Organizational Behavior and Human Decision Processes
Vol. 82, No. 1, May, pp. 117–133, 2000
doi:10.1006/obhd.2000.2891, available online at http://www.idealibrary.com on IDEAL®

Exploring the Performance Benefits of Group Training: Transactive Memory or Improved Communication?

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Several experiments (see Hollingshead, 1998a; Moreland, 1999) have shown that groups perform tasks better if their members are trained together rather than apart. The performance benefits of group training have been attributed to the development of transactive memory systems. This experiment tested whether such benefits are due instead to improved communication among group members. The results indicated that they are not. Groups whose members were trained apart, with no chance to communicate with one another, performed well after receiving information about one another's skills. Their performance was comparable to that of groups whose members were trained together, and both types of groups performed significantly better than did groups whose members were trained apart. The relationship between transactive memory and communication processes was discussed briefly, along with the prospect of using feedback about workers' skills to create transactive memory systems in large organizations as well as in small groups.

For years now, large organizations have become increasingly dependent on small groups or teams to achieve their goals. Are those teams really effective? The available evidence suggests they are, but some teams do fail, and improvements could probably be made in most teams. Many suggestions for improving the performance of work teams have been offered (see Hackman, 1998; Sundstrom, 1998), but these often focus on changes in management practices. Our approach is different—we suggest that the performance of most teams can be

We thank Sean Fitzgerald, Jamie McMinn, Christa Sherwood-Houser, and Maggie Yi for helping to collect or code data.

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0749-5978/00 $35.00

improved by changing how their members are trained (see Moreland, Argote, & Krishnan, 1998).

How are people trained for teamwork? Many organizations provide no formal training at all for their workers, and when they do, teamwork is generally ignored. A few organizations do provide team training, but it tends to be decontextualized—workers learn broad principles and basic skills that are assumed to apply to every group. Much of this learning occurs without practice, and when practice does occur, it often involves *ad hoc* groups created just for training purposes. Few linkages are made between the jobs that workers will be doing and the groups in which that work will actually occur. Such training has its advocates, but we believe that training people for teamwork is not so simple and that a different kind of training is needed.

We are most interested in the formation of new work groups and the possible benefits of training their members together, rather than apart. One such benefit is the development of a transactive memory system (see Wegner, 1987, 1995). According to Wegner, people often try to improve their own memories, which are limited and sometimes unreliable, with external aids. These include objects (e.g., appointment books) as well as people. Wegner was especially interested in the use of people as memory aids. He argued that transactive memory systems develop in many groups to ensure that important information is recalled. These systems combine what individual group members know with a shared awareness of who knows what. When group members need information, but cannot recall it themselves or mistrust their own memories, they can turn to each other for help. In this way, a transactive memory system can provide a group's members with more and better information than any of them could recall alone.

The potential benefits of transactive memory for work group performance are clear. If workers know more about one another, they can plan more sensibly, assigning tasks to the people who will perform them best. Coordination should improve as well because workers can anticipate, rather than simply react to, each other's behavior (see Murnighan & Conlon, 1991; Wittenbaum, Vaughan, & Stasser, 1998). As a result, people can work together more efficiently, even if task assignments are unclear. Finally, problems that arise should be solved more quickly and easily if workers know more about one another because they can then match problems with the people who are most likely to solve them (Moreland & Levine, 1992). Once those people are identified, they can be asked for help, or the problems can be given to them to solve.

Does group training help transactive memory systems to develop, and does work group performance improve as a result? We have found the answers to these questions in a series of experiments (see Liang, Moreland, & Argote, 1995; Moreland, 1999; Moreland, Argote, & Krishnan, 1996, 1998), all using the same basic paradigm. In the first experiment (Liang et al., 1995), we created small work groups whose task was to build transistor radios from kits containing dozens of parts. Two types of training, group or individual, were provided. In the Group training condition, members of the same work group were trained together, but in the Individual training condition, they were

trained apart. The content of training was otherwise the same in both conditions. Three measures of group performance were later collected: (a) how well the groups recalled the procedure for assembling radios, (b) how quickly they assembled the radios, and (c) how many assembly errors were made. Groups from the two training conditions did not differ in how quickly they assembled radios, but there were significant differences in both procedural recall and assembly errors. Groups whose members were trained together recalled more about how to assemble radios, and made fewer assembly errors, than did groups whose members were trained apart.

Were these performance benefits of group training due to transactive memory? Liang et al. (1995) explored this issue by studying videotapes of the groups as they worked on their radios. Behaviors symptomatic of the operation of transactive memory systems were evaluated, which allowed a broad index of transactive memory to be computed. Scores on that index were significantly higher in the Group than in the Individual training condition. Moreover, hierarchical regression analyses showed that these differences in transactive memory were responsible for the apparent performance benefits of group training. That is, once differences in transactive memory among groups were taken into account, training group members together rather than apart no longer made any difference in group performance.

