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Testing Three Team Training Strategies in Intact Teams

A Meta-Analysis

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This article describes the results of a meta-analytic integration of the relative contributions of three different components of team training to the efficacy of team training interventions. The three specific components of team training that have received empirical scrutiny in the past are cross-training, team coordination and adaptation training, and guided team self-correction training. The results of this effort show a significant, small-to-moderate tendency for team training to lead to an increase in team performance. This basic beneficial effect of team training was clearly moderated by the degree to which specific components of team training were involved in team training interventions. The results of two different analytic strategies converge to suggest that, at this time, the most potent contribution to effective team training appears to include a focus on coordination and adaptation. This suggests that the optimal team training intervention appears to be requiring that team members learn how to alter their coordination strategies and to reduce the amount of communication necessary for successful team performance.

Keywords: *team training; team performance; meta-analysis*

Several recent summaries have delineated a variety of team training interventions proposed to increase team effectiveness and team performance (e.g., Cannon-Bowers & Salas, 1998; Kozlowski & Bell, 2003;

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Salas, Stagl, & Burke, 2004). These reviews summarize existing research and describe the results of several empirical studies of several different types of team training interventions. In this article, we describe an effort to conduct a meta-analytic integration of the evidence on the effectiveness of team training interventions. As Stout, Salas, and Fowlkes (1997) have noted: "There is a lack of clear understanding of what the effective instructional strategies for enhancing teamwork are. Second, there are few systematic evaluations of the effectiveness of particular team training efforts" (p. 169). The purpose of this meta-analytic research is to cumulate and summarize existing team training efforts and to provide a compass heading for further research efforts.

Approach

The underlying assumption of studies of team training interventions is that teams can be led to perform better and more effectively when the team members participate in a training intervention directed toward the team as a whole. Several recent reviews have delineated a variety of team training interventions proposed to increase team effectiveness and team performance (e.g., Blickensderfer, Cannon-Bowers, & Salas, 1997; Campbell & Kuncel, 2001; Salas et al., 2004). These summaries typically describe the results of several disparate studies of several unrelated team training interventions and conclude with a call for additional research on the effects of team training interventions. As far as they go, these previous efforts to summarize the weight of available evidence are noteworthy and laudable. However, they fall short of their goal of providing clear and practicable recommendations for effective team training interventions. Specifically, none of these previous efforts is able to specify the relative potency of different team training interventions.

The strategy employed in this article is empirical and has had a high success rate in similar domains: A meta-analytic integration (Glass, 1976; Mullen, 1989; Mullen & Rosenthal, 1985; Rosenthal, 1991) was conducted on research examining the effectiveness of team training interventions. The central consideration in this effort is to delineate the relative contributions of various specific components of team training interventions. Therefore, different components of team training interventions will first be defined and explained. Then, the relative contributions of these components of team training to training effectiveness will be examined in a meta-analysis.

Overview of Meta-Analysis Methodology

Meta-analysis refers to the statistical integration of the results of several independent studies. Procedures for combining and comparing the results of independent studies have been available for some time (e.g., Fisher, 1932; Pearson, 1933; Thorndike, 1933). However, it was not until Glass (1976) labeled this perspective as meta-analysis that this approach received the popularity and the currency that it enjoys today. The term meta-analysis does not describe a single statistical procedure that distills a domain of research into one simple answer. Rather, meta-analysis embodies a constellation of different statistical techniques, developed and suited for specific purposes, and a general conceptual approach to the problems of summarizing, integrating, and testing of practical questions and theoretical issues with the results of previous research.

For example, Driskell, Copper, and Moran (1994) conducted a meta-analysis of the research literature examining the effects of mental practice on performance. This analysis, integrating the results of 35 studies and representing the data for 3,214 participants, revealed a significant ($z = 9.731$, $p < .001$), weak ($z_{\text{Fisher}} = 0.261$, $r = .255$) effect of mental practice on performance. Moreover, this analysis revealed, for the first time, how this effect of mental practice was moderated by retention interval. Specifically, the magnitude of the effects of mental practice decreased as the delay between mental practice and performance increased, $r = –.216$, $z = 2.453$, $p = .007$. Thus, meta-analysis allows us to summarize and integrate, with greater certainty and precision, the significance, the strength, and the predictable variation of the phenomenon under consideration.

