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Computer-Assisted Communication and Team Decision-Making Performance: The Moderating Effect of Openness to Experience

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This study examined the effects of computer-assisted communication on team decision-making performance as a function of the team's openness to experience. Seventy-nine teams performing a multiple-cue probability learning task were randomly assigned to 1 of 2 experimental conditions: (a) verbal communication or (b) computer-assisted communication (which combined verbal and computerized communication). The results indicated that access to computer-assisted communication improved the decision-making performance of teams, but only when the teams were high in openness to experience. This effect was observed using both global openness and more specific openness facets, as well as a variety of team-level aggregation strategies. Moreover, the beneficial effects of openness in computer-assisted conditions were mediated by the efficiency with which teams integrated verbal and computerized forms of communication.

Contemporary organizations differ from those of just a decade ago in many important ways. As detailed in Howard's (1995) *The Changing Nature of Work* and Ilgen and Pulakos's (1999) *The Changing Nature of Performance: Implications for Staffing, Motivation, and Development*, two trends have changed the way in which work is presently conducted. The first trend is the increased use of work teams, as organizations have attempted to create greater flexibility and autonomy throughout their structures (Kozlowski, Gully, Nason, & Smith, 1999; Mohrman & Cohen, 1995). The second trend is the rapid rate of technological change, as computer networks, E-mail, and the Internet have changed the way in which employees communicate with one another (Davis, 1995; Hesketh & Neal, 1999; Van der Spiegel, 1995).

Employees in today's organizations find themselves at the confluence of these two trends. They are likely to perform many of their tasks in a team setting. Some of their work will occur in face-to-face meetings using verbal communication, but an increasing amount of this work will be conducted by exchanging faxes, sending E-mails, transferring files electronically, or posting messages on Internet bulletin boards. Although most teams are given access to such forms of communication, it is usually up to them to figure out how best to integrate them with traditional verbal communication (Johansen et al., 1991).

The purpose of the present study was to explore what types of teams respond best to *computer-assisted communication*, defined herein as communication consisting of a combination of computerized and traditional verbal communication. Existing research has focused more attention on *computer-mediated communication*, where all communication occurs via a computer. We would argue that computer-mediated communication is much less common in today's organizations, relative to computer-assisted communication (e.g., Hollingshead & McGrath, 1995). With the exception of so-called virtual teams, the vast majority of teams using computerized technology also rely on verbal communication to some degree.

Teams working in computer-assisted communication contexts have to quickly learn the strengths and weaknesses of various technologies, as well as imagine ways to effectively integrate those technologies with more traditional modes of communication. Thus, succeeding in computer-assisted contexts requires both learning proficiency and creativity to efficiently integrate different communication forms. The general proposition guiding the present research is that this type of proficiency and creativity will be greater in teams that are high in openness to experience. This general proposition was examined with both broad and narrow approaches to defining openness, as well as alternative methods for aggregating individual-level openness scores to reflect the construct at a team level of analysis.

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Openness to Experience as a Moderator of Computer-Assisted Communication Effects

The bulk of the literature on computerized communication has contrasted face-to-face verbal communication with completely computer-mediated communication. Although there is somewhat of a disconnect between this research and our focus on computer-assisted communication, many findings are relevant here. For example, computer mediation typically results in suppression of information because members find it more difficult to exchange information (e.g., Hedlund, Ilgen, & Hollenbeck, 1998; Hollingshead, 1996; Kiesler & Sproull, 1992). In a related manner, computer-mediated groups usually take longer to arrive at a decision, particularly when there are no time constraints (e.g., Siegel, Dubrovsky, Kiesler, & McGuire, 1986). However, the same constraints that suppress information also make member participation more equal in computer-mediated than face-to-face conditions (Siegel et al., 1986; Weisband, 1992).

The net result of the aforementioned effects is usually a superiority of face-to-face versus computer-mediated conditions in terms of decision-making quality on intellective tasks (i.e., tasks requiring teams to solve problems that have correct answers; McGrath, 1984). Of the eight intellective task studies covered in Hollingshead and McGrath's (1995) review, five found better decision-making performance for face-to-face groups, one found the reverse, and two found no differences. Subsequent studies have replicated the superiority of face-to-face teams (e.g., Hedlund et al., 1998), whereas others have yielded inconsistent results (e.g., Hollingshead, 1996).

