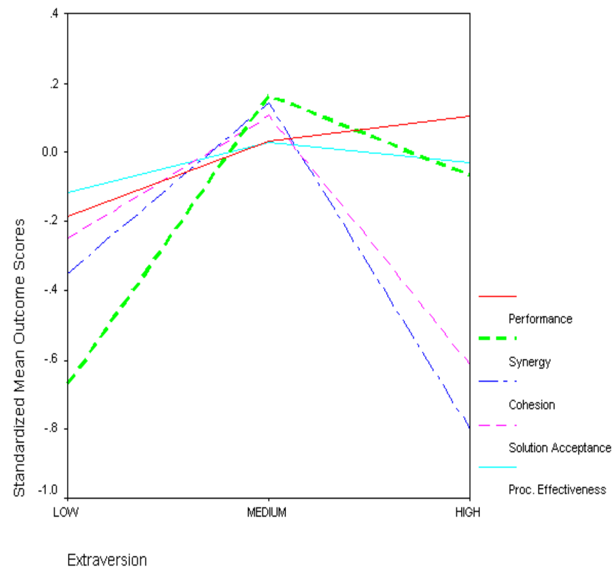

Figure 2. Performance by Levels of Extraversion

For instance, we unexpectedly found that extraversion can inhibit the development of constructive and/or aggressive/defensive styles and variations in extraversion within a team lead to passive/defensive styles and non-constructive behaviors. Further, our correlations could not detect a significant relationship between extraversion and performance measures. This finding seems to contradict the work of McCrae and Costa (1992) who found that too much extraversion lead to decrease in performance. A potential explanation to our pattern of correlations might be derived from the work of Barry and Stewart (1997) who noticed that the proportion of high extraversion members in a group has a curvilinear relationship to group processes and performance. To test this assertion in our dataset, we split our extraversion data into three sub-groups. The “low” grouping was made up of teams with extraversion scores at least one standard deviation below the mean. The “high” grouping was made up of teams with extraversion scores at least one standard deviation above the mean. Remaining groups were deemed “medium.” We then plotted the relationship between the three levels of extraversion and contextual performance measures (see Figure 2) and ran ANOVA and *post hoc t*-test analyses comparing the three groups. Performance z-scores were used to achieve a standard scale in this graph.

Main effects for level of extraversion were found for cohesion ($F(2,61)=3.11$, $p<.05$) and team synergy ($F(2,61)=3.21, p<.05$). For example, there was an 8% increase in cohesion between teams with low levels of extraversion and teams with medium levels of extraversion, and a 14% decrease from teams with