There are several distinct steps in the development of a responsible and informative meta-analytic integration (for more detailed presentation, see Mullen, 1989; Mullen & Rosenthal, 1985). First, the hypothesis test to be examined must be carefully and precisely defined. The specific operationalizations of the independent variables (e.g., team training) and the dependent variables (e.g., team performance) must be clearly articulated. After the well-defined hypothesis test has been identified, the relevant studies must be located and retrieved. Relevant studies may be located in published academic journals, scholarly textbooks, unpublished papers presented at conferences, unpublished theses and dissertations, and published and unpublished technical reports. Several distinct strategies are used to locate relevant studies. The ancestry approach uses the bibliographies and reference sections of relevant studies that have already been retrieved to locate earlier relevant studies. The descendancy approach uses indexing sources (e.g., the Social Science Citation Index) to locate subsequent relevant studies that have cited earlier relevant studies. Abstracting services (e.g., PsychInfo) allow the user to identify studies associated with keywords and phrases. All three approaches can be conducted via online computer databases. The *invisible college* approach refers to the informal network of scientists working on a given problem. Letters, phone calls, and conversations with researchers most active in a particular research domain can sometimes uncover new, unpublished studies at various stages of being "in the works."

Once the relevant studies have been retrieved, the appropriate tests of the well-defined hypothesis must be derived from the study report. Of course, one study may report a *t* test, a second study may report a chi-square, a third study may report a correlation coefficient, and so on. Because these different statistics are on different metrics, they must be transduced to more standard, common metrics. The two common metrics for statistical results are significance levels (z and one-tailed p) and effect size (z_{Fisher} and r).

Once placed on these common metrics of significance level and effect size, the results of separate hypothesis tests can be combined, compared, and examined for the fit of predictive models. Meta-analytic combinations of significance levels and effect sizes provide a gauge of the overall combined probability and strength of effects. Meta-analytic focused comparisons provide a gauge of the extent to which these effects increase or decrease as a function of some theoretically relevant or practically important predictors. Formulae and computational procedures for these meta-analytic techniques are presented in Mullen (1989), Mullen and Rosenthal (1985), and Rosenthal (1991).

Team Training Strategies

Although several different facets of team training have been written about over the past several years, three specific components of team training have received empirical scrutiny: cross-training, team coordination and adaptation training, and guided team self-correction training (see Cannon-Bowers & Salas, 1998). Cross-training (e.g., Cannon-Bowers, Salas, Blickensderfer, & Bowers, 1998) refers to a team training intervention in which team members rotate positions during training to develop an understanding of the knowledge and skills necessary to successfully perform the tasks of other team members. Cross-training is assumed to give team members an overall framework for understanding the team's task and how each individual's role is important to it. Team coordination and adaptation training (e.g., Entin & Serfaty, 1994) refers to a team training intervention in which team members are trained to alter their coordination strategy and to reduce the amount of communication necessary for successful task performance. Team coordination and adaptation training are assumed to help team members learn about specific teamwork skills and how to optimize the value of idle periods when task demands are low by anticipating and discussing potential problems. Finally, guided team self-correction training (e.g., Smith-Jentsch, Zeisig, Acton, & McPherson, 1998) refers to a team training intervention in which team members learn to diagnose the team's problems and to develop effective solutions. Guided team self-correction training is assumed to foster correct expectations (i.e., shared mental models) among team members, thereby contributing to more effective team performance.

Each of these aspects of team training has received empirical attention. However, to date there has been no summary of the relative contributions of these components of team training to the overall effectiveness of team training. In lieu of primary level experimental comparisons of these components of team training, the currently available evidence can be used to compare the relative contributions of these components of team training to training effectiveness. There are two different approaches to gauging the relative contributions of these components of team training. One analytic approach is to examine the extent to which the effectiveness of team training interventions varies as a function of the degree to which the specific components of team training were implemented. For example, some tests of the effects of team training will be conducted with relatively high degrees of cross-training, whereas other tests of the effects of team training will be conducted with relatively low degrees of cross-training. These variations in the extent to which the specific components of team training were implemented might account for variability in the effectiveness of team training interventions.