Although this initial experiment was promising, it did not rule out other possible explanations for why group training improves group performance. For example, newly formed groups often experience special problems (see Tuckman, 1965) that can limit their performance. These problems include anxiety about acceptance, interpersonal conflicts, and uncertainty about group norms. Training a work group's members together provides more time for these problems to be resolved. This suggests that enhanced development may contribute to the performance benefits of group training. Another explanation for those benefits may be strategic learning. Working in groups often creates coordination problems (see Wittenbaum, Vaughan, & Stasser, 1998), some of which can be solved by using simple strategies that are relevant to most groups. These strategies, which include building commitment to the group and organizing group activities, require little information about any one group. Training the members of a work group together would allow some of these strategies to be employed. This suggests that strategic learning also may have contributed to the performance benefits of group training.

To evaluate these alternative explanations, we performed a second experiment (see Moreland, 1999; Moreland et al. 1996, 1998) that included two new training conditions. One of these was identical to the Individual training condition, except that a special team-building exercise was included in each group's training. The other new condition was identical to the Group training condition, except that all the groups were "scrambled" between training and testing—people were reassigned to new groups in ways that separated those who were trained together. The Team-building condition was meant to enhance group development without providing people with the information needed to develop transactive memory systems. The Reassignment condition was meant

to disable whatever transactive memory systems had developed by making them irrelevant, leaving strategic learning as the major advantage of group training. If group development and strategic learning were indeed key factors in the performance benefits of group training, then the groups in these two new conditions should have performed well. But if the performance benefits of group training depend on the operation of transactive memory systems, then these groups should have performed poorly. Groups lacked transactive memory systems in the Team-building condition, and those systems were no longer relevant in the Reassignment condition.

As in the first experiment, different training methods had no effect on how quickly the radios were built. But significant differences were found for both procedural recall and assembly errors. Group training led to better performance on both of these measures than did any of the other training methods, which did not differ from one another. Scores on the transactive memory index were also higher in the group training condition than in the other three training conditions, which did not differ from one another. Once again, hierarchical regression analyses were performed to test whether the effects of training methods on group performance were mediated by transactive memory. The results showed that they were.

This second experiment replicated several results from the first and helped us to rule out at least two alternative explanations for the performance benefits of group training. We thus became more confident that training work-group members together rather than apart fosters the development of transactive memory systems and that the operation of such systems improves group performance. One factor that we have not yet considered, however, is communication. When group members are trained together, they may learn to communicate better with one another about their task, and that improvement may help their group perform better as well. This explanation can account for the results from both of the experiments described earlier. Consider, for example, the poor performance of groups in the Team-building and Reassignment conditions from the second experiment. Participating in a team-building exercise may have helped group members to communicate better with each other, but not about the key topic, namely how to build radios. And maybe reassignment from one group to another was harmful because it forced people to work together without the benefit of any prior communication at all.

Three kinds of evidence support this viewpoint. First, the workers in some groups do develop special “languages” that are difficult for people outside of those groups to understand (Fine, 1996; Fulk, 1993; Laffey, 1998; Lyon, 1974; Truzzi & Easto, 1972; Scheff, 1995; see also Levine & Moreland, 1991). These languages can have both verbal and nonverbal components. Group members not only use jargon to signify different aspects of their work, but they may also find special meaning in gestures, voice tones, and even silences. People who speak such languages can thus work together more efficiently than those who do not. A problem encountered by many newcomers, for example, is learning how to make sense of what the other group members are saying and how to

speak in ways that reflect an understanding and acceptance of the group's unique culture (see Levine & Moreland, 1991).

Second, there seems to be a positive relationship between how often group members communicate with one another and how well their group performs (see Finholt, Sproull, & Kiesler, 1990; O'Reilly & Roberts, 1977; see also Krauss & Fussell, 1990). In fact, as Orr (1990) found in his well-known study of copy-machine repairmen, the performance of some groups can be improved simply by helping their members to communicate with one another more often.

Finally, miscommunication is a problem in many work groups (see DiSalvo, Nikkel, & Monroe, 1989), one that can have serious consequences for groups that perform dangerous work. For example, fatal accidents on both the flight decks of aircraft carriers (Weick & Roberts, 1993) and on skyscrapers during construction (Haas, 1974, 1977) can sometimes be traced to miscommunication among workers.