Although these results remain equivocal, it seems clear that process gains from computer-mediated communication may not outweigh process losses (Hedlund et al., 1998; Hollingshead, 1996; Kiesler & Sproull, 1992; Siegel et al., 1986; Straus & McGrath, 1994; Weisband, 1992). Of course, these findings have in no way slowed the expansion of computerized communication in today's organizations. Thus, it is critical to explore moderators of computer-assisted effects to see what types of teams respond better or worse to new forms of communication technology (Hollingshead & McGrath, 1995).

Team characteristics that help teams take advantage of process gains while reducing process losses could act as important moderators. One characteristic that could fulfill such a role is team members' level of openness to experience, a Big Five factor composed of the following six facets: (a) ideas (e.g., having intellectual curiosity), (b) actions (e.g., valuing experimentation and learning), (c) fantasy (e.g., having an active imagination), (d) aesthetics (e.g., being intrigued by art, poetry, and music), (e) feelings (e.g., often experiencing strong emotions), and (f) values (e.g., believing that moral issues and social policies should change rather than be based on religion or principle; Costa & McCrae, 1992).

Although openness has not garnered the research attention of some of its Big Five counterparts (Mount & Barrick, 1998), there are reasons to expect that openness will be an advantage for teams working under computer-assisted conditions. For example, existing research has linked openness to *learning proficiency*. In a meta-analytic review of research on the Big Five, Barrick and Mount (1991) found a corrected correlation of .25 between openness and learning proficiency across five occupational groups. It is surprising that this finding has not generated much research activity in the training literature (Colquitt, LePine, & Noe, 2000). Indeed, Mount and Barrick (1998), when reflecting on the aforementioned openness result, noted that "we have been somewhat surprised that this finding has not had more of an impact" (p. 851).

In one of the few replications of Barrick and Mount's (1991) openness result, Cellar, Miller, Doverspike, and Klawsky (1996) showed that open individuals received more favorable training evaluations in the context of flight attendant courses. Several characteristics of open individuals may help explain such findings. For example, open individuals are more likely to use learning strategies that deepen understanding of trained material (Blickle, 1996; Busato, Prins, Elshout, & Hamaker, 1999). They are also likely to remain confident in the face of adversity (Schutte et al., 1998) and adapt when contextual changes make learned behaviors counterproductive (LePine, Colquitt, & Erez, 2000). These results suggest that teams with more open members should be able to more quickly learn the strengths and weaknesses of verbal and computerized forms of communication.

Existing research has also linked openness to *creativity*, defined herein as the ability to use imagination and skill to develop a new or unique thought, process, or object (Scott, 1995). For example, McCrae (1987) showed that openness predicted both creativity and divergent thinking. In a similar manner, Furnham (1999) linked openness to self-assessed ratings of creativity, although it did not correlate with actual creativity scores. Others have related openness to creativity and creative accomplishments, even after controlling for academic ability (King, Walker, & Broyles, 1996). Such linkages are consistent with other research showing that open individuals enjoy effortful thinking and creating new solutions to complex problems (Ackerman & Goff, 1994; Sadowski & Cogburn, 1997). These results suggest that open teams should have the creativity necessary to integrate verbal and computerized communication in computer-assisted contexts.

In summary, we suggest that open teams can leverage their learning proficiency and creativity to more quickly decide which tasks are best suited to verbal communication and which tasks are best suited to computerized communication. For example, open teams might quickly decide to share specific pieces of technical information through the computer but rely on verbal communication to provide subjective views and opinions. The more quickly such tasks are accomplished, the more teams can minimize the kinds of process losses that likely plague computer-assisted conditions. We therefore made the following hypothesis:

> *Hypothesis 1*: Working under computer-assisted versus verbal communication conditions will have more beneficial decision-making effects for more open teams than for less open teams.

Alternative Conceptualizations of Team Openness to Experience

As we noted earlier, openness has received less research attention than many of its Big Five counterparts. This is likely due to the fact that openness has not been shown to be highly related to job performance. For example, Barrick and Mount's (1991) meta-analysis reported a correlation of −.02 between openness and job performance, pooled across six occupational groups. Salgado's (1997) meta-analysis lists correlations of .00 and .06 using job performance ratings and personnel data as criteria, respectively.