Alternatively, a second analytic approach to differences between specific team training interventions is to conduct cluster analyses on hypothesis tests. For example, clusters or subsets of hypotheses tests that show relatively stronger effects of team training can be compared with clusters or subsets of hypotheses tests that show relatively weaker effects of team training. Specifically, the team training characteristics of hypothesis tests that render the most effective training results can be compared with the team training characteristics of hypothesis tests that render the least effective training results. Both the prediction by components analytic strategy and the clustering analytic strategy were employed here.

Procedure

Using all of the standard literature search techniques, an exhaustive search was conducted for studies testing the effects of team training on team performance. Specifically, online searches were conducted, using the keywords team(s), crew(s), group(s), train(ing), learn(ing), and performance. These computer searches were supplemented by ancestry approach and descendancy approach searches and by browsing through the past 25 years of social and applied psychology journals (see Mullen, 1989, for a discussion of literature search techniques). Any studies that were available as of July 2000 were eligible for inclusion in this integration.

Studies That Were Not Included in the Meta-Analytic Database

Before proceeding to summarize the specific sets of studies that were subjected to meta-analytic statistical analysis, it may be useful to delineate the various types of studies that were omitted from the analysis. This will help to specify the nature of the resultant meta-analytic database. This will also clarify the various strategies pursued in an effort to scrutinize the effectiveness of team training interventions as well as the exhaustive nature of the literature search process.

Studies providing incomplete or insufficient data for extraction of statistical tests. One of the attributes that characterizes this research literature is a remarkable paucity in the reporting of precise statistical tests of the effects of team training interventions. Indeed, practically all of the hypothesis tests included in the meta-analytic database (delineated below) had to be reconstructed from raw data presented in tables or figures in the published articles or from means and standard errors of the means presented in the text of the published articles. Several studies that are frequently cited regarding the effects of team training interventions failed to provide complete or sufficient data to allow the extraction of statistical tests of the effects of team training (e.g., Peron, 1993; Stout et al., 1997; Travillian, Volpe, Cannon-Bowers, & Salas, 1993). None of these studies was included in our analysis.

In many of these articles, if any statistical result is reported at all, it typically takes the form of statements such as, "The team training intervention exerted a significant [or no significant] effect on team performance." Standard operating procedure for some meta-analysts is to treat statements of a significant effect as representing a p value equal to .05 and to treat statements of no significant effect as representing a p value equal to .50. These conservative reconstructions are imprecise and introduce error into the meta-analytic database.

We can illustrate the consequences of following these crude approximations for imprecisely reported statistical tests. Consider Entin and Serfaty's (1994) report of the effects of a team coordination and adaptation training intervention. Entin and Serfaty's (1994) discussion of Figure 3-1 and Table 3-1 (pp. 18–19) indicates that the team coordination and adaptation training intervention rendered a significant improvement in performance relative to the control group (the significance of this difference is indicated by the parenthetical report of $p < .05$). If we were to take this imprecisely reported statistical test at face value, then the magnitude of effect for this team training intervention would be reconstructed as $r = .582$ (because this is the effect size that corresponds to a significance level of $p = .05$ with a sample size of 8). However, when we actually extract the precise statistical test, $t(9) = 3.078$, we see that the actual magnitude of effect for this team training intervention is $r = .716$. Thus, any studies in which reports did not allow the reconstruction of a precise statistical test could not be included in our analysis.

Studies examining the effects of team training in a case study paradigm. A few studies that are frequently cited in support of the efficacy of team training interventions were actually reports of case studies (e.g., Kasis, 1984; Maher, 1980). Although these types of anecdotal reports may be of historical interest, they do not provide statistical tests that can be included in a meta-analytic statistical integration of the weight of available evidence. None of these studies were included in our analysis.

