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THE SCIENCE OF TRAINING: A Decade of Progress

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■ **Abstract** This chapter reviews the training research literature reported over the past decade. We describe the progress in five areas of research including training theory, training needs analysis, antecedent training conditions, training methods and strategies, and posttraining conditions. Our review suggests that advancements have been made that help us understand better the design and delivery of training in organizations, with respect to theory development as well as the quality and quantity of empirical research. We have new tools for analyzing requisite knowledge and skills, and for evaluating training. We know more about factors that influence training effectiveness and transfer of training. Finally, we challenge researchers to find better ways to translate the results of training research into practice.

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INTRODUCTION

In the 30 years since the first review of training in the *Annual Review of Psychology*, things have progressed dramatically in terms of both the science and practice of training. On the practice side, socio-cultural, technological, economic, and political pressures have all combined to force modern organizations to take a closer look at their human capital in general, and training in particular (Thayer 1997, Howard 1995). In fact, now more than ever, organizations must rely on workplace learning and continuous improvement in order to remain competitive (London & Moore 1999). In addition, organizations have shifted their views about training from a separate, stand-alone event to a fully integrated, strategic component of the organization. New training-related approaches, including action learning, just-in-time training, mentoring, coaching, organizational learning, and managing skill portfolios are all currently being explored. Finally, modern organizations must cope with training needs associated with the changing demographics of the population—both an older and more diverse workforce can be expected as we move into the new millennium.

It is important to note that improved training comes at a cost. Recent estimates suggest that the investment in training activities in organizations ranges from $55.3 billion to $200 billion annually (Bassi & Van Buren 1999, McKenna 1990), an investment that has not only created a growing interest in training, but also in learning technologies and performance-improvement processes, practices, and services. In fact, there is an increasing concern in organizations that the investment made in training must be justified in terms of improved organizational performance—increased productivity, profit, or safety; reduced error, enhanced market share (e.g. Huselid 1995, Martocchio & Baldwin 1997, Salas et al 2000).

The past 30 years have also witnessed tremendous growth in training research. This trend has been so pronounced that we are led to conclude that there has been nothing less than an explosion in training-related research in the past 10 years. More theories, models, empirical results, reviews, and meta-analyses are available today than ever before. Whether this research is having an effect on training practice—that is, a meaningful impact on how organizations actually train—is a matter of some debate. We return to this issue after documenting the many advances in training research over the past decade.

This is the sixth review of training and development to appear in the *Annual Review of Psychology* (see Campbell 1971, Goldstein 1980, Wexley 1984, Latham 1988, Tannenbaum & Yukl 1992). In this review, we focus on research published from 1992 to January 2000. Similar to Tannenbaum & Yukl's (1992), our review is

selective and descriptive. We focus primarily on the research that is concerned with the design, delivery, and evaluation of training in work organizations. Our review is organized as follows. We first discuss the recent theoretical advancements in training over the past decade. Then we address the relevant research on training needs analysis, including organization, job/task, and person analysis. Following this, we address antecedent training conditions (i.e. pretraining variables) that may enhance or disrupt learning. Next we turn our discussion to research on training methods and instructional strategies. In this section we discuss recent developments in simulation-based training, learning approaches, team training, and the influence of technology on training research and practice. Finally we review the research on post-training conditions. This includes a discussion of training evaluation and transfer of training. Wherever appropriate we point out the research needs and gaps. We conclude with a few observations and trends and a word about the future. Consistent with previous reviews, this review does not cover basic issues involved in skill acquisition and learning, organizational development, socialization in organizations, or educational psychology. We also do not synthesize the large literature in practitioner-oriented publications.

Initial Observations

Our first observation is that in 30 years of documenting the progress of training research, it is clear that the field, by any measure, has changed dramatically—for the better. Now, as recent reviews have documented, training-related theories abound. As noted earlier, there is also more empirical training-related research going on—in the field as well as in the lab—than ever before. Researchers are adopting a systems view of training and are more concerned with the organizational context. There are new models, constructs (e.g. opportunity to perform), and influences (e.g. technology) in the reported research. The traditional training evaluation paradigm has been expanded, and there are more evaluations being conducted and reported. There are better tools with which to conduct training evaluations, and better (and more practical) experimental designs have emerged. The field can now offer sound, pedagogically based principles and guidelines to practitioners and instructional developers. Furthermore, the impact of training on performance and organizational effectiveness is being felt (Bassi & Van Buren 1999), although clearly more documentation is needed here. Finally, there are more books and textbooks related to training (e.g. Ford et al 1997, Quinones & Ehrestein 1997, Noe 1999, Wexley & Latham 2000, Goldstein 1993; plus over 20 more that have been reviewed in *Personnel Psychology*). The science of training has progressed and matured—it is now truly an exciting and dynamic field. As evidence for this assertion, we summarize some of the latest theoretical advances in the next section.