Although the openness–job performance relationship is not directly relevant to this article, the meta-analyses listed earlier seem to have had a dampening effect on openness research in general, particularly in the organizational sciences. For example, three recent articles examining personality in team contexts did not even include openness in the study (Barrick, Stewart, Neubert, & Mount, 1998; Barry & Stewart, 1997; LePine, Hollenbeck, Ilgen, & Hedlund, 1997). We believe that many of the inconsistent or nonsignificant results for openness are due, in part, to how the variable is conceptualized, especially in team contexts. In particular, conceptualizing team openness encompasses issues surrounding both bandwidth versus fidelity (e.g., Cronbach & Gleser, 1965) and aggregation (e.g., Rousseau, 1985).

The bandwidth versus fidelity debate centers on the relative merits of broad personality factors versus more narrow personality facets. Ones and Viswesvaran (1996) argued that broad personality factors will have better predictive validity because of their superior reliability. However, others have argued that broad factors are better predictors of broad outcomes whereas narrow facets are better predictors of more narrow outcomes (Ashton, 1998; Hogan & Roberts, 1996; Hough, 1992). In a test of this notion, Mount and Barrick (1995) compared the predictive validities of a broad factor (conscientiousness) and two narrow facets (achievement and dependability) for global criteria such as overall job performance and specific criteria such as reliability, quality, and effort. They found moderately better validities for narrow facets, but only when there was a strong conceptual linkage between the facet and the criterion.

In the context of the present study, the issue is whether the moderation effect for openness predicted in Hypothesis 1 is best explored using the global openness factor or more narrow openness facets. In the language of the bandwidth versus fidelity debate, the outcome of decision-making performance is a narrow criterion. Moreover, the moderating role of openness is predicated on the expectation that open teams will more quickly learn to integrate computerized and verbal communication. This is an even narrower dimension of performance, which suggests that narrow facets of openness may comprise a more powerful test of Hypothesis 1.

As we noted previously, the broad factor of openness to experience subsumes six facets: ideas, actions, fantasy, aesthetics, feelings, and values. Of these facets, the first three appear to be most relevant to our moderation hypothesis, because each captures an intellectual tendency that should aid in the combination of computerized and verbal communication. However, the second three facets do not appear to be as relevant. Aesthetics, feelings, and values each reference emotional subjects such as being excited by poetry or art, often experiencing strong emotions, and believing that religious authorities should guide stances on moral issues. There are few reasons to expect these facets to moderate the relationship between computer-assisted communication and decision-making performance. We therefore predicted the following:

> *Hypothesis 2*: The openness moderation effect predicted in Hypothesis 1 will be significant using the intellect facets of openness (ideas, actions, and fantasy) but not using the emotion facets of openness (feelings, aesthetics, and values).

In addition to the bandwidth versus fidelity issue, conceptualizing team openness requires exploring issues surrounding aggregation (e.g., Rousseau, 1985). The most common operationalization of team personality has been an additive operationalization (Kichuk & Wiesner, 1997; Neuman, Wagner, & Christiansen, 1999). Following Steiner's (1972) typology, this operationalization assumes that task performance depends on the performance of all team members (LePine et al., 1997). LePine et al. (1997) argued that other operationalizations, such as aggregating the lowest or highest scoring person's value, may be appropriate for conjunctive tasks (in which performance depends on the weakest member) or disjunctive tasks (in which performance depends on the strongest member), respectively.

In a study focusing on team decision-making performance, LePine et al. (1997) elected to use a conjunctive aggregation of personality because the design of the team's task required worthwhile contributions from all members. However, tasks are often multidimensional with various role requirements, some of which may be of an additive nature and some of which may be of a conjunctive or disjunctive nature. Barrick et al. (1998) recently used all three aggregation operationalizations in their study of assembly and manufacturing teams because, they argued, some aspects of the teams' work were additive whereas others were conjunctive or disjunctive.

Our predictions in Hypotheses 1 and 2 were generated using primarily an additive conceptualization of team openness. Each team member had the potential to improve the efficiency of the computer-assisted communication by better managing his or her part of the team's total communication load. However, if one further examines the task of efficiently integrating verbal and computerized communication, it becomes clear that, in some ways, it is disjunctive. A single creative or well-reasoned suggestion from just one member could radically alter the team's ability to manage communication. For example, if one especially open member suggests that the team should share specific pieces of technical information through the computer but rely on verbal communication to provide subjective opinions, he or she has fundamentally changed the whole team's communication.