Studies examining the effects of team training on non–performance outcome indicators. A few studies that are frequently cited in support of the efficacy of team training interventions employed some non–performance outcome indicators (e.g.. Boss, McConkie, Ringer, Polok, & Goodman, 1995; Engstrom, 1986). If there were a critical mass of studies that employed comparable non–performance outcome indicators, an additional effort could integrate the effects of team training interventions on these measures; however, these non–performance outcome indicators included an inconsistent array of self-reports of satisfaction, team cohesion, communicative acts, and so on. None of these studies were included in the present effort.

Studies examining the effects of team training among exceptional/abnormal participant samples. A few studies that are frequently cited in support of the efficacy of team training interventions were conducted with teams on which some or all of the team members were sampled from exceptional or abnormal participant populations (e.g., Chaplin, Koulouris, & Katami, 1996; Payne & Ogletree, 1995). These types of studies may be of practical benefit to practitioners working with these special populations. However, differences between the results of these two types of studies might be due to the specific differences in the training interventions employed or to the differences in sample characteristics. None of these studies were included in the present effort.

Studies examining the effects of team training among non-intact teams. A few studies that are frequently cited in support of the efficacy of team training interventions were conducted by training people in one team configuration, then having people perform in a different team configuration (e.g., Cooley, 1994; Smith-Jentsch, Jentsch, Payne, & Salas, 1996). These types of studies may be of practical benefit to practitioners working in settings in which teams may not be able to maintain intact membership. However, differences between the results of these studies and the results of studies conducted with intact team membership would be uninterpretable. That is, differences between the results of these two types of studies might be due to the specific differences in the training interventions employed or to the differences in team membership stability. None of these studies were included in the present effort. Future meta-analysis efforts in this domain should examine levels of team membership stability as a potential moderator variable.

Studies That Were Included in the Meta-Analytic Database

As conveyed in the foregoing discussion of study exclusions, to be included in the present effort a study had to provide one or more clear and unequivocal tests of the effects of team training interventions. Specifically, studies had to provide sufficient information for the accurate reconstruction of a precise test of the effects of team training interventions. Studies were included if they met the following criteria: (a) Participants in the studies had to be adolescents or adults not sampled from abnormal populations; (b) studies had to employ a team training intervention involving at least some degree of cross-training, team coordination and adaptation training, and/or guided team self-correction training; and (c) the effects of these team training interventions had to be compared to some specified no-training control condition on some external indicator of performance. That is, hypothesis tests had to report the effects of team training on either supervisory ratings or on objective productivity measures. Hypothesis tests were coded as having a positive direction of effect if the team training rendered an increase in performance as compared with the no-training control and as having a negative direction of effect if the team training rendered a decrease in performance compared to the no-training control.

These selection criteria rendered a total of seven studies (Blickensderfer et al., 1997; Buller & Bell, 1986; Cannon-Bowers et al., 1998; Cohen, 1993; Dionne, 1998; Entin & Serfaty, 1994; Volpe, Cannon-Bowers, Salas, & Spector, 1996). These 7 studies yielded 28 separate tests of the effects of team training interventions on performance, representing the responses of 695 team members in 178 teams.[1] In addition to the requisite statistical information, each hypothesis test was categorized as employing either supervisory ratings of performance or objective productivity measures of performance. This categorization was conducted by two judges with perfect unanimity. In addition, each hypothesis test was rated for the three components of team training described above: cross-training, team coordination and adaptation training, or guided team self-correction training. These components of team training were rated by two judges on a scale from 0 (*low*) to 100 (*high*) with near perfect unanimity (values represent interjudge reliability and Spearman-Brown effective reliability, respectively; cross-training: $r = .9999$, $R = .99995$; team coordination and adaptation training: $r = .9940$, $R = .99699$; guided team self-correction training: $r = .9779$, $R = .98883$). The means of the judges' ratings were used as indicators of the three components of team training. The hypothesis tests included in this meta-analysis, along with the corresponding statistical information, the measurement type, and the mean judged level of the three components of team training for each hypothesis test, are presented in Table 1.