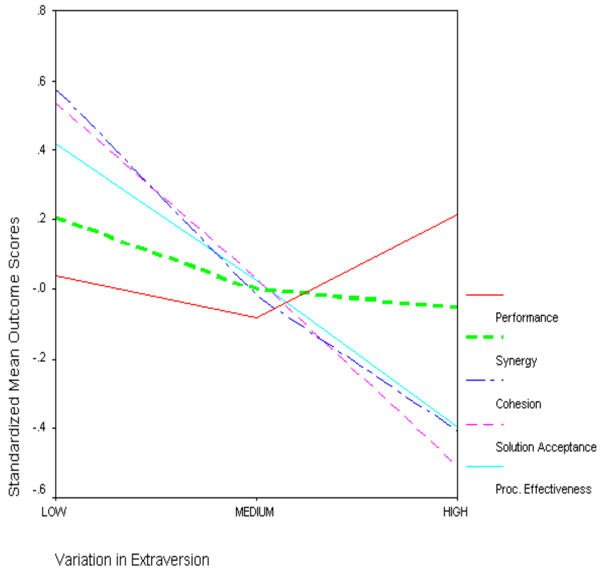

Figure 3. Performance by Levels of Variation in Extraversion

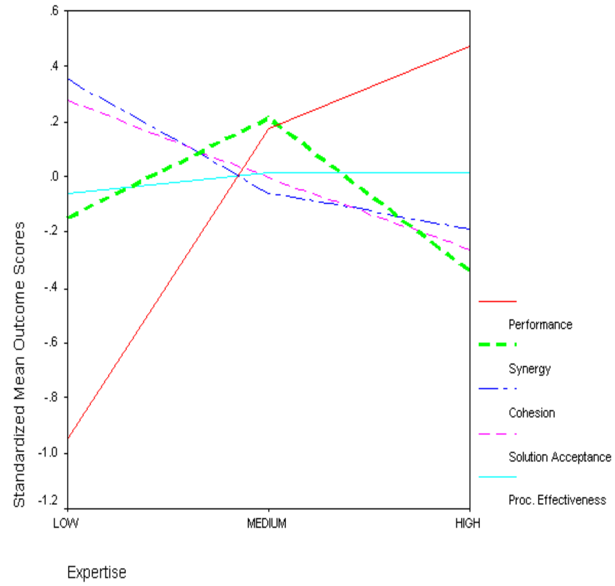

Figure 4. Performance by Levels of Expertise

medium levels of extraversion and teams with high levels of extraversion. Further, *post hoc* analysis also showed a significant differences in team synergy (t=2.35, p<.01) between teams having low and medium levels of extraversion; in cohesion (t=2.17, p<.05) and solution acceptance (t=1.69, p<.05) between teams with medium and high levels of extraversion.

Variation in extraversion within virtual teams, which connotes the presence of both extraverts and non-extraverts, appear to trigger largely negative interaction characteristics (see Figure 3). For example, variation in extraversion begets passive/defensive interaction styles and non-constructive behaviors. It also inhibits contextual performance. Main effects were found for cohesion (F(2,61)=3.49, p<.5) and solution acceptance (F(2,61)=3.99, p<.05). The variation in extraversion measure was found to have a linear relationship with all outcome measures, except performance, which improved at a greater pace in teams with the largest variation in extraversion. Again, performance z-scores were used to achieve a standard scale in this graph.

As depicted in Figure 4, we found that level of expertise progressively improves performance on the task at hand (F(2,61)=10.80, p<.01) but provides relatively little help to the on-going group process. Also, as the expertise of the best expert increases, it becomes increasingly difficult (but not impossible) for the team to outperform its most expert member.

Perhaps most importantly, the present study indicates that it is mostly group interaction styles, not individual personality or the expertise of one individual, that have predictive power on contextual outcomes in virtual teams. Figure 5 demonstrates this effect by plotting performance by predominant group interaction style. That is, differences along the three GSI factor scores were used to identify and compare teams whose interactions were characterized by a single predominant style. At the group level of analysis, each team's passive and aggressive factor scores were added together and then subtracted from their constructive score and the 10 groups with the largest residual scores were deemed predominantly constructive. Similarly, passive/defensive and constructive factor scores were added together and then subtracted from aggressive/defensive scores to identify the 10 most aggressive/defensive groups, and aggressive/defensive and constructive scores were added together and then subtracted from passive/defensive scores to identify the 10 most passive/defensive teams. Main effects for predominant interaction style were found for cohesion (F(2,61)=2.14, p<.01), solution acceptance (F(2,61)=4.31, p<.01), and process effectiveness (F(2,61)=4.44, P<.01).

How a team interacts determines its ability to make quality decisions and to achieve a shared satisfaction with the decision and the group's processes. As one might expect from these three predominant interaction styles, the virtual teams with a constructive interaction style have members whose communication behaviors support intra-group communication. Relevant know-