The task of efficiently integrating computerized and verbal communication does not necessarily require each and every team member to be open, however. If one highly open member suggests a communication strategy, he or she can explain that strategy to the other members. Likewise, a few open members can instruct less open members on the proper communication mix. For this reason, a conjunctive operationalization of team openness does not seem as appropriate as the additive and disjunctive conceptualizations discussed earlier. Our tests of Hypotheses 1 and 2 explored all three aggregation strategies. We predicted the following:

> *Hypothesis 3*: The openness moderation effect predicted in Hypotheses 1 and 2 will be significant using the additive and disjunctive operationalizations of team openness, but not the conjunctive operationalization.

The openness moderation effect predicted in our hypotheses is predicated on the notion that open teams will more efficiently integrate verbal and computerized communication when working in computer-assisted contexts. To test this notion, we created an index of the efficiency with which teams combined verbal and computerized communication in the computer-assisted condition. Given that teams in the verbal condition were not faced with the task of integrating two different forms of communication, the efficiency variable was not created for those teams. Our expectation was that openness would have beneficial effects on decision-making performance in computer-assisted conditions and that these effects would be mediated by the efficiency index. Thus, for the teams in the computer-assisted condition, we predicted the following:

> *Hypothesis 4:* The beneficial effects of openness on decision-making performance in the computer-assisted condition will be mediated by the efficiency with which teams integrate verbal and computerized communication.

Method

Participants

Participants were 237 undergraduates enrolled in an introductory management course at a large midwestern university. Of the participants, 126 were male, and 111 were female. Participants were placed into 79 three-person teams. All received course credit in exchange for their participation, and they were also given a chance to earn a small cash incentive (between $10 and $20) based on their team's performance during the experiment.

Task

Past research shows that the team's task is a critical consideration when the effects of different forms of communication are being examined (Hollingshead & McGrath, 1995). The present study focused on teams working on an intellective task, and the specific task used was a multiple-cue probability learning task called the Team Interactive Decision Exercise for Teams Incorporating Distributed Expertise ($TIDE^2$). An extensive description of this task, which simulates a military command-and-control context, is given in Hollenbeck et al. (1995; see also Hollenbeck, Ilgen, LePine, Colquitt, & Hedlund, 1998).

Three participants served as a team and were stationed at networked computer terminals. Participants were randomly assigned to roles termed *Alpha*, *Bravo*, and *Charlie* and were required to classify aircraft as friendly or threatening on the basis of certain pieces of information. Bravo and Charlie (referred to as staff members) provided classification recommendations to Alpha, who served as the team's leader. The team as a whole was responsible for gathering a total of nine specific pieces of information about an aircraft (e.g., its speed, range, altitude, angle, radar type). Each member was assigned three specific pieces of information to gather and was given extensive training on how to transform information values into probable threat levels. Members obtained information by clicking on a pull-down "Measure" menu and selecting the piece of information that they were interested in. However, each team member had personal access to only one of the three pieces of information that he or she was in charge of gathering; thus, each member also needed to communicate with teammates to receive the other pieces of information.

Once Alpha, Bravo, and Charlie had obtained the three pieces of information they were in charge of gathering, they used that information to ascertain the aircraft's probable threat level. Bravo and Charlie then made a recommendation to Alpha about the aircraft. This recommendation took the form of a course of action to take regarding the aircraft, on a 7-point continuum of aggressiveness (1 = *ignore*, 2 = *review*, 3 = *monitor*, 4 = *warn*, 5 = *ready*, 6 = *lock-on*, and 7 = *defend*). Once Bravo and Charlie had made their recommendation to Alpha, he or she combined those recommendations and made one final team decision.

Once Alpha registered the final decision into the computer, it was compared with the correct decision. Teams were then given feedback via the computer on the absolute difference between their decision and the correct decision. Alpha's decision, the correct decision, and Bravo and Charlie's recommendations were all listed on this feedback screen, along with aggregate information on how the team had performed on all trials to date. The same procedure was repeated for 23 trials, including 5 practice trials used to teach participants the rules of the game. Trials alternated between 150 and 120 s in length.

Experimental Conditions

Teams were randomly assigned to one of two experimental conditions.