Results

General Effects

For the overall database of $k = 28$ hypothesis tests, there was a significant, $z = 7.503$, $p = 1.07^{-13}$, small-to-moderate, $z_{\text{Fisher}} = 0.293$, $r = .286$, tendency for team training to improve team performance. The failsafe number associated with these effects, $N_{\text{fs}(p=.05)} = 628.7$, indicates that more than 600

Table 1
Studies Included in the Meta-Analytic Database

Study	*N* (Number of Teams, Number of People)	Statistic (*df*)	Direction of Effect	Effect Size (z_{Fisher})	Measurement Type	Components		
						CT	TCAT	GTSCT
Blickensderfer, Cannon-Bowers, & Salas (1997)	40, 120	$F(1,37) = 0.03$	+	0.028	Productivity	0.0	0.0	100.0
Buller & Bell (1986)	10, 27	$t(16) = 0.995$	+	0.246	Productivity	0.0	59.5	100.0
		$t(16) = 6.063$	+	1.203	Productivity	0.0	59.5	100.0
		$t(16) = 1.113$	+	0.275	Productivity	0.0	60.0	100.0
		$t(16) = 3.924$	+	0.868	Productivity	0.0	60.0	100.0
Cannon-Bowers, Salas, Blickensderfer, & Bowers (1998)	20, 60	$t(34) = 1.117$	–	–0.190	Productivity	100.0	18.5	0.0
		$t(34) = 1.850$	+	0.312	Productivity	100.0	18.5	0.0
Cohen (1993)	4, 120	$t(21) = 0.186$	–	–0.041	Productivity	0.0	0.0	12.5
		$t(21) = 0.257$	–	–0.056	Productivity	0.0	0.0	12.5
		$t(21) = 0.083$	+	0.018	Productivity	0.0	0.0	12.5
		$t(21) = 0.178$	+	0.039	Productivity	0.0	0.0	12.5
Dionne (1998)	20, 82	$t(24) = 1.285$	+	0.259	Productivity	0.0	73.0	48.5
Entin & Serfaty (1994)	8, 40	$t(9) = 1.111$	+	0.362	Rating	7.0	100.0	87.5
		$t(9) = 3.078$	+	0.900	Rating	7.0	100.0	87.5
Volpe, Cannon-Bowers, Salas, & Spector (1996)	20, 40	$t(39) = 2.745$	+	0.427	Productivity	100.0	18.5	0.0
		$t(39) = 2.490$	+	0.389	Productivity	100.0	18.5	0.0
		$t(39) = 2.205$	+	0.346	Productivity	100.0	18.5	0.0
		$t(39) = 1.305$	+	0.215	Productivity	100.0	18.5	0.0
		$t(39) = 1.903$	+	0.300	Productivity	100.0	18.5	0.0
		$t(39) = 2.103$	+	0.331	Productivity	100.0	18.5	0.0
		$t(39) = 1.667$	+	0.264	Productivity	100.0	18.5	0.0
		$t(39) = 1.433$	+	0.227	Productivity	100.0	18.5	0.0
		$t(39) = 2.457$	+	0.384	Productivity	100.0	18.5	0.0
		$t(39) = 2.028$	+	0.319	Productivity	100.0	18.5	0.0
		$t(39) = 2.064$	+	0.325	Rating	100.0	18.5	0.0
		$t(39) = 1.815$	+	0.287	Rating	100.0	18.5	0.0
		$t(39) = 2.045$	+	0.322	Rating	100.0	18.5	0.0
		$t(39) = 1.748$	+	0.276	Rating	100.0	18.5	0.0

Note: + = team training led to increased team performance; – = team training led to decreased team performance; CT = cross-training; TCAT = team coordination and adaptation training; GTSCT = guided team self-correction training.

studies averaging null effects would be needed before the combined probability reported above of $p = 1.07^{-13}$ would be reduced to the "just significant" value of $p = .05$. This $N_{fs(p=.05)} = 628.7$ exceeds Rosenthal's (1991) benchmark of $5k + 10$ (which would in this case be $5(28) + 10 = 150$), indicating that these results seem robust to future disconfirmations.[2]

Effects of Measurement Type

The basic effect presented above was not moderated by the type of measurement. For the $k = 22$ hypothesis tests using objective productivity measures of performance, there was a significant, $z = 6.148$, $p = 5.23^{-10}$, small-to-moderate, $z_{Fisher} = 0.278$, $r = .271$, tendency for team training to improve team performance. For the $k = 6$ hypothesis tests using supervisory ratings of performance, there was a significant, $z = 4.382$, $p < .001$, small-to-moderate, $z_{Fisher} = 0.340$, $r = .328$, tendency for team training to improve team performance. These two sets of effects were not significantly different, $z = 0.673$, $p = .2503$, and therefore measurement type was collapsed across in the analyses reported below.