Theoretical Developments

There have been some influential theories developed about training since 1992. In fact, the past decade has offered us myriad new and expanded theoretical

frameworks, as well as concepts and constructs. This thinking is deeper, richer, more comprehensive, and more focused. More importantly, the field has been energized by these developments so that empirical work has followed. Some of these frameworks and concepts are broad, general, and integrating. For example, Tannenbaum and colleagues provided an integrative framework for all the variables that influence the design and delivery of training (see Tannenbaum et al 1993, Cannon-Bowers et al 1995). The framework outlines in detail the pretraining and during-training conditions that may influence learning, as well as the factors that may facilitate the transfer of skills after training. Kozlowski & Salas (1997), drawing from organizational theory, discussed the importance of characterizing the factors and processes in which training interventions are implemented and transferred in organizations. Moreover, Kozlowski and colleagues (Kozlowski et al 2000) consider organizational system factors and training design issues that influence the effectiveness of vertical transfer processes. Vertical transfer refers to the upward propagation of individual-level training outcomes that emerge as team- and organizational-level outcomes. This issue has been largely neglected by researchers yet is suggested to be crucial to training effectiveness. Similarly, researchers have begun to understand and outline the barriers and myths that exist in organizations as they implement training (Dipboye 1997, Salas et al 1999). In other work, Kraiger et al (1993) provided new conceptualizations of learning and evaluation theory, approaches, and measurement. These authors expanded Kirkpatrick's (1976) evaluation typology by incorporating recent notions in cognitive psychology.

Other conceptual developments are more focused. For example, Ford et al (1997) invoked "the opportunity to perform" construct as a way to understand the transfer of training process. Colquitt et al (2000) summarized (qualitatively and quantitatively) the literature on training motivation and offered a new, integrative model. Cannon-Bowers & Salas (1997) proposed a framework for how to conceptualize performance measurement in training. Thayer & Teachout (1995) developed a model to understand the climate for transfer in organizations, as well as in-training conditions that enhance transfer. Cannon-Bowers et al (1998) advanced a number of conditions, concepts, and interventions that may enhance practice. Ford and colleagues have looked at individual differences and learner control strategies (e.g. Ford et al 1998). Training researchers have also examined variables such as the pretraining context (e.g. Baldwin & Magjuka 1997, Quinones 1995), conscientiousness and training outcomes (e.g. Colquitt & Simmering 1998, Martocchio & Judge 1997), individual and situational characteristics that influence training motivation (e.g. Facteau et al 1995, Mathieu & Martineau 1997), and participation in developmental activities (e.g. Noe & Wilk 1993, Baldwin & Magjuka 1997), just to name a few.

In sum, these theoretical advancements have provided a much needed forum in which to discuss, debate, analyze, and understand better the design and delivery of training in organizations. Moreover, they have provided an organized framework in which systematic research could be couched. Our conclusion is that training

research is no longer atheoretical as charged by our predecessors. We believe the field is healthier because of these influences and all the empirical work that has followed.

TRAINING NEEDS ANALYSIS

It is well acknowledged that one of the most important steps in training development is conducting a training needs analysis. This first step in training development focuses on the process of deciding who and what should be trained. A training needs analysis is primarily conducted to determine where training is needed, what needs to be taught, and who needs to be trained (Goldstein 1993). This phase has several outcomes. One is the specification of learning objectives, which in turn shape the design and delivery of training, as well as the process of criterion development. Consistent with Tannenbaum & Yukl (1992), we found a limited amount of empirical work on training needs analysis. In this section we discuss two components: organizational analysis and job/task analysis. We briefly address the third phase—person analysis.

Organizational Analysis

The purpose of an organizational analysis is to outline the systemwide components of the organization that may affect the delivery of a training program (Goldstein 1993). That is, it focuses on the congruence between training objectives with such factors as organizational goals, available resources, constraints, and support for transfer. Unfortunately, many training programs fail to reach their goals because of organizational constraints and conflicts, which could have been identified and ameliorated before training was implemented. Hence, conducting an organizational analysis is an important first-step training design. The best treatment of this topic can be found in Goldstein (1993).

Only recently have training researchers begun to pay attention to organizational analysis. One study, conducted by Rouiller & Goldstein (1993) in a chain of fast food restaurants, demonstrated that organizational climate (e.g. situational cues, consequences) was a powerful predictor of whether trainees transferred the learned skills. A second study conducted in a chain of supermarkets by Tracey et al (1995) showed that organizational climate and culture were directly related to posttraining behaviors. Clearly, these two studies illustrate how powerful an effect the organizational environment can have on whether newly acquired knowledge, skills, and attitudes (KSAs) are applied on the job (see also the transfer of training section).

As job requirements change, so does the need to help organizations plan their human resources activities. A number of issues have emerged that are related to organizational analysis. For example, authors have expressed the need to understand how the organizational context influences human resources strategies (e.g. Tannenbaum & Dupuree-Bruno 1994) to enhance continuous learning

environments (e.g. London & Moore 1999), to manage knowledge effectively (e.g. Tannenbaum 1997), and to determine the best organizational strategy (e.g. who is responsible for training?) for learning and training (e.g. Martocchio & Baldwin 1997). Obviously, organizational analysis is crucial for ensuring the success of a training program. However, more research is needed to develop practical and diagnostic tools to determine the organizational context relative to training.