Verbal. In verbal communication conditions, all participants communicated by talking to one another. Aircraft information such as size, speed, and so forth was exchanged verbally, as were task questions, task strategies, and preliminary and final decision recommendations (although the latter were also entered into the computer so that the on-screen feedback could be provided). Participants still used the computer to initially measure aircraft information. All participants wore headsets that were attached to tape-recording equipment, allowing the communication within the team to be captured.

Computer-assisted. In the computer-assisted communication conditions, participants could communicate through a mixture of verbal and computer-mediated communication. Aircraft information could be verbally shared or transmitted through the computer network via the "Transmit" function. Task information could be verbally requested or performed through the computer via the "Query" function. Task questions, task strategies, and decision recommendations could be verbally discussed or typed as text messages through the computer. As in the other conditions, participants still used the computer to initially measure aircraft information and to register their final recommendations. As in the verbal condition, participants wore headsets attached to tape-recording equipment.

Measures

Openness to experience. Openness was measured with the 48-item scale ($\alpha = .87$) from the Revised NEO Personality Inventory (Costa & McCrae, 1992). This scale has 8-item measures for the six openness facets: ideas ($\alpha = .73$), fantasy ($\alpha = .75$), actions ($\alpha = .60$), aesthetics ($\alpha = .77$), feelings ($\alpha = .67$), and values ($\alpha = .64$).

Team decision-making performance. Team decision-making performance was operationalized as mean square error, defined as the square of the difference between the team's decision and the correct decision, aggregated across the multiple trials (Gigone & Hastie, 1997; Hollenbeck, Colquitt, Ilgen, LePine, & Hedlund, 1998). Recall that decisions took the form of a scale ranging from 1 (*ignore*) to 7 (*defend*). If a team was off from the correct decision by an average of three levels per trial, their mean square error would be 9 (3×3).

Efficiency in integrating verbal and computerized communication. In computer-assisted conditions, we computed an index of the efficiency with which teams integrated verbal and computerized communication. This index was created by subject matter experts from the U.S. Air Force, in conjunction with the study authors, and used the recordings of the teams' verbal communication, transcripts of the teams' text messages, and preexisting indices created by the $TIDE^2$ simulation. The efficiency index captured the degree to which teams used verbal communication for the tasks best suited to verbal communication and used the computer for tasks

Table 1
Means, Standard Deviations, and Zero-Order Intercorrelations

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. Computer-assisted communication	0.68	0.47	—								
2. Additive openness	3.40	0.27	.11	—							
3. Disjunctive openness	3.67	0.32	.13	.84*	—						
4. Conjunctive openness	3.14	0.32	.10	.81*	.39*	—					
5. Additive actions	2.98	0.29	.21*	.45*	.38*	.34*	—				
6. Disjunctive actions	3.33	0.38	.13	.40*	.55*	.09	.76*	—			
7. Conjunctive actions	2.66	0.36	.16	.32*	.05	.49*	.76*	.23*	—		
8. Additive ideas	3.41	0.43	.12	.56*	.52*	.41*	.13	.18	.04	—	
9. Disjunctive ideas	3.81	0.53	.18	.48*	.61*	.19*	.10	.22*	−.07	.86*	—
10. Conjunctive ideas	2.97	0.50	.02	.40*	.20*	.50*	.06	−.02	.17	.77*	.39*
11. Additive fantasy	3.36	0.44	.01	.75*	.64*	.61*	.16	.14	.16	.30*	.19*
12. Disjunctive fantasy	3.76	0.55	.08	.61*	.73*	.31*	.06	.19*	−.06	.28*	.29*
13. Conjunctive fantasy	2.96	0.52	−.03	.59*	.27*	.72*	.22*	.00	.36*	.14	−.02
14. Additive feelings	3.73	0.33	−.01	.64*	.59*	.47*	.10	.21*	−.03	.18	.25*
15. Disjunctive feelings	4.08	0.36	−.03	.35*	.50*	.07	−.13	.12	−.28*	.05	.18
16. Conjunctive feelings	3.36	0.46	.03	.57*	.39*	.57*	.24*	.21*	.16	.18	.18
17. Additive aesthetics	3.34	0.51	.09	.79*	.54*	.73*	.28*	.19*	.26*	.37*	.30*
18. Disjunctive aesthetics	3.80	0.52	.10	.68*	.64*	.43*	.28*	.39*	.08	.31*	.39*
19. Conjunctive aesthetics	2.86	0.68	.06	.64*	.28*	.80*	.19*	−.04	.35*	.33*	.13
20. Additive values	3.56	0.41	−.02	.65*	.58*	.47*	.25*	.25*	.16	.02	.09
21. Disjunctive values	3.90	0.45	.14	.56*	.65*	.28*	.26*	.41*	.03	.09	.23
22. Conjunctive values	3.22	0.50	−.14	.53*	.35*	.49*	.17	.03	.28*	−.04	−.04
23. Efficiency	5.17	4.95	—[a]	.36*	.37*	.15	.30*	.29*	.23	.30*	.36*
24. Mean square error	1.73	0.79	−.11	−.05	.01	−.05	−.07	.04	−.03	−.01	−.04