Effects of Components of Team Training

The extent to which the specific components of team training were implemented in each hypothesis was used to predict the effects size for each hypothesis test. There was no significant prediction of team training effectiveness by the extent to which cross-training was implemented, $r = -.092$, $z = 0.264$, $p = .3958$. There was a significant prediction of team training effectiveness by the extent to which guided team self-correction training was implemented, $r = .448$, $z = 1.851$, $p = .0321$. And, there was an even stronger significant prediction of team training effectiveness by the extent to which team coordination and adaptation training was implemented, $r = .607$, $z = 1.718$, $p = .0429$.

It should be noted that the relative contributions of these three components of team training may be obscured by the coincidental covariation among these indicators of components of team training. Specifically, hypothesis tests that employed relatively high levels of cross-training tended to employ relatively low levels of team coordination and adaptation training, $r(26) = -.408$, $p = .0156$, or guided team self-correction training, $r(26) = -.773$, $p = 7.50^{-7}$, and hypothesis tests that employed relatively high levels of team coordination and adaptation training tended to employ relatively high levels of guided team self-correction training, $r(26) = .708$, $p < .001$.

In light of these intercorrelations between these three components of team training, an effort was made to gauge their independent contributions (similar to the approach developed by Mullen & Copper, 1994, to gauge the independent contributions of components of cohesiveness). Three new predictors were derived for each hypothesis test. The degree to which each hypothesis test's implementation of team training involved a given component was regressed on the degree to which that implementation of team training involved the other two components. The residuals from these regressions represent the variability in that one component of team training after the variability attributable to the other two components has been removed. For example, the residual cross-training predictor for each hypothesis test represented the degree to which its implementation of team training involved cross-training (partialling out the extent to which it also involved team coordination and adaptation training and guided team self-correction training).

Analyses of these residual component predictors indicated that cross-training did not make an independent contribution to the effectiveness of team training, $r = .289$, $z = 0.544$, $p = .2932$. Similarly, guided team self-correction training did not make an independent contribution to the effectiveness of team training, $r = .235$, $z = 0.684$, $p = .2471$. However, team coordination and adaptation training still made a marginally significant independent contribution to the effectiveness of team training even after the contributions of the other two components were partialled out, $r = .299$, $z = 1.319$, $p = .0936$.

These results reveal that cross-training does not seem to render any significant contribution to the effectiveness of team training, whereas both guided team self-correction training and team coordination and adaptation training seem to render beneficial effects, and although the beneficial effects of the latter two components appear to be highly interrelated in our meta-analytic database, the more potent contribution to effective team training appears to be team coordination and adaptation training.

Clustering Analysis

With an eye toward identifying the characteristics of hypothesis tests that render the most effective team training interventions, clusters or subsets of hypotheses tests that showed relatively stronger effects of team training were compared with clusters or subsets of hypotheses tests that showed relatively weaker effects of team training. Specifically, all $k = 28$ hypothesis tests were disaggregated into three clusters of hypothesis tests:

hypothesis tests demonstrating relatively small effects of team training, $k = 9$, where $z_{Fisher} < 0.2460$; hypothesis tests demonstrating relatively moderate effects of team training, $k = 10$, where $0.3299 > z_{Fisher} > 0.2459$; and hypothesis tests demonstrating relatively large effects of team training, $k = 9$, where $z_{Fisher} > 0.330$. By definition, the overall effects increased from the small effects cluster, $k = 9$, $z = 0.890$, $p = .1867$, $z_{Fisher} = 0.067$, $r = .067$, to the moderate effects cluster, $k = 10$, $z = 5.416$, $p = 3.37^{-8}$, $z_{Fisher} = 0.295$, $r = .287$, to the large effects cluster, $k = 9$, $z = 6.914$, $p = 4.75^{-12}$, $z_{Fisher} = 0.502$, $r = .464$. And, it is not surprising that the trend from the smallest effects cluster to the largest effects cluster was significant, $z = 2.046$, $p = .0204$.