Job/Task Analysis

Historically, job/task analysis has been used to identify the information necessary to create the learning objectives (Goldstein 1993). A job/task analysis results in a detailed description of the work functions to be performed on the job, the conditions under which the job is to be performed, and the KSAs needed to perform those tasks.

In the past decade, new research aimed at developing solid methods, approaches, and knowledge elicitation techniques for determining training needs and requirements have emerged. For example, Arvey et al (1992) explored the use of task inventories to forecast skills and abilities necessary for a future job. The results indicated that such forecasting predictions could represent useful information to training analysis. Wilson & Zalewski (1994) tested an expert system program as a way to estimate the amount of 11 abilities required for performing a job. The results indicated that most incumbents preferred the expert system method to the traditional ability rating scales.

Some attention has been given to better understanding the job/task analysis process for training purposes. For example, Ford et al (1993) examined the impact of task experience and individual factors on task ratings of training emphasis. Results indicated that as experience (and self-efficacy) increased over time, it tended to cause trainees to increase their ratings of training emphasis. Also, a few researchers have focused on outlining a task analysis procedure for teams (e.g. Baker et al 1998, Bowers et al 1993, Blickensderfer et al 2000). Much more research is needed, however. Specifically, we need to design and develop a methodology that helps instructional designers and analysts uncover the team-based tasks and their related KSAs.

Cognitive Task Analysis Cognitive task analysis refers to a set of procedures for understanding the mental processing and mental requirements for job performance. It has received much attention recently (see Dubois et al 1997/1998, Schraagen et al 2000), fueled primarily by interest in understanding how trainees acquire and develop knowledge, and how they organize rules, concepts, and associations (see Zsambok & Klein 1997). In addition, research aimed at uncovering the nature of expertise and how experts make decisions in complex natural environments has led to the development of tools such as cognitive task analysis (see Salas & Klein 2000, Schraagen et al 2000).

Cognitive task analysis is based on techniques (e.g. verbal protocols) used by cognitive scientists to elicit knowledge from subject matter experts. Products of a cognitive task analysis include information-generating templates for mental model development, cues for fostering complex decision-making skills, cues for developing simulation and scenarios used during training, and information for designing performance measurement and feedback protocols. For example, Neerincx & Griffoen (1996) applied a cognitive task analysis to assess the task load of jobs and to provide indicators for the redesign of jobs. This new application showed its benefits over the "old" task load analysis.

A cognitive task analysis can complement existing (behavioral) forms of training-need analysis. For example, research on meta-cognition suggests that through continued practice or experience, individuals automatize complex behaviors, thus freeing up cognitive resources for monitoring and evaluating behavior (Rogers et al 1997). By determining trainees' current complex cognitive skills, instructional designers can gain insight into trainees' capacity for proficiency and diagnose performance deficiencies. Thus, training-needs analysis should identify not only the requisite knowledge and skills to perform tasks, but also the cues and cognitions that enable trainees to know when to apply those skills. By incorporating the development of these skills into training, instructional designers can provide trainees with valuable self-help tools. Cognitive task analysis is becoming a useful tool but needs more development. Specifically, a theoretically driven methodology that clearly outlines the steps to take and how to analyze the data is needed.

We found no empirical work regarding the third phase of training-needs analysis—person analysis. However, the emerging literature of 360° feedback may be relevant. This approach identifies individual strengths and weaknesses, but perhaps more importantly, provides suggestions for improvement that often revolve around training and development activities.

In summary, it is interesting to note that whereas most training researchers believe and espouse that training-needs analysis is the most important phase in training, this phase remains largely an art rather than a science. We need more research that would enable us to develop a systematic methodology to determine the training needs of organizations.

ANTECEDENT TRAINING CONDITIONS

Events that occur before training can be as important as (and in some cases more important than) those that occur during and after training. Research has shown that activities that occur prior to training have an impact on how effective training turns out to be (Tannenbaum et al 1993). These factors fall into three general categories: (*a*) what trainees bring to the training setting, (*b*) variables that engage the trainee to learn and participate in developmental activities, and (*c*) how the training can be prepared so as to maximize the learning experience. Each of these is described in more detail below.

Individual Characteristics

Cognitive Ability Research aimed at understanding how characteristics the trainee brings to the training environment influence learning has proliferated in the past decade. For example, Ree et al (1995) developed a causal model showing the role of general cognitive ability and prior job knowledge in subsequent job-knowledge attainment and work-sample performance during training. The resulting model showed that ability influenced the attainment of job knowledge directly, and that general cognitive ability influenced work samples through job knowledge. Similar findings have been obtained by Ree & Earles (1991), Colquitt et al (2000), Randel et al (1992), Quick et al (1996), Kaemar et al (1997), Warr & Bunce (1995), and many others. Therefore, it is safe to conclude, based on this body of evidence (and others as well, e.g. Hunter 1986), that *g* (general intelligence) is good—it promotes self-efficacy and performance, and it helps a great deal with skill acquisition. Clearly, those who have high cognitive ability (all other things being equal) will likely learn more and succeed in training.