Note. $N = 79$ teams, except for efficiency, which exists only in the computer-assisted condition ($N = 45$).
[a]This variable did not exist in one of the experimental conditions and therefore could not be correlated with the experimental condition variable.
*$p < .05$, one-tailed.

best suited to computerized communication. Tasks best suited to verbal communication were sharing subjective opinions about a trial (e.g., "This one seems threatening," "What do you think of this one?") and asking for information (e.g., "Send me altitude," "Do you know the speed?"), because those tasks could be completed more quickly verbally. A task best suited to the computer was sending information (e.g., altitude = 30,200 ft [9,204.96 m]), because the receiver of the information could visually inspect the number.

The efficiency index also captured coordination problems within the team. Poor coordination was evidenced verbally by discussion of coordination problems (e.g., "We need to get things to each other much more quickly") and the frequent need to repeat previous communication (e.g., "Could you tell me that again?"). Poor computerized coordination was also evidenced by indices created by the $TIDE^2$ computer (e.g., failing to read an information request from a teammate, failing to view aircraft information sent from a teammate). The index was computed using the following formula: (Number of Proper Uses of Voice Communication − Number of Improper Uses of Voice Communication) + (Number of Proper Uses of Computerized Communication − Number of Improper Uses of Computerized Communication) − (Number of Verbal and Computerized Instances of Poor Coordination); that index was averaged across the multiple trials. Computing the efficiency index on a trial basis and treating trials as multiple measurements yielded a coefficient alpha of .96.

Results

The means, standard deviations, and zero-order intercorrelations for all study variables are shown in Table 1. The study's hypotheses were tested using Baron and Kenny's (1986) prescriptions for moderation and mediation. The regression results are shown in Table 2, which is organized into a 3 (global vs. intellect facets vs. emotion facets operationalization) × 3 (additive vs. disjunctive vs. conjunctive aggregation) matrix. The main effects of experimental condition and team openness were not significant. However, the interaction between computer-assisted communication and openness was significant using global openness, as well as the intellect facets of openness, with either an additive or a disjunctive aggregation strategy. The intellect facet effect was driven by significant effects for the actions and fantasy facets, but not the ideas facet. The patterns of the six significant interactions are summarized in Table 3, in which it can be seen that computer-assisted communication had beneficial effects for more open teams but detrimental effects for less open teams, supporting Hypothesis 1. The Computer-Assisted Communication × Openness interaction effect was not significant using the emotion facets of openness, providing support for Hypothesis 2. Moreover, the interaction was not significant using conjunctive aggregation, providing support for Hypothesis 3.

Hypothesis 4 predicted that the beneficial effects of openness in the computer-assisted condition would be mediated by the efficiency index. As shown in Table 1, global openness and the actions and fantasy facets were significantly correlated with the efficiency index when additive or disjunctive aggregation was used (*r*s ranging from .28 to .37). The efficiency index was then significantly correlated with mean square error ($r = -.41$). Tests of the degree to which the efficiency index mediated the effects of openness on mean square error are shown in Table 4. Using a global operationalization and additive aggregation, openness explained a significant 11% of the variance in mean square error in