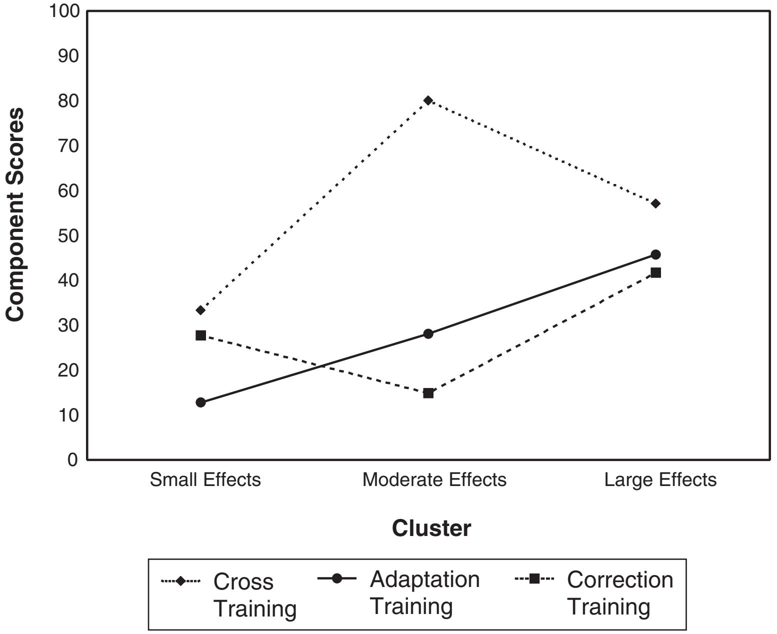
However, the point of this clustering of hypothesis tests is to delineate the differences in the components of team training among team training interventions that are differentially effective. This required an analysis of the components of team training, using a 3 (cluster of team training effectiveness: small, moderate, and large) X 3 (component of team training: cross-training, team coordination and adaptation training, and guided team self-correction training) Analysis of Variance (ANOVA) with repeated measures on the second factor. The results of this analysis of the components of team training are presented in Figure 1. As illustrated in this figure, there is no systematic trend from small to moderate to large effects clusters either for cross-training, $F(1,25) = 1.121$, $p = .2998$, or for guided team self-correction training, $F(1,25) = 0.499$, $p = .4866$. However, there was a significant trend from small to moderate to large effects clusters for team coordination and adaptation training, $F(1,25) = 7.267$, $p = .0124$. These results triangulate on the results reported above that examine the effects of specific components of team training: The more potent contribution to effective team training appears to be team coordination and adaptation training.

Discussion

The results reported above show a significant, small-to-moderate tendency for team training to lead to an increase in team performance. This result is consistent with another recent meta-analytic effort (see Klein et al., 2006). This basic pattern is not moderated by the type of measurement: A significant, small-to-moderate tendency for team training to lead to an increase in team performance was found both for objective productivity measures of performance and for supervisory ratings of performance.

The results reported above also show that this basic beneficial effect of team training was clearly moderated by the degree to which specific components of team training were involved in team training interventions.