At this point, we probably need to look more closely at low-ability trainees and conduct research on how to optimize learning for them. Also, it might be worthwhile to examine in more depth concepts such as tacit knowledge and practical intelligence (Sternberg 1997) and their relation to on-the-job learning. Finally, it is worth noting that cognitive ability is a viable predictor of training performance (i.e. learning), but not necessarily performance on the job. Many jobs have requirements that go beyond cognitive ability (e.g. psychomotor demands), and/or depend on other factors (e.g. motivation) for success. Therefore, it is important to understand the nature of the job to determine whether cognitive ability will be a valid predictor of training transfer.

Self-efficacy This construct has been widely studied in this past decade. The findings are consistent: Self-efficacy, whether one has it before or acquires it during training, leads to better learning and performance. Self-efficacy (the belief that one can perform specific tasks and behaviors) is a powerful predictor of performance, as has been shown time and time again (e.g. Cole & Latham 1997 Eden & Aviram 1993, Ford et al 1998, Mathieu et al 1993, Martocchio 1994, Martocchio & Webster 1992, Mathieu et al 1992, Quinones 1995, Mitchell et al 1994, Phillips & Gully 1997, Stevens & Gist 1997, Stajkovic & Luthans 1998). Self-efficacy also mediates a number of personal variables including job satisfaction, organizational commitment, intention to quit the job, the relationship between training and adjustment in newcomers (Saks 1995), and the relationship between conscientiousness and learning (Martocchio & Judge 1997). Self-efficacy has also been shown to have motivational effects (e.g. Quinones 1995), to influence training reactions (Mathieu et al 1992), and to dictate whether trainees will use training technology (Christoph et al 1998).

In sum, it is well established that self-efficacy enhances leaning outcomes and performance. A research need that still remains is to expand what we know about

self-efficacy at the team level. Whereas a few studies have investigated collective efficacy in training (e.g. Guzzo et al 1993, Smith-Jentsch et al 2000), considerably more work is needed to better understand the mechanisms of collective efficacy in learning as a means to raise team performance. In addition, it might be useful to consider the use of self-efficacy as a deliberate training intervention (i.e. developing training targeted at raising self-efficacy), as well as a desirable outcome of training (i.e. as an indicator of training success).

Goal Orientation Goal orientation has received considerable attention in recent years (e.g. Brett & VandeWalle 1999, Ford et al 1998, Phillips & Gully 1997). This construct is broadly conceptualized as the mental framework used by individuals to interpret and behave in learning- or achievement-oriented activities. Two classes of goal orientation have been identified (Dweck 1986, Dweck & Leggett 1988): (*a*) mastery (or learning) goal orientation, whereby individuals seek to develop competence by acquiring new skills and mastering novel situations, and (*b*) performance goal orientation, whereby individuals pursue assurances of their own competence by seeking good performance evaluations and avoiding negative ones. There is a debate in the literature as to whether goal orientation is a disposition, a state, or both (e.g. Stevens & Gist 1997), whether it is a multidimensional construct (e.g. Elliot & Church 1997, VandeValle 1997), or whether these two goal strategies are mutually exclusive (Buttom et al 1996). Although continued research will bring more conceptual clarity, recent studies have shown, in general, that goal orientation influences learning outcomes and performance. For example, Fisher & Ford (1998) found that a mastery orientation was a strong predictor of a knowledge-based learning outcome. Ford et al (1998) showed that mastery orientation was positively related to the meta-cognitive activity of the trainee. Phillips & Gully (1997) demonstrated that mastery goal orientation was positively related to self-efficacy. All these results are promising. More research is needed to determine how goal orientation is developed. Specifically, it must be determined whether goal orientation is a relatively stable trait, or if it can be modified prior to training. Should the latter be true, then efforts to move trainees toward a mastery orientation should be developed.

Training Motivation

Training motivation can be conceptualized as the direction, effort, intensity, and persistence that trainees apply to learning-oriented activities before, during, and after training (Kanfer 1991, Tannenbaum & Yukl 1992). Recently, several studies have found (and confirmed) that trainees' motivation to learn and attend training has an effect on their skill acquisition, retention, and willingness to apply the newly acquired KSAs on the job (e.g. Martocchio & Webster 1992, Mathieu et al 1992, Quinones 1995, Tannenbaum & Yukl 1992). Whereas the literature is, in general, clear about the influence of training motivation on learning outcomes, it has lacked some conceptual precision and specificity, and has been somewhat

piecemeal. An exception is a recent effort by Colquitt et al (2000) that has shed light on the underlying processes and variables involved in understanding training motivation throughout the training process. Their integrative narrative and meta-analytic review suggest that training motivation is multifaceted and influenced by a set of individual (e.g. cognitive ability, self-efficacy, anxiety, age, conscientiousness) and situational (e.g. climate) characteristics. This effort provides the beginnings of an integrative theory of training motivation—a much needed synthesis and organization.