10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
—														
.33*	—													
.20*	.83*	—												
.28*	.76*	.31*	—											
.05	.45*	.50*	.28*	—										
−.09	.32*	.46*	.03	.69*	—									
.13	.35*	.27*	.37*	.83*	.23*	—								
.33*	.48*	.26*	.51*	.36*	.13	.36*	—							
.06	.35*	.28*	.25*	.38*	.23*	.33*	.82*	—						
.49*	.45*	.18	.57*	.22*	−.02	.28*	.86*	.43*	—					
−.12	.41*	.38*	.28*	.45*	.32*	.33*	.38*	.40*	.23*	—				
−.12	.30*	.38*	.08	.41*	.36*	.25*	.30*	.39*	.12	.84*	—			
−.06	.40*	.27*	.38*	.34*	.14	.32*	.31*	.24*	.25*	.87*	.50*	—		
.18	.31*	.28*	.20	.30*	.12	.28*	.21	.32*	.01	.04	.06	.02	—	
.09	−.02	.03	−.15	−.09	.04	−.21	−.01	−.05	.05	.05	.14	−.03	−.41*	—

the computer-assisted condition. After we controlled for the efficiency index, this effect was reduced to a nonsignificant 5%. This pattern was repeated for the actions and fantasy facets and for disjunctive aggregation, although the facet direct effects were not significant when a disjunctive aggregation was used.

Discussion

As we mentioned at the outset, the increased use of work teams and the rapid rate of technological change are two trends that have shaped the changing nature of work (Howard, 1995; Ilgen & Pulakos, 1999). As a result of these trends, many employees find themselves working in teams that communicate in a variety of ways, from verbal conversations, to E-mail, to Internet chat rooms. The present study examined the effects of such computer-assisted communication, in particular investigating whether team openness moderated its effects on decision-making performance.

What stands out most from our results is the strong support for openness as a moderator of computer-assisted communication's effects. Six separate interaction effects suggested that computer-assisted communication had a beneficial effect on decision-making performance at high levels of openness (or its facets). In contrast, computer-assisted communication often had slightly detrimental, though nonsignificant, effects on decision-making performance at low levels of openness (or its facets). We predicted this type of interaction on the basis of past research linking openness with learning proficiency (Barrick & Mount, 1991; Cellar et al., 1996) and creativity (e.g., Griffin & McDermott, 1998; King et al., 1996; McCrae, 1987, 1994). It seems that open teams were more able to learn the strengths and weaknesses of verbal versus computerized communication and leverage their creativity to find ways of integrating them. Indeed, when considering only the computer-assisted conditions, openness (or its facets) had a beneficial effect on decision-making performance, one that was mediated by the team's efficiency in integrating the verbal and computerized modes of communication.

The predicted interaction effect was observed using both global and specific facet operationalizations of openness. The key criterion in this study was the ability to integrate verbal and computerized communication under computer-assisted conditions. Given the narrowness of this criterion, we reasoned that narrow facets of openness, such as actions, ideas, and fantasy, might be strong predictors. However, openness's other facets did not appear as relevant. Indeed, our results showed that the actions and fantasy facets had stronger effects than the more global openness measure, whereas the feelings, aesthetics, and values facets had no significant effects.

In keeping with recent research on team-level personality, we also tested our hypotheses using multiple methods of aggregating openness to the team level. Our results were significant using the most common operationalization, the mean level of openness across all members. This result suggests that teams respond better to computer-assisted communication when they have a high level of openness in general. However, our predictions were also supported using a disjunctive operationalization. Taken together, these results show that teams may benefit from computer-assisted communication so long as they have one very open member or several

Table 2
Results for Computer-Assisted Communication × Openness Moderated Regressions

Openness operationalization	Additive aggregation ΔR^2	Additive aggregation β	Disjunctive aggregation ΔR^2	Disjunctive aggregation β	Conjunctive aggregation ΔR^2	Conjunctive aggregation β
Global openness						
1. Computer-assisted communication	.01	−.11	.01	−.11	.01	−.11
2. Openness to experience	.00	−.03	.00	.02	.00	−.04
3. Computer-Assisted Communication × Openness to Experience	.13*	−4.46*	.12*	−3.88*	.05	−2.19
Total R^2	.14*		.13*		.06	
Intellect facets of openness						
1. Computer-assisted communication	.01	−.11	.01	−.11	.01	−.11
2. Actions	.00	−.05	.01	.05	.04	.03
Ideas		.03		−.04		.14
Fantasy		−.02		.04		−.20
3. Computer-Assisted Communication × Actions	.19*	−2.92*	.19*	−2.24*	.07	−1.97
Computer-Assisted Communication × Ideas		−0.75		−0.27		−0.45
Computer-Assisted Communication × Fantasy		−2.11*		−2.09*		−0.25
Total R^2	.20*		.21*		.12	
Emotion facets of openness						
1. Computer-assisted communication	.01	−.11	.01	−.11	.01	−.11
2. Feelings	.02	−.14	.04	−.02	.05	−.24
Aesthetics		.01		−.11		.12
Values		.11		.21		.00
3. Computer-Assisted Communication × Feelings	.06	−0.83	.03	0.13	.06	0.06
Computer-Assisted Communication × Aesthetics		−0.17		−0.86		−0.18
Computer-Assisted Communication × Values		−1.61		−0.70		−1.54
Total R^2	.09		.08		.12	