Figure 1
Mean Component Scores for Three Clusters



The results of the direct predictor tests converge with the results of the clustering analysis to suggest that the most potent contribution to effective team training appears to be the focus on adaptive team mechanisms. This suggests that requiring team members to rotate positions during training to develop an understanding of the knowledge and skills necessary to successfully perform the tasks of other team members (cross-training) may not be the optimal team training intervention (although, as noted, it has some benefits). This strategy needs further refinement and testing. The results suggest that requiring team members to learn to diagnose the team's problems and to develop effective solutions (guided team self-correction training) may result in an improvement in team performance. However, the critical component of an optimal team training intervention appears to be when team members are taught to alter or shift their coordination strategy and to reduce the amount of communication necessary for successful team performance—training teams to be adaptive, and to shift these behavioral coordinating mechanisms as demands emerge (see Burke, Stagl, Salas, Pierce, & Kendall, 2006 for a recent review). Team coordination and adaptation training is assumed to help team members learn about specific teamwork skills and how to optimize the value of idle periods when task demands are low by anticipating and discussing potential problems. The weight of the evidence reviewed above indicates that the strategy labeled team coordination and adaptation training renders the most efficacious team training intervention so far. Better and more robust validations are needed.

Summary

In a recent review of team research, Ilgen (1999) described several critical constructs that are at the core of current work on teams. Current emphases include work on team performance, team composition, and team training. It is interesting to note in the section that Ilgen provided on team training that of 18 citations provided, not one represented an empirical test of the effects of team training on performance. This is perhaps symptomatic of emerging research domains—that there are a large number of theoretical and conceptual efforts describing needed work and a much smaller subset of empirical studies. Our review and analysis underscore the need for further empirical work examining the direct effects of team training on performance (see also Salas et al., 2006, for a review).

Finally, we should consider the impact of these results on subsequent research. Some scholars (articulated in Schmidt, 1992) express concern that meta-analytic efforts will kill the incentive to conduct primary level studies. Once a meta-analysis has been conducted summarizing the results of studies in a given domain, is there any point to conducting subsequent studies on the phenomenon under consideration? The answer is "Yes and no." The "no" part of the answer is that beyond a certain point, there is little value in conducting additional studies geared toward simply establishing the existence of a phenomenon that a meta-analytic integration has conclusively documented. The "yes" part of the answer is that even though we may become fairly confident of the significance, magnitude, and replicability of a basic effect through a meta-analytic integration, several subsequent questions may emerge as a result of the meta-analysis that deserve further empirical examination. For example, our results both document the value of the team training approach and also provide direction for subsequent research efforts. In this research domain, we clearly do not have a large body of conclusive research establishing the mechanisms through which team training interventions determine performance. We have a relatively small body (but growing in aviation, military, and medical domains) of empirical results that hint of the components of team training that drive enhancements in team performance (Salas et al., 2006). Researchers interested in the problems of bolstering team performance might direct and channel primary level research efforts into these promising directions.

Notes

1. The included studies reported varying numbers of hypothesis tests, ranging from 1 per study (e.g., Blickensderfer, Cannon-Bowers, & Salas, 1997) to 14 per study (e.g., Volpe, Cannon-Bowers, Salas, & Spector, 1996). In the meta-analysis reported below, each hypothesis test was treated as an independent observation. This assumption of independence is patently false. For example, each of the 14 hypothesis tests included in Volpe et al. (1996) was derived from the same subject population at the same time. However, without making this assumption of nonindependence, one would be forced to select the "best" hypothesis test from a study such as Volpe et al. (1996) or to pool the results from the reported hypothesis tests into a single test. In the present context, these alternatives seem even more arbitrary and capricious than the present assumption of independence. The effects of this assumption of independence are examined later.

2. As indicated in Note 1, the assumption that each of the 28 hypothesis tests represented an independent observation is false. However, it can be seen that such an assumption does not seem to render an inflated summary of this research domain. Consider the results of a supplementary meta-analysis of wholly independent effects in which multiple hypothesis tests obtained from a single study were combined into a single test. This heavy-handed solution precludes the examination of the effects of type measurement and the relative contributions of components of team training, but it does eliminate the problem of nonindependence. This produced seven distinct, wholly independent hypothesis tests, one from each includable study. The results of this supplemental meta-analysis revealed the same pattern reported above: There was a significant, $z = 2.553$, $p = .00534$, small-to-moderate, $z_{\text{Fisher}} = 0.235$, $r = .231$, tendency for team training to improve team performance. These results indicate that the degree of distortion engendered by the assumption of independence of the original 28 hypothesis tests is (at worst) tolerable.

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