A number of important implications for research and practice can be drawn from Colquitt et al's review. For example, they point out the need to assess trainee's personality during training-needs analysis, a much neglected or ignored assessment during person analysis. In fact, Colquitt et al also called for the need to expand the kind of personality variables we have examined in recent years to include emotions, adaptability, trait goal orientation, and other Big Five variables. Another important implication is the link they found between age and motivation to learn—older workers showed lower motivation, learning, and post-training efficacy. However, it may be prudent to consider this conclusion carefully because a host of other issues must be considered when discussing the training needs of older workers (including the design of training itself). Clearly, in an era of technology-driven instruction and an aging workforce, a challenge for instructional developers will be to design learning environments where older trainees can be trained (and retrained) with ease.

In the future, we also need to continue gaining a deeper understanding of training motivation because it is crucial for learning and has direct implications for the design and delivery of training. Future work should consider those factors that influence training motivation for job development activities and for situations in which workers acquire new skills through informal learning mechanisms. Longitudinal studies are also needed.

Training Induction and Pretraining Environment

Considerable research has gone into understanding which factors help trainees to optimize the benefits of training. These are usually interventions employed before training to ensure that the trainee gets the most out of the learning experience.

Prepractice Conditions It is well documented that practice is a necessary condition for skill acquisition. However, all practice is not equal. In fact, the precise nature of practice and its relationship to learning outcomes has been largely ignored or misunderstood. Recent thinking and research is beginning to suggest that practice may be a complex process, not simply task repetition (e.g. Ehrenstein et al 1997, Shute & Gawlick 1995, Schmidt & Bjork 1992); we address this issue further in Specific Learning Approaches. For example, Cannon-Bowers et al (1998) provided a framework for delineating the conditions that might enhance the

utility and efficacy of practice in training. They drew from the literature a number of interventions (e.g. meta-cognitive strategies, advanced organizers, and preparatory information) that can be applied before actual practice as a way to prepare the trainee for training. Empirical verification of these interventions needs to be conducted.

The Pretraining Environment and Climate Can pretraining contextual factors also affect learning outcomes? Recent research suggests that the manner in which the organization frames the training and the nature of trainees' previous experiences in training do influence learning outcomes. For example, Quinones (1995) demonstrated that the manner in which training was framed (i.e. as advanced or remedial) influenced training motivation and learning (see also Quinones 1997). Martocchio (1992), who labeled the training assignment as an "opportunity," showed similar findings. Smith-Jentsch et al (1996a) demonstrated that trainees' previous experiences with training (e.g. prior negative events) affected learning and retention. Baldwin & Magjuka (1997) explored the notion of training as an organizational episode and laid out a framework of other pretraining contextual factors (e.g. voluntary versus mandatory attendance) that may influence motivation to learn. These studies suggest that experience with training (both task-based and event-based) is important to subsequent training outcomes. This is certainly a neglected area, and one in which much more work is needed. Specifically, we need to know how these experiences shape self-efficacy, expectations about the training, motivation to learn and apply skills on the job, and learning.

TRAINING METHODS AND INSTRUCTIONAL STRATEGIES

Instructional strategies are defined as a set of tools (e.g. task analysis), methods (e.g. simulation), and content (i.e. required competencies) that, when combined, create an instructional approach (Salas & Cannon-Bowers 1997). Most effective strategies are created around four basic principles: (*a*) They present relevant information or concepts to be learned; (*b*) they demonstrate the KSAs to be learned; (*c*) they create opportunities for trainees to practice the skills; and (*d*) they provide feedback to trainees during and after practice. Because there is no single method to deliver training, researchers continue to address how to best present targeted information to trainees. Specifically, researchers are seeking cost-effective, content-valid, easy-to-use, engaging, and technology-based methods (e.g. Baker et al 1993, Bretz & Thompsett 1992, Steele-Johnson & Hyde 1997). In the next section, we review research related to instructional strategies in several major categories. First, we review specific learning approaches and learning technologies and distance training. Next, we cover simulation-based training and games, followed by a review of recent work in team training.

Specific Learning Approaches

Traditionally, training researchers have investigated how to optimize learning and retention by manipulating feedback, practice intervals, reinforcement schedules, and other conditions within the learning process itself. In this regard, Fisk, Kurlik, and colleagues (Kirlik et al 1998) improved performance in a complex decision-making task by training consistently mapped components of the task to automaticity (i.e. so that they could be performed with little or no active cognitive control). Along these same lines, Driskell et al (1992) conducted a meta-analysis of the effects of overlearning on retention. The results of their analysis showed that overlearning produces a significant effect on retention which, in turn, is moderated by the degree of overlearning, length of retention period, and type of task.