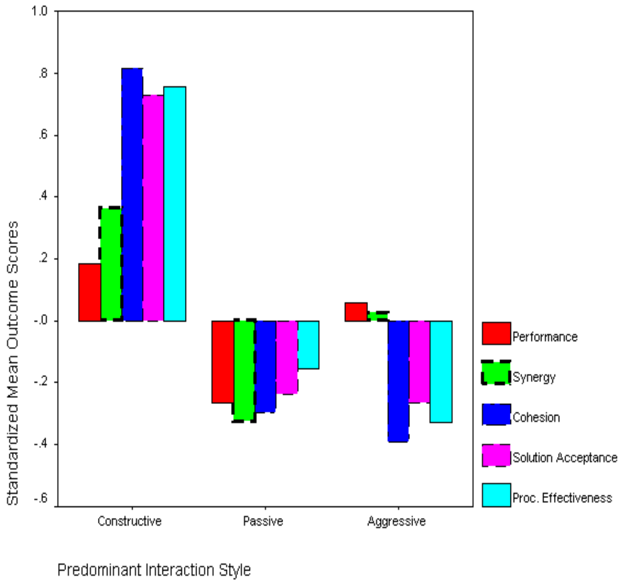

Figure 5. Performance by Predominant Group Interaction Style

ledge held by any group member is contributed, respected, and distributed to the other group members. Better decisions are made because all knowledge resources are brought to bear on the problem. Decisions have much greater support because of a greater sense of substantive contribution and perceived equity of group processes. Conversely, it is also possible for groups to be defensive in nature. In passive/defensive interaction style virtual teams, there may be disinterest, free riding, and “groupthink” type conformity. Opinions are often suppressed and knowledge is often ignored, discounted, or not shared. In aggressive/defensive interaction style groups, dominators in these groups may also make it hard for others to contribute, and overemphasis on the task (and under-emphasis on people’s feelings and process fairness) makes for a very unsatisfying group experience.

These results are provocative for organizations adopting virtual teams in that they imply that steps need to be taken to help distributed personnel adopt constructive interaction styles before they embark on team tasks. Some have suggested that initial face-to-face meetings are warranted before the virtual team proceeds. It may also be rational that team-building exercises should precede team performance tasks. In fact, Weisband (2000) has found that groups that meet face-to-face prior to working in a distributed way do have better group outcomes than those who do not have initial face-to face meetings. Although we agree with these activities, many virtual teams do not have the luxury of a co-located beginning.

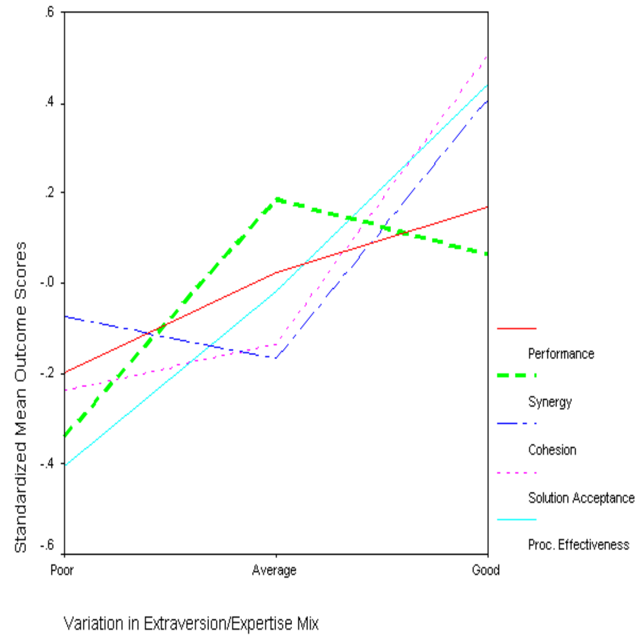

Figure 6. Performance by Levels of Variation in Extraversion/Expertise

As a more prescriptive approach, we provide the first step in a framework to evaluate interpersonal skills for virtual teamwork where no model classification system currently exists. Traditionally, practitioners adopt a one-dimensional definition of performance as equal to task performance, which overshadows the importance of personality and interpersonal skills and accentuates the importance of intelligence over process. We attempted to separate performance into two parts: task performance and contextual performance. Task performance is the traditional notion of ability: for instance, how well participants perform and complete the Ethical Decision Challenge. Contextual performance measures aspects of performance that may be unrelated to specific tasks — putting in extra effort, cooperating, following rules and procedures, keeping everyone “on their toes”— but are equally important to overall team performance, especially in a virtual environment. Ultimately, task performance and contextual performance contribute independently to overall performance. Whereas expertise predicted task performance better than contextual performance in this study, personality contributed to contextual performance better than it contributed to task performance.

It seems that, without any intervention, most virtual teams left to their own devices to complete a task will suffer from the development of aggressive/defensive or passive/defensive interaction styles, and the quality of the outcomes will be severely compromised. A purely technological solution will not succeed unless it acknowledges the softer side of virtual team performance. Although much work remains, these insights support a methodology that managers can use to assess interaction styles in their virtual teams, and proactively manage any interaction-based challenges that could threaten team performance.