Note. $N = 79$ teams.
$^*p < .05$.

members with at least above-average openness. Our results using the conjunctive operationalization were not significant, suggesting that members need not be uniformly open to respond well to the new technology.

This study has some limitations that should be noted. Although the laboratory setting allowed us to test causal relationships, minimize threats to internal validity, record and code within-team communication, and create objective indices of communication efficiency and decision-making performance, the types of teams examined here differ from those in organizations in important ways. It is therefore an empirical question whether our findings will generalize to teams that can have the opportunity to practice

Table 3
Computer-Assisted Communication–Mean Square Error Correlations by Level of Openness

Openness operationalization	$r_{\text{CAC MSE}}$ Additive aggregation	$r_{\text{CAC MSE}}$ Disjunctive aggregation
Global openness		
High levels of openness	−.34*	−.33*
Low levels of openness	.22	.11
Actions facet		
High levels of actions	−.19	−.35*
Low levels of actions	.02	.22
Fantasy facet		
High levels of fantasy	−.29†	−.38*
Low levels of fantasy	.07	.13

Note. *N*s ranged from 36 to 43 teams. Higher levels of error reflect lower performance, so negative correlations reflect beneficial effects for computer-assisted communication. $r_{\text{CAC MSE}}$ = correlation between the computer-assisted communication versus verbal communication dummy code and mean square error.
†$p < .10$. $^*p < .05$, one-tailed.

Table 4
Mediation of Beneficial Openness Effects Under Computer-Assisted Conditions

Openness operationalization	Additive aggregation ΔR^2	Additive aggregation β	Disjunctive aggregation ΔR^2	Disjunctive aggregation β
Global openness				
Openness direct effect	.11*	−.32*	.07*	−.26*
Openness effect, controlling for efficiency	.05	−.24	.03	−.19
Intellect facets of openness				
Actions direct effect	.15*	−.23†	.08	−.14
Fantasy direct effect		−.27*		−.22
Actions effect, controlling for efficiency	.07	−.10	.04	−.05
Fantasy effect, controlling for efficiency		−.24		−.18

Note. $N = 45$ teams.
†$p < .10$. $^*p < .05$.

their communication over several months or compensate for lack of efficiency with longer hours worked.

It is also an empirical question whether our results will generalize to nonintellective tasks, such as planning or subjective judgment tasks (Hollingshead & McGrath, 1995). Finally, McCrae (1987) suggested that openness and cognitive ability (*g*) may be correlated, suggesting that some of our openness results may be confounded by *g*. Although we did not measure *g* in this specific study, openness–*g* correlations have tended to be weak in our subject pool (correlations ranging from .00 to .16, depending on the openness facet). Moreover, controlling for teams' grade point average had no significant effect on our tests of hypotheses.

Despite these limitations, our results offer practical implications for managers of teams integrating new communication technologies. Specifically, our results suggest that the systems responsible for staffing those teams should consider openness. Many organizations already collect Big Five data in selection or employee development, so openness scores may already be part of many employees' profiles. If openness data are not available, recent research shows that observer ratings of some Big Five characteristics are just as valid as self-ratings, so supervisors may be able to judge openness more informally (Mount, Barrick, & Strauss, 1994). If teams cannot be staffed with open members, then supervisors may need to extensively train members on how to efficiently integrate verbal and computerized communication. Although this suggestion may seem straightforward, such training is often not conducted because of the mistaken belief that teams need only rely on "common sense" to manage that process (Johansen et al., 1991).

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