Attention has also been focused on developing collaborative training protocols. This is distinguished from team training (see below) by the fact that team training applies to training competencies that are required for performance of a team task. Collaborative learning, on the other hand, refers to situations where trainees are trained in groups, but not necessarily to perform a team task. The idea is that there are features of group interaction that benefit the learning process (e.g. the opportunity for vicarious learning or interaction with peers). For example, Arthur et al (1997) provided strong support and justification for the ongoing use of innovative dyadic protocols (i.e. training two trainees at once) for the training of pilots and navigators in both military and nonmilitary settings. However, Arthur et al (1996) showed that the comparative effectiveness of dyadic versus individual protocols for computer-based training is moderated by trainees' level of interaction anxiety, with only low interaction anxiety trainees benefiting from dyadic protocols (see also Arthur et al 1997). Collaborative protocols have also been shown to reduce required instructor time and resources by half (Shebilske et al 1992), and to provide observational learning opportunities that compensate for hands-on practice efficiently and effectively, as predicted by social learning theory (Shebilske et al 1998).

Researchers have also studied the conditions of practice as they relate to learning. For example, Goettl et al (1996) compared an alternating task module protocol, which alternated sessions on video game–like tasks and algebra word problems, with a massed protocol, which blocked sessions on the tasks. The findings showed that alternating task modules provided an advantage in learning and retention in both the video games and algebra word problems.

Along these lines, Bjork and colleagues (Schmidt & Bjork 1992, Ghodsian et al 1997) have provided an interesting reconsideration of findings regarding practice schedules. These authors argued that introducing difficulties for the learner during practice will enhance transfer (but not necessarily immediate posttraining performance). By reconceptualizing interpretation of data from several studies, Schmidt & Bjork (1992) provided a compelling case for a new approach to arranging practice. This approach includes introducing variation in the way tasks are ordered for practice, in the nature and scheduling of feedback, and in the versions of

the task to be practiced, and also by providing less frequent feedback. In all cases, the authors argue that even though acquisition (i.e. immediate) performance may be decreased, retention and generalization are enhanced owing to additional—and most likely deeper—information processing requirements during practice. Shute & Gawlick (1995) supported this conclusion in an investigation of computer-based training for flight engineering knowledge and skill.

In other work, Driskell and colleagues (Driskell & Johnston 1998, Johnston & Cannon-Bowers 1996; JE Driskell, E Salas, JH Johnston, submitted) have investigated the use of stress-exposure training (SET) as a means to prepare trainees to work in high stress environments. SET, which is based on clinical research into stress inoculation, has several phases. In the first phase, trainees are provided with preparatory information that includes a description of which stressors are likely to be encountered in the environment and what the likely impact of those stressors on the trainee will be. The second phase—skill acquisition—focuses on behavioral- and cognitive-skills training designed to help trainees cope with the stress. In the final phase, application and practice of learned skills is conducted under conditions that gradually approximate the stress environment. Results of investigations of this protocol have indicated that SET is successful in reducing trainees' subjective perception of stress, while improving performance. Moreover, the effects of SET generalized to novel stressors and tasks.

Learning Technologies and Distance Training

There is no doubt that technology is shaping how training is delivered in organizations. While still relying heavily on classroom training, organizations have begun to explore technologies such as video conferencing, electronic performance support systems, video discs, and on-line Internet /Intranet courses. Indeed, Web-based training may make "going-to" training obsolete. It is being applied in education, industry, and the military at an alarming rate (these days, one can get a PhD through the Web). What is probably more alarming is that this implementation is happening without much reliance on the science of training. Many issues about how to design distance learning systems remain open. Theoretically-based research is needed to uncover principles and guidelines that can aid instructional designers in building sound distance training. A few have begun to scratch the surface (e.g. Schreiber & Berge 1998) of this topic, but a science of distance learning and training needs to evolve. Specifically, it must be determined what level of interaction is needed between trainees and instructors. Moreover, the nature of such interaction must be specified. For example, do instructors need to see trainees in order to conduct effective instruction? Do trainees need to see instructors or is it better for them to view other material? What is the best mechanism for addressing trainee questions (e.g. through chat rooms or e-mail)? Should learners have control over the pace and nature of instruction [some evidence from studies of computer-based training support the use of learner control (see Shute et al 1998), but the extent of its benefits for distance learning is not known]? These and

other questions must be addressed as a basis to develop sound distance-training systems.

Advances in technology are also enabling the development of intelligent tutoring systems that have the potential to reduce or eliminate the need for human instructors for certain types of learning tasks. Early indications are that intelligent software can be programmed to successfully monitor, assess, diagnose, and remediate performance in tasks such as computer programming and solving algebra problems (e.g. see Anderson et al 1995). As this technology becomes more widely available (and less costly to develop), it may provide organizations with a viable alternative to traditional computer-based or classroom training.

Simulation-Based Training and Games

Simulation continues to be a popular method for delivery training. Simulators are widely used in business, education, and the military (Jacobs & Dempsey 1993). In fact, the military and the commercial aviation industry are probably the biggest investors in simulation-based training. These simulations range in cost, fidelity, and functionality. Many simulation systems (including simulators and virtual environments) have the ability to mimic detailed terrain, equipment failures, motion, vibration, and visual cues about a situation. Others are less sophisticated and have less physical fidelity, but represent well the KSAs to be trained (e.g. Jentsch & Bowers 1998). A recent trend is to use more of these low-fidelity devices to train complex skills. There is also more evidence that skills transfer after training that uses these simulations (e.g. MT Brannick, C Prince, E Salas, unpublished manuscript; Gopher et al 1994). For example, some researchers are studying the viability of computer games for training complex tasks. Gopher et al (1994) tested the transfer of skills from a complex computer game to the flight performance of cadets in the Israeli Air Force flight school. They argued that the context relevance of the game to flight was based on a skill-oriented task analysis, which used information provided by contemporary models of the human processing system as the framework. Flight performance scores of two groups of cadets who received 10 hours of training in the computer game were compared with a matched group with no game experience. Results showed that the groups with game experience performed much better in subsequent test flights than did those with no game experience. Jentsch & Bowers (1998) and Goettl et al (1996) have reported similar findings.