Such evidence led us to perform another experiment (using our usual paradigm) that would allow us to investigate the roles of transactive memory and communication in mediating the performance benefits of group training. Our strategy was to create a training condition in which group members were given the kinds of information needed to develop a transactive memory system, but had no opportunity to learn how to communicate with one another about building radios. We accomplished this by training the members of some groups individually, but later providing them with feedback about one another's performance before they worked together as a group. If improved communication is the reason why groups perform well when their members are trained together, then groups trained this way should perform poorly. But if transactive memory is the reason why groups whose members are trained together perform well, then the performance of groups trained in this new way should be good, comparable to that achieved through group training.

METHOD

Participants

One hundred eighty-nine students (93 males and 96 females), from introductory psychology classes at the University of Pittsburgh, participated in our research in order to satisfy a course requirement. The students were randomly assigned to 63 three-person, same-sex groups, which were then assigned to either Individual ($N = 20$), Performance Feedback ($N = 20$), or Group ($N = 23$) training conditions.[1]

Equipment and Materials

Participants were taught to build transistor radios, using kits purchased from the Tandy Corporation (Model 28-175). Each kit included a circuit board

[1] One group, in the Group training condition, did not seem to take our research seriously—it made more than twice as many assembly errors as any other group. We chose to drop this group from the sample.

and dozens of mechanical and electronic components (e.g., capacitors, resistors, transistors, batteries). The circuit board contained prepunched holes marked with special symbols that showed where different components should be placed. The participants learned how to distinguish components from one another, where to insert components into the circuit board, and how to wire components together properly. To help them perform this complex task, we only required the participants to assemble the AM portions of the radios. We also prepared the circuit boards in ways that made the radios easier to assemble and provided some small screwdrivers to the participants.[2]

While working on the radios, participants were taped using a Panasonic Videorecorder (AF-X6 CCD) and a Realistic PZM microphone (Model 33-1090B). This equipment was in full view of the participants, and videotaping was done only with their permission.

Toward the end of their research participation, everyone was asked to complete a brief questionnaire. Every item on the questionnaire required a response on a 7-point (1 to 7) rating scale. Four items measured participants' feelings about their groups and one another: (a) "How much do you like or dislike the other people in this work group?"; (b) "How much do the other people in this work group seem to like or dislike you?"; (c) "Some work groups have a warm and friendly atmosphere, but the atmosphere in other groups is cold and unfriendly. How does this work group feel to you?"; and (d) "Does this work group seem more like one group, or three separate individuals?" Higher ratings on these items indicated more positive feelings about the group and its members. We included these items to measure any negative reactions (e.g., jealousy, embarrassment) from groups in the Performance Feedback condition to the information that we provided about the relative skills of their members.

Four other items on the questionnaire measured participants' familiarity with one another, especially regarding the distribution of radio-building knowledge and skills in their groups: (e) "How familiar do the other people in this work group seem to you?"; (f) "The job skills of a work group's members can vary from one person to the next. How similar are the members of this work group, in terms of their radio-building skills?"; (g) "How much do you know about the radio-building skills of the other people in this work group?"; and (h) "How much do you think the other members of this work group know about your radio-building skills?" Higher ratings on three of these items (e/g/h) indicated greater familiarity; ratings on the other measure (f) were reversed so that higher ratings on that measure could be interpreted similarly. We included these items to see whether levels of familiarity among group members from the Performance Feedback condition were comparable to those in the Group training condition.

Three other items also appeared in the questionnaire. One measured participants' levels of motivation: (i) "How much did you want your group to succeed

[2] We inserted all the spring coils into the circuit boards, then we copied, from the front of each circuit board to the back, the location numbers for all the holes in which the components should be placed.

at winning one of the prizes?" Another measured participants' beliefs about the experimenter's attitude toward their group: (j) "How much did you think the experimenter wanted your group to succeed?" A final item measured how well the participants felt they had communicated with one another: (k) "How difficult was it for you to communicate clearly about the radio with the other members of your work group?"

Higher ratings on these three measures indicated that participants were more eager to build their radios well, believed more strongly that the experimenter wanted their groups to succeed, and found it easier to communicate with one another while building the radios. We included the first item (i) to check whether the levels of motivation among groups were comparable from one training condition to another. The second item (j) was included to see whether groups in the Performance Feedback condition, who were given valuable information by the experimenter about the relative skills of their members, believed that the experimenter wanted or expected them to do well. The third item (k) was included to see whether communication about the task was indeed more difficult among groups (from the Individual and Performance Feedback conditions) whose members were trained apart.

Finally, at the end of each research session, participants received a debriefing sheet that explained the theoretical rationale for the experiment, described our hypotheses and explained how data collected during the experiment could help us test those hypotheses, and offered further information about this research area to anyone with a special interest in it. For example, a paper on transactive memory was cited at the bottom of the debriefing sheet, and participants were encouraged to contact us if they had questions or comments later on about our research.

After each experimental session, we used two special scoring forms to evaluate what the group could recall about building a radio and how quickly and accurately a radio was actually built by the group. We can provide copies of these forms, and of the debriefing sheet, to anyone who requests them.