The Expertise-Extraversion Mix

To do well in either a virtual or FTF setting, (i.e., less errors, more synergy, improved contextual performance) there has to be adequate knowledge within the team and a willingness to share and build upon that knowledge base toward synergistic solutions that are superior to those of the best individual within a virtual team. We found that in this particular virtual setting extraversion is an important personality trait to promote that interaction and that teams with lower variations in extraversion do best, especially in teams with good knowledge to start off with. This result within virtual teams is consistent with the finding that extraversion is especially important in work settings where social interaction is particularly salient (Barrick & Mount, 1991).

To emphasize this finding we created a hybrid measure -- the product of average individual error (the inverse of expertise) and variation in extraversion. The new measure would then produce a range of values from low numbers representing teams with high levels of expertise (low levels of errors) and small variations in extraversion to high numbers representing teams with low expertise (high levels of errors) and large variations in extraversion. We then split our new "variation in extraversion/expertise mix" data into three groups following the recipe used previously. That is, the "poor" grouping was made up of teams with "mix" scores at least one standard deviation above the mean. The "good" grouping was made up of teams with "mix" scores at least one standard deviation below the mean. Remaining groups were deemed "average." We then plotted the relationship between specific levels of "mix" and all performance measures (see Figure 6) and ran *t*-tests comparing the three groups. Performance z-scores were used in this analysis to achieve a standard scale for the measures having different scales on the same graph.

Main effects for different levels of "mix" were found for process effectiveness ($F(2,61)=3.27$, $p<.05$) and solution acceptance ($F(2,61)=3.15$, $P<.05$) ($t=2.10$, $p<.05$), cohesion ($t=1.43$, $p<.05$), and team synergy ($t=1.37$, $p<.05$). Although the team performance measure improved by approximately 5%, it is not a significant improvement at our level of power. Thus, virtual teams with higher expertise and small differences in extraversion have significantly better contextual performance scores than virtual teams with low expertise and/or large differences in extraversion.

However, as with the Barry and Stewart study (1997), there exist generally curvilinear functions between our "mix" and most measures of performance. Cohesion and solution acceptance present an upward curve. For these measures, performance in poor and average "mix" teams is mediocre but improves significantly between medium and good "mix" teams ($t=2.15$, $p<.05$ for cohesion; $t=2.60$, $p<.01$ for solution acceptance). Team synergy presents a downward curve. Teams with average expertise/variations in extraversion do significantly better than poor teams ($t=1.83$, $p<.05$) but it becomes increasingly difficult to improve upon the performance of a best member, even with much expertise and little variations in extraversion. Team performance and process effectiveness present linear functions.

Limitations And Conclusion

In virtual teams, the mix of expertise and personality traits does its work via the group interaction style it promotes. Organizations often collect personality data on their members and this information should be scrutinized when assembling a virtual team. Distributed expertise is only valuable when it can be brought to bear. Combined with an inappropriate level and distribution of individual extraversion, it may promote a non-constructive interaction style that prevents a team from reaching synergy and robs them of satisfaction with the team process. As many academics as well as practitioners can profess, expertise and extraversion is not an uncommon combination, and one that can often make team work less productive and pleasant than it can be.

The results of the present study are preliminary. Although our subjects interacted with each other for an entire semester, they were formed into interdependent teams for only the relatively brief duration of our task. However, beyond the convenience of conducting the study as we did, research suggests that many of the *initial* ways in which members interact and approach group problems become normative (Feldman, 1984). These behavioral patterns continue to be evident until group process interventions are implemented (Hackman & Morris, 1975) or until members perceive that such behavioral patterns will interfere with their ability to reach their goals (Gersick, 1988).

A second related limitation concerning generalizability of our findings to real life virtual teams is whether the present study is a laboratory study or a field study. We believe that our study contains positive and negative elements of both types of research. Although we did not have the motivational factors in place that might occur in a strict field study of virtual team decision-making, we did enforce time limits and link participation with significant course credit. Also, although we enjoyed the technical convenience of a computer-supported lab study, subjects were able to participate during the trials from a standard browser interface; exactly how many virtual teams operate (though we recognize that such teams have other communication modes available and may use them as deemed appropriate).