Precisely why simulation and simulators work is not well known. A few studies have provided preliminary data (e.g. Bell & Waag 1998, Jentsch & Bowers 1998, Ortiz 1994), but there is a somewhat misleading conclusion that simulation (in and of itself) leads to learning. Unfortunately, most of the evaluations rely on trainee reaction data and not on performance or learning data (see Salas et al 1998). More systematic and rigorous evaluations of large-scale simulations and simulators are needed. Nonetheless, the use of simulation continues at a rapid pace in medicine, maintenance, law enforcement, and emergency management settings. However,

some have noted (e.g. Salas et al 1998) that simulation and simulators are being used without much consideration of what has been learned about cognition, training design, or effectiveness. There is a growing need to incorporate the recent advances in training research into simulation design and practice. Along these lines, some have argued for an event-based approach to training with simulations (Cannon-Bowers et al 1998, Oser et al 1999, Fowlkes et al 1998). According to this perspective, simulation-based training should be developed with training objectives in mind, and allow for the measurement of training process and outcomes, and provisions for feedback (both during the exercise and for debriefing purposes).

In related work, Ricci et al (1995) investigated the use of a computer-based game to train chemical, biological, and radiological defense procedures. In this case, the game was not a simulation (as discussed above), but a computer-based slot machine that presented trainees with questions about the material. Trainees earned points for correct answers, and received corrective feedback for incorrect ones. The authors argued that motivation to engage in this type of presentation (over text-based material) would result in higher learning. Results indicated that reactions and retention (but not immediate training performance) were higher for the game condition.

Behavior role modeling is another type of simulation-based training that has received attention over the years. Recently, Skarlicki & Latham (1997) found that a training approach that included role-playing, and other elements of behavior modeling, was successful in training organizational citizenship behavior in a labor union setting. Similarly, Smith-Jentsch et al (1996b) found that a behavior modeling approach emphasizing practice (i.e. role playing) and performance feedback was superior to a lecture only or lecture with demonstration format for training assertiveness skills. Also studying assertiveness, Baldwin (1992) found that behavioral reproduction (i.e. demonstrating assertiveness in a situation that was similar to the training environment) was best achieved by exposing trainees only to positive model displays. Conversely, the combination of both positive and negative model displays was most effective in achieving behavioral generalization (i.e. applying the skill outside of the training simulation) four weeks later.

Team Training

As noted by Guzzo & Dickson (1996) and Tannenbaum & Yukl (1992), teams are heavily used in industry, government, and the military. Therefore, these organizations have invested some resources in developing teams (Tannenbaum 1997). A number of theoretically-driven team training strategies has emerged. These include cross-training (Blickensderfer et al 1998), team coordination training (Prince & Salas 1993), team leadership training (Tannenbaum et al 1998), team self-correction (Smith-Jentsch et al 1998), and distributed team training (Dwyer et al 1999). All of these have been tested and evaluated with positive results (see Cannon-Bowers & Salas 1998a).

The aviation community has arguably been the biggest advocate and user of team training (see Helmreich et al 1993). The airlines and the military have extensively applied a strategy labeled crew resource management (CRM) training. This strategy has a 20-year history in the aviation environment. It is used as a tool to improve teamwork in the cockpit but, more importantly, to reduce human error, accidents, and mishaps (Helmreich & Foushee 1993). CRM training has gone through several evolutions (Helmreich et al 1999) and is maturing. Systematic procedures for designing and developing CRM training have been developed (Salas et al 1999), and the evaluation data are encouraging (see Leedom & Simon 1995, Salas et al 1999, Stout et al 1997). CRM training seems to work by changing the crew's attitudes toward teamwork, and by imparting the relevant team competencies. Crew that have received CRM training exhibit more teamwork behaviors in the cockpit (Salas et al 1999, Stout et al 1997). However, more and better evaluations are needed. Most of the evaluations conducted have been in simulation environments. Only recently have evaluations begun to determine the transfer of this training to the actual cockpit.

Other research in team training has focused on developing strategies to train specific competencies (see also Cannon-Bowers & Salas 1998b). For example, Smith-Jentsch et al (1996b) examined determinants of team performance–related assertiveness in three studies. These studies concluded that, whereas both attitudinally focused and skill-based training improved attitudes toward team member assertiveness, practice and feedback were essential to producing behavioral effects. In addition, Volpe et al (1996) used shared mental model theory (Cannon-Bowers et al 1993) as a basis to examine the effects of cross-training and workload on performance. The results indicated that those who received cross-training were more effective in teamwork processes, communication, and overall team performance.