Procedure

Students chose to participate in our experiment, rather than in other research projects, after reading a brief and general summary of our research, which was described as an exploration of different methods for training work-group members.

Two experimenters, one male and one female, worked to collect the data. The male experimenter ran 42 groups; the female experimenter ran 21 groups. For each experimenter, the proportions of groups that were male versus female, and that received each type of training, were balanced.

The experiment was run in several "waves," each lasting for 2 weeks. Every group met twice during its wave. These meetings lasted about an hour each, and occurred a week apart, at the same day and time. During the first week of each wave, up to five students (of the same sex) were scheduled for each meeting. Only three students were needed to form a group, so if four or five

students arrived at the laboratory, we randomly chose one or two of them to dismiss. These "extra" students were given credit for attempting to participate in the experiment, and then they were thanked and urged to select another day and time, later in the semester, when they could participate more fully.

Every group's first meeting was devoted to learning how to build the radios. The meeting began with a demonstration by the experimenter, who stood in front of the participants (seated around a circular table) and built a radio, explaining all the while what he or she was doing. This demonstration lasted about 20 min and was the same for every group. Participants were allowed to ask questions about the radio at any time during that period. Next, participants had up to 30 min to practice building a radio themselves. That radio was then evaluated by the experimenter. All the participants were videotaped during this period and were allowed to ask any questions about the radio at anytime. In the Individual and Performance Feedback training conditions, each person sat at a small table in a different corner of the room, facing away from the others. No communication among these participants was permitted. Any questions about the radios were asked and answered quietly, so that no one could eavesdrop. In contrast, participants in the Group training condition remained seated around the circular table, where they worked together on a single radio. They were allowed to communicate freely, both among themselves and with the experimenter, while they worked.

At the end of their first group meeting, participants were informed that their ability to build the radios would be tested at their next group meeting. As an incentive, we had already promised to award a cash prize of $10 to every member of the two best groups. But we also made it clear to participants that it was the performance of their *groups* that would be evaluated, rather than the performance of any one person in those groups. Everyone was told they would be building radios together, as a group, at their next meeting,

At the second meeting of each group, the initial agenda varied somewhat from one training condition to another. Groups in the Performance Feedback condition were given prepared handouts (see Fig. 1) that summarized the radio-building skills of each group member. The information on these handouts was based on actual performance data obtained from the group's first meeting. After receiving their handouts, these groups had 5 min to review their contents. The handouts ranked each group member (first, second, and third place) on several radio-building skills and included specific information about the number of points earned by each group member for each of those skills. We offered no instructions or guidance to groups in this condition about whether and how the information on their handouts ought to be used. However, most of those groups seemed interested in the handouts and spent a few minutes discussing members' skills.

The same agenda was then followed for every meeting, regardless of how a group was trained. First, we began to videotape the group. We then gave the group a blank sheet of paper and asked its members, working together, to recall as much as they could about how to build a radio. Every group had up

Summary of Radio-Building Skills

Group Number

Skill	*First Place*	*Second Place*	*Third Place*
Resistors			
Capacitors			
Transistors			
Other Components			
Wiring			

These results are based on individual performance during last week's training session. The number of points that each person earned for each skill is shown in parentheses next to that person's name.

FIG. 1. A (blank) sample of the handouts given to groups in the Performance Feedback training condition.

to 10 min to finish this task, without any other materials or any help from the experimenter. After collecting its recall sheet, we gave each group a kit and asked it to build a radio as quickly and accurately as possible. Every group had up to 30 min to finish this task, again without any other materials or any help from the experimenter. After collecting the radios, we gave each group member a copy of the questionnaire. Everyone had up to 5 min to complete that questionnaire, working at individual tables located at different corners of the room, without discussing the items or revealing their ratings. Next, we collected addresses from everyone so that cash prizes could be mailed to members of the best groups. All participants were then debriefed, first by asking them what they thought our research was really about and then by explaining it to them, both orally and in writing (by distributing the debriefing sheets). Finally, we thanked the participants for their help and dismissed them.

TABLE 1

Summary of Mean Scores across Training Conditions

Measures	Training condition		
	Individual	Performance feedback	Group
Group Performance			
Procedural recall	18.80	25.50	25.78
Assembly errors	49.85	35.30	28.70
Assembly time	26.45	27.45	27.44
Group Behavior (Videotapes)			
Transactive memory index	2.74	3.80	4.54
Questionnaire Responses			
Attraction index	5.58	5.48	5.28
Familiarity index	3.15	3.93	4.07
Motivation to succeed	5.50	5.53	5.67
Experimenter's motives	4.38	4.30	4.38
Ease of communication	5.23	5.73	5.62

Note. Assembly time was measured in minutes. All of the videotape and questionnaire measures involved 7-point (1 to 7) rating scales.