A concern that bridges both of these limitations is that of our use of the term "virtual" to describe our computer-mediated teams. The literature on virtual teams identifies three key dimensions to characterize the "virtualness" of virtual teams: relative permanence of the team, team dispersion, and technological enablement. Several researchers have suggested a limited life span, dependent on transient organizational needs, as the significant feature of virtual teams (Jarvenpaa et al., 1998; Townsend et al., 1998). Team dispersion has been defined in terms of geographical and temporal space. Technological enablement —that is, the availability and use of a broad range of communication technology— has been identified as a mediator of the effects of physical distance between team members (Griffith & Neale, 2000; Mittleman & Briggs, 1999). Using a composite of the taxonomies defined by these researchers, our virtual teams would be precisely defined as having *ad hoc* team membership, a (very) transient life span, "same time - different place" dispersion (simulated geographical dispersion), and enabled by a semi-synchronous text-based communication system (e.g., e-mail, chat room). Although synthetic and atypically short in duration, our virtual teams appear to be consistent with the theoretical boundaries of "virtualness." The most important reason that we use the term "virtual team," however, is that the task and measurement instruments used here were developed and are used for *team* building. Originally developed through research at the University of Michigan's Institute for Social Research, several million of these types of instruments have been used by organization development consultants around the world and remain recognized as the industry standard. So although one might take issue with our use of the term "virtual team" for our groups, the present research is squarely relevant to the assessment and development of teams, virtual or otherwise.

Also, our technology did not include real-time audio such as conference calling that real virtual teams sometimes use. It is not clear precisely how adding this feature to our technology would affect our results, although we can speculate that this type of channel may permit greater expression of extraversion if it is manifested as domination of a verbal dialogue. In addition, this type of channel may permit more clear expression and/or perception of expertise, but that would probably depend in large part on the verbal skills of the participants, and of course, on the interaction style of the team (which may or may not support such expression). As noted earlier, previous research (Potter et al., 2000) validated our instrument for determining group interaction style in the text-based virtual channel, showing it to perform slightly better than its traditional paper-based counterpart used in face-to-face groups. Adding a real-time audio channel to the present technology is not likely to alter that instrument's ability to identify the interaction styles. Clearly, though, additional studies should be carried out to determine if our results regarding extraversion and expertise generalize to groups that can be more convincingly considered real virtual teams.

Although the team performance and synergy findings are directionally consistent with those found in earlier studies using different tasks, they are not at a generally acceptable level of significance in our study (Cooke & Kernaghan, 1987; Cooke & Szumal, 1994; Libby et al., 1987; Yetton & Bottger, 1982). This is not unexpected given the nature of the Ethical Decision Challenge task. That is, the different issues and situations presented would be considered very similar by ethics professionals who have a number of objective methods to use in their process. On the other hand, rather than using objective ethical analysis, untrained participants attempt the task using their idiosyncratic but deeply held beliefs derived from culture, religion, and personal experiences. Nonprofessionals represent a potentially tremendously diverse set of perspectives, which members may mistake for expertise. As such any challenges or benefits afforded by the predominance of a behavioral style are not likely to have significant effect given the typical amount of difference in quality between professional and nonprofessional processes and solutions. A more informative test of the success of a team, then, may lie in the contextual performance outcomes it attains, as they are (in this case) more accurate indicators of the quality of the team consensus achieved (regardless of expertise).

Finally, we recognize the common methods problem that potentially exists when correlating interaction style measures with our contextual measures of performance. Specifically, all of these measures were obtained from a common source (i.e., the participants) after the completion of their group activities. Thus, we addressed the issue in part via the design of the task protocol and by *post hoc* statistical analysis. First, we collected process measures in two distinct time periods. So, although still a common source, the participants would answer a subset of our questions with a different "mindset" and perspective. We also reanalyzed the data by randomly selecting from each team's data a subset of team members for performance measures and a distinct subset for the group interaction styles. Although our findings are essentially the same, the increase in variability / decrease in power and the presence of several three-member teams that cannot be split into two multi-member subsets have forced us to accept the limited threat to our findings due to common methods. Ultimately, most of the relationships hypothesized in this study (e.g., involving extraversion and expertise) were not affected by potential common method problems.

In summary, we have presented a methodology that can be used to assess individual personalities, expertise, and the interaction styles of virtual teams. Practitioners can use this methodology to determine how their potential virtual team lineups are going to perform. With a virtual team that—due to personality and/or expertise issues—interacts with a passive/defensive or aggressive/defensive style, an investment in improving these negative dynamics before the team is released to its actual task is likely to pay great dividends.

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