RESULTS

Some preliminary analyses were performed to see whether the sex of each group, or which experimenter ran that group, altered participants' behavior. Because no evidence of such influence was found, those variables are not discussed further in this article.

Group Performance

A summary of the procedural recall and assembly error scores can be found in Table 1. There was a significant difference among the training conditions for procedural recall, $F(2, 60) = 6.68$, $p < .01$. Post hoc tests showed that groups from the Performance Feedback and Group training conditions remembered significantly more about how to build the radios than did groups from the Individual training condition.[3] There was no significant difference in procedural recall, however, between groups from the Performance Feedback and Group training conditions. Assembly errors also varied significantly across the training conditions, $F(2, 60) = 9.62$, $p < .01$. Post hoc tests showed that significantly fewer mistakes were made by groups in the Performance Feedback and Group training conditions than by groups in the Individual training condition. There was no significant difference in assembly errors, however, between groups from the Performance Feedback and Group training conditions. Finally, different kinds of training had no effect on how quickly the groups built their radios. Our earlier experiments produced the same finding.

[3] Whenever an analysis of variance showed significant differences among the training conditions, Tukey tests were carried out to determine which means differed significantly ($p < .05$) from one another.

Group Behavior (Videotapes)

Technical problems forced us to discard eight videotapes, two for groups from the Individual training condition, four for groups from the Performance Feedback training condition, and two for groups from the Group training condition. These groups did not seem exceptional in any way and performed about the same as groups (comparably trained) whose videotapes we were able to use.

All of the 55 remaining videotapes were coded by two judges. One judge was unaware of our research hypotheses, and both judges were unaware of the training conditions associated with the videotapes they were shown. The coding process began with a training period in which a sample of videotapes was coded independently by both judges, who met a few times to discuss their views about what those tapes revealed. Cohen's kappa was used to assess the reliability of their coding. After 21 of the videotapes were coded in this way, acceptable reliability levels (kappas of .75 or higher, all significant at $p < .05$ or better) were achieved. Each judge, working independently, then went on to code half of the remaining videotapes.[4]

As in our earlier research (see Liang et al., 1995; Moreland, 1999; Moreland et al., 1996, 1998), the videotapes were coded for three sets of behavior that reflect the operation of transactive memory systems.[5] *Memory differentiation* involves specialization among group members who remember different aspects of the assembly process. For example, one person may remember where some components ought to be inserted into the circuit board, whereas another person remembers how those same components ought to be wired together. *Task coordination* involves the ability of group members to work together efficiently while assembling the radio. There should be less confusion and more cooperation in groups with stronger transactive memory systems. Finally, *task credibility* involves how much a group's members trust one another's radio-building knowledge. In groups with stronger transactive memory systems, there should be less need to publicly claim expertise, more acceptance of suggestions by other members, and less criticism of their work. The judges watched each videotape and rated the levels of memory differentiation, task coordination, and task credibility in that group. These ratings, made on 7-point (1 to 7) scales, were strongly correlated with one another, so we averaged them together to produce a transactive memory index (Cronbach's $\alpha = .78$). Scores on that index are summarized in Table 1.

Transactive memory index scores differed significantly across training conditions, $F(2, 52) = 12.95$, $p < .01$. Post hoc tests showed that groups in the

[4] These ratings were not biased by the actual performance of the groups because it was not possible (given the quality of the videotapes) to judge group performance just by watching the videotapes.

[5] In an earlier experiment, the validity of this behavioral coding was confirmed by measuring (a) the actual skills of individual group members and (b) the beliefs of group members' about those skills. We found that when group members are trained together, rather than apart, their beliefs about one another's skills are more detailed, accurate, and shared. Moreover, these direct measures of transactive memory were highly correlated with the behavioral measures (videotape ratings) we have used in all our research.

TABLE 2

Summary of Hierarchical Regression Analysis of Assembly Error Scores

Predictor variables	Regression coefficient	Standard deviation	Variance explained
Stage One			24.30%
Performance feedback training	−14.55*	5.06	
Group training	−21.15*	4.89	
Stage Two			37.50%
Performance feedback training	−7.02	5.62	
Group training	−8.49	5.99	
Transactive memory	−6.75*	1.92	

Note. Regression coefficients marked with an asterisk are significantly different from zero at $p < .01$. All of the nonsignificant coefficients have probabilities greater than .15.

Performance Feedback and Group training conditions did not differ significantly from one another, but groups in both of these conditions earned higher scores than did groups from the Individual training condition.

Scores on the transactive memory index were strongly correlated with both procedural recall, $r = +.43$, $p < .01$, and with assembly errors, $r = -.59$, $p < .01$. We believed, given our past research, that differences in transactive memory among groups were responsible for the apparent effects of different training methods on group performance. A hierarchical regression analysis of assembly errors was thus performed (Baron & Kenny, 1986).[6] The results of the analysis are summarized in Table 2. In the first stage of the analysis, we regressed assembly errors on two dummy variables representing training conditions. These variables were scored in ways that contrasted both the Performance Feedback and Group training conditions with the Individual training condition. Obviously, given the analysis of variance results we just reported involving these same variables, that regression was significant, accounting for about 24% of the variance in assembly errors. The regression coefficients for both dummy variables were significant and negative, indicating that fewer errors were made by groups in the Performance Feedback or Group training conditions, rather than the Individual training condition. The second stage of the analysis, when transactive memory index scores were added to the regression equation, was more interesting. If transactive memory mediated the effects of different training methods on group performance, then the regression coefficient for transactive memory in that analysis should have been significant and negative, and the coefficients for the dummy variables should have become nonsignificant. That is exactly what we found. The final regression was significant, $F(3, 51) = 10.21$, $p < .01$, and accounted for about 38% of the variance in assembly errors.

[6] Because our measure of transactive memory reflected group behavior while radios were assembled, changes in group performance that depended on such behavior had to be measured after the radios were finished. This ruled out an analysis of whether transactive memory also mediated the effects of training methods on procedural recall.

Because of our interest in communication among group members, we also attempted to measure their use of *jargon*—special terms that could not be understood by people outside of the group. But after coding many of the videotapes, it became clear that jargon was rarely used, so no further efforts were made to measure it. Nonverbal communication was not measured either, in part because the videotapes did not permit it (see Footnote 4).

Questionnaire Responses

Two indices were also created from participants' responses to the questionnaire items. As we noted earlier, the first four items on that questionnaire were meant to measure participants' feelings about their groups and one another. Responses to those items were indeed strongly correlated, so we averaged them together to create an attraction index (Cronbach's $\alpha = .91$). The next four questionnaire items were meant to measure participants' familiarity with one another, focusing on who knew what about building radios. Responses to those items were correlated strongly with one another as well, so we averaged them together to create a familiarity index (Cronbach's $\alpha = .74$). The last three questionnaire items were scored separately.

There were no significant differences in attraction scores across the training conditions, which suggests that providing work group members with information about "who knows what" need not be divisive. But there were significant differences across the training conditions in familiarity scores, $F(2, 60) = 10.09$, $p < .01$. Post hoc tests showed that group members felt more familiar with one another in the Performance Feedback and Group training conditions than in the Individual training condition. However, there was no significant difference in familiarity between the Performance Feedback and Group training conditions.

Differences among the training methods had no significant effect on participants' motivation to succeed or on whether they believed that the experimenter wanted them to do well. The latter finding was reassuring—we were concerned that giving performance feedback to some groups might lead them to believe that they were receiving "extra" help. There was also no significant effect of training methods on how easily group members felt they could communicate with one another while working on the radios. The fact that scores for groups in the Individual and Performance Feedback training conditions were comparable suggests that groups in the latter condition did not benefit from improved communication about their task. And the fact that scores for groups in the Group training condition were comparable to those for all of the other groups suggests that improved communication was not an important factor in this or other research we have conducted on the performance benefits of group training.

There were a few significant correlations worth noting among the questionnaire indices and scales and between those measures and our measures of group performance and transactive memory. For example, communication among group members was easier if people felt more attracted to one another,

$r = +.52$, $p < .01$, or more familiar with one another, $r = +.31$, $p < .01$. Communication was also easier in groups with higher transactive memory scores, $r = +.29$, $p < .05$. Participants also felt more familiar with one another in groups with higher transactive memory scores, $r = +.51$, $p < .01$.

DISCUSSION

The major goal of this experiment was to determine whether the performance benefits associated with group training are due to improved communication among workers rather than to transactive memory. The results clearly showed that they are not. Three findings support this conclusion. First, members of groups in the Performance Feedback condition had no opportunity to communicate with one another about building radios until their testing sessions began, yet their groups performed well—just as well as groups in the Group training condition. There were no significant differences in either procedural recall or assembly errors between groups from the Performance Feedback and Group training conditions, and groups from both those conditions performed significantly better on these performance measures than did groups from the Individual training condition. Second, different training methods had no influence on group members' ratings of how easy it was to communicate with one another about building the radios.[7] If communication of that sort were a critical factor in group performance, then those ratings ought to have been lower in the Individual and the Performance Feedback training conditions than in the Group training condition. Finally, we found little evidence in the videotapes that different groups developed their own jargon for building the radios. If people had been moved from one group to another, it would not have been very difficult for them to communicate about the task with their new coworkers.

We are not arguing, of course, that communication is unimportant. Our findings may have been biased by methodological factors that weakened the impact of communication and/or strengthened the impact of transactive memory on group performance. For example, communication may be more important in work groups that have more diverse members who perform more complex tasks for longer periods of time (see Hirokawa, 1990; Salazar, 1996). And we cannot be sure that the information about their members' skills that we gave to groups in the Performance Feedback training condition was comparable to the information acquired naturally by groups whose members were trained together (in the Group training condition). The information contained in our handouts may have been more detailed or organized in more useful ways. It was also accurate, and known to be accurate by the people who received it,

[7] Because there was little evidence that communication varied across training conditions, it is unlikely that it mediated the positive effects of group training on group performance (see Baron & Kenny, 1986). Nevertheless, we performed a hierarchical regression analysis in which communication ratings by group members were used in the same way as we had used the scores from our transactive memory behavioral index. The results showed no mediation. A similar result was recently reported by Hollingshead (1998b).

whereas the skill assessments made by group members who are trained together are less certain. Finally, our communication measures may not have been sensitive enough to detect the impact of communication on group performance.

All of this suggests the need for more research on the role of communication in group training and performance, especially on how communication processes and transactive memory intersect. For example, do the members of work groups ever talk about who knows what, and if so, what do they say? How is information about a group's transactive memory system relayed to people in (or out) of the group? Finally, how and when do work group members ask for help in recalling information about tasks? Intriguing research on such issues has only recently appeared (see Hollingshead, 1998b).

Another goal of this experiment was to discover whether transactive memory systems can be created in other ways than by training the members of a work group together. It is difficult or impossible to arrange such training in some work settings, so this issue has practical importance. Our results indicate that group training is *not* necessary—it is possible to create transactive memory systems in other ways and thereby enjoy their benefits for group performance. But once again, further research is needed. For example, what is the best format and procedure for relaying information to a group's members about their relative skills? Perhaps all they need or want to know is who the best worker is overall. And must everyone in the group receive such information, or can it be given to just one person? If so, then who should that person be? Finally, what if feedback about group members' relative skills were accompanied by strategic suggestions about how to take advantage of those skills? How much more would the group's performance then benefit than if either type of information were provided without the other?

If transactive memory systems can indeed be created by simply providing the members of work groups with information about one another's skills, then it may possible to create even larger transactive systems, within entire organizations, in a similar way. Several analysts, such as Anand, Manz, and Glick (1998), Moreland (1999), and Stewart (1995a, 1995b, 1997) have already discussed such projects, and several organizations are now investing great resources in them. If these projects succeed, then the performance benefits that they produce for both work groups and organizations could be substantial.

REFERENCES

Anand, V., Manz, C. C., & Glick, W. H. (1998). An organizational memory approach to information management. *Academy of Management Review,* **23,** 796–809.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology,* **51,** 1173–1182.

DiSalvo, V., Nikkel, E., & Monroe, C. (1989). Theory and practice: A field investigation and identification of group members' perceptions of problems facing natural work groups. *Small Group Behavior,* **20,** 551–567.

Fine, G. A. (1996). Justifying work: Occupational rhetorics as resources in restaurant kitchens. *Administrative Science Quarterly,* **41,** 90–115.

Finholt, T., Sproull, L., & Kiesler, S. (1990). Communication and performance in ad hoc task groups. In J. Galagher, R. E. Kraut, & C. Egido (Eds.), *Intellectual teamwork: Social and technological foundations of cooperative work* (pp. 291–325). Hillsdale, NJ: Erlbaum.

Fulk, J. (1993). Social construction of communication technology. *Academy of Management Journal*, **36,** 921–950.

Haas, J. (1972). The stages of the high steel iron worker apprentice's career. *Sociological Quarterly*, **15,** 93–108.

Haas, J. (1977). Learning real feelings: A study of high steel ironworkers' reactions to fear and danger. *Sociology of Work and Occupations*, **4,** 147–170.

Hackman, J. R. (1998). Why teams don't work. In R. S. Tindale, L. Heath, J. Edwards, E. J. Posavac, F. B. Bryant, Y. Suarez-Balcazar, E. Henderson-King, & J. Myers (Eds.), *Theory and research on small groups* (pp. 245–267). New York: Plenum.

Hirokawa, R. Y. (1990). The role of communication in group decision-making efficacy: A task-contingency perspective. *Small Group Research*, **21,** 190–204.

Hollingshead, A. B. (1998a). Group and individual training: The impact of practice on performance. *Small Group Research*, **29,** 254–280.

Hollingshead, A. B. (1998b). Distributed knowledge and transactive processes in decision-making groups. In M. A. Neale, E. A. Mannix, & D. H. Gruenfeld (Eds.), *Research on managing groups and teams* (Vol. 1, pp. 105–125). Greenwich, CT: JAI Press.

Hollingshead, A. B. (1998c). Retrieval processes in transactive memory systems. *Journal of Personality and Social Psychology*, **74,** 639–671.

Krauss, R. M., & Fussell, S. R. (1990). Mutual knowledge and communication effectiveness. In J. Galagher, R. E. Kraut, & C. Egido (Eds.), *Intellectual teamwork: Social and technological foundations of cooperative work* (pp. 111–145). Hillsdale, NJ: Erlbaum.

Laffey, M. (1998, August 10). Word on the street. *The New Yorker*, 36–39.

Levine, J. M., & Moreland, R. L. (1991). Culture and socialization in work groups. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 257–279). Washington, DC: APA Press.

Liang, D. W., Moreland, R. L., & Argote, L. (1995). Group versus individual training and group performance: The mediating role of transactive memory. *Personality and Social Psychology Bulletin*, **21,** 384–393.

Lyon, E. (1974). Work and play: Resource constraints in a small theater. *Urban Life and Culture*, **3,** 71–97.

Moreland, R. L. (1999). Transactive memory: Learning who knows what in work groups and organizations. In L. Thompson, D. Messick, & J. Levine (Eds.), *Shared cognition in organizations: The management of knowledge* (pp. 3–31). Mahwah, NJ: Erlbaum.

Moreland, R. L., Argote, L., & Krishnan, R. (1996). Socially shared cognition at work: Transactive memory and group performance. In J. L. Nye & A. M. Brower (Eds.), *What's social about social cognition? Research on socially shared cognition in small groups* (pp. 57–84). Thousand Oaks, CA: Sage.

Moreland, R. L., Argote, L., & Krishnan, R. (1998). Training people to work in groups. In R. S. Tindale, L. Heath, J. Edwards, E. J. Posavac, F. B. Bryant, Y. Suarez-Balcazar, E. Henderson-King, & J. Myers (Eds.), *Theory and research on small groups* (pp. 37–60). New York: Plenum.

Moreland, R. L., & Levine, J. M. (1992). Problem identification by groups. In S. Worchel, W. Wood, & J. A. Simpson (Eds.), *Group process and productivity* (pp. 17–48). Newbury Park, CA: Sage.

Murnighan, J. K., & Conlon, D. E. (1991). The dynamics of intense work groups: A study of British string quartets. *Administrative Science Quarterly*, **36,** 165–186.

O'Reilly, C. A., & Roberts, K. H. (1977). Task group structure, communication, and effectiveness in three organizations. *Journal of Applied Psychology*, **63,** 674–681.

Orr, J. E. (1990). Sharing knowledge, celebrating identity: War stories and community memory among service technicians. In D. S. Middleton & D. Edwards (Eds.), *Collective remembering: Memory in society* (pp. 169–189). Newbury Park, CA: Sage.

Salazar, A. J. (1996). Ambiguity and communication effects on small-group decision-making performance. *Human Communication Research*, **23,** 155–192.

Scheff, T. J. (1995). Academic gangs. *Crime, Law, & Social Change*, **23,** 157–162.

Scribner, S., & Sachs, P. (1990, February). *A study of on-the-job training*. New York: National Center on Education and Employment (Technical Paper No. 13).

Stewart, T. A. (1995a, Oct. 30). Mapping corporate brainpower. *Fortune*, 209–212.

Stewart, T. A. (1995b, Nov. 27). Getting real about brainpower. *Fortune*, 201–203.

Stewart, T. A. (1997, Sept. 29). Does anyone around here know. . .? *Fortune*, 279–280.

Sundstrom, E. (Ed.) (1998). *Supporting work team effectiveness*. San Francisco, CA: Jossey–Bass.

Truzzi, M., & Easto, P. (1972). Carnivals, road shows, and freaks. *Trans-Action*, **9,** 26–34.

Tuckman, B. W. (1965). Developmental sequence in small groups. *Psychological Bulletin*, **63,** 384–399.

Wegner, D. M. (1987). Transactive memory: A contemporary analysis of the group mind. In B. Mullen & G. R. Goethals (Eds.), *Theories of group behavior* (pp. 185–205). New York: Springer-Verlag.

Wegner, D. M. (1995). A computer network model of human transactive memory. *Social Cognition*, **13,** 319–339.

Weick, K. E., & Roberts, K. H. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly*, **38,** 357–381.

Wittenbaum, G. M., Vaughan, S. I., & Stasser, G. (1998). Coordination in task-performing groups. In R. S. Tindale, L. Heath, J. Edwards, E. J. Posavac, F. B. Bryant, Y. Suarez-Balcazar, E. Henderson-King, & J. Myers (Eds.), *Theory and research on small groups* (pp. 177–204). New York: Plenum.

Received November 24, 1998