In sum, the literature has begun to provide evidence that team training works. It works when the training is theoretically driven, focused on required competencies, and designed to provide trainees with realistic opportunities to practice and receive feedback. Also, guidelines for practitioners have emerged (e.g. Swezey & Salas 1992, Salas & Cannon-Bowers 2000), tools for designing team training strategies have surfaced (e.g. Bowers et al 1993), and a number of strategies are now available for team training (e.g. Cannon-Bowers & Salas 1997). In the future, we need to know more about how to diagnose team cognitions during training. We also need better and more rigorous measurement protocols to assess shared knowledge. In addition, we need to understand better the mechanisms by which to conduct effective distributed team training.

POST-TRAINING CONDITIONS

Events that occur after training are as important as those that occur before and during training. Therefore, recent research has focused on improving the methods and procedures we use to evaluate training, and on examining the events that ensure

transfer and application of newly acquired KSAs. In examining this body of work, we get a clear sense that it is in these two areas where we probably have made the most significant progress. There are theoretical, methodological, empirical, and practical advances. All the issues have not been solved, but meaningful advances have been made in the last decade. This is very encouraging. We first look at training evaluation and then at transfer of training.

Training Evaluation

Kirkpatrick's Typology and Beyond Kirkpatrick's typology (Kirkpatrick 1976) continues to be the most popular framework for guiding evaluations. However, recent work has either expanded it or pointed out weaknesses, such as the need to develop more diagnostic measures. For example, Kraiger et al (1993) proposed a multi-dimensional view of learning, implying that learning refers to changes in cognitive, affective, and/or skill-based outcomes. The proposed taxonomy can be used to assess and document learning outcomes. In a meta-analysis of studies employing Kirkpatrick's model, Alliger et al (1997) noted that utility-type reaction measures were more strongly related to learning and performance (transfer) than affective-type reaction measures. Surprisingly, they also found that utility-type reaction measures are more predictive of transfer than learning measures. Kraiger & Jung (1997) suggested several processes by which learning outcomes can be derived from instructional objectives of training. Goldsmith & Kraiger (1997) proposed a method for structural assessment of an individual learner's knowledge and skill in a specific domain. This model has been used with some success in several domains (e.g. Kraiger et al 1995, Stout et al 1997).

Clearly, Kirkpatrick's typology has served as a good foundation for training evaluation for many decades (Kirkpatrick 1976). It has been used, criticized, misused, expanded, refined, adapted, and extended. It has served the training research community well—but a richer, more sophisticated typology is needed. Research needs to continue finding better, more diagnostic and rigorous assessments of learning outcomes. The next frontier and greatest challenge in this area is in designing, developing, and testing on-line assessments of learning and performance. As we rely more on technology for training delivery, we need better and more protocols to access learning not only after but also during training (e.g. Ghodsian et al 1997).

Evaluation Design Issues Training evaluation is one of those activities that is easier said than done. Training evaluation is labor intensive, costly, political, and many times is the bearer of bad news. We also know that it is very difficult to conduct credible and defensible evaluations in the field. Fortunately, training researchers have derived and tested thoughtful, innovative and practical approaches to aid the evaluation process. For example, Sackett & Mullen (1993) proposed other alternatives (e.g. posttesting-only, no control group) to formal experimental designs when answering evaluation questions. They suggested that those questions

(e.g. How much change has occurred? What target performance has been reached?) should drive the evaluation mechanisms needed, and that each requires different designs. Haccoun & Hamtiaux (1994) proposed a simple procedure for estimating effectiveness of training in improving trainee knowledge—the internal referencing strategy. This situation tests the implicit training evaluation notion that training-relevant content should show more change (pre-post) than training-irrelevant content. An empirical evaluation using internal referencing strategy versus a more traditional experimental evaluation indicated that the internal referencing strategy approach might permit inferences that mirror those obtained by the more complex designs.

The costs of training evaluation have also been addressed recently. Yang et al (1996) examined two ways to reduce costs. The first method is by assigning different numbers of subjects into training and control groups. An unequal group size design with a larger total sample size may achieve the same level of statistical power at lower cost. In a second method, the authors examined substituting a less expensive proxy criterion measure in place of the target criterion when evaluating the training effectiveness. Using a proxy increases the sample size needed to achieve a given level of statistical power. The authors described procedures for examining the tradeoff between the costs saved by using the less expensive proxy criterion and the costs incurred by the larger sample size. Similar suggestions have been made by Arvey et al (1992).

Evaluations It is refreshing to see that more evaluations are being reported in the literature; we hope this trend continues. It is only by drawing lessons learned from past evaluations that the design and delivery of training will continue to progress. Several field training evaluations have been reported in team training settings (e.g. Leedom & Simon 1995, Salas et al 1999), sales training (e.g. Morrow et al 1997), stress training (e.g. Friedland & Keinan 1992), cross-cultural management training (e.g. Harrison 1992), transformational leadership training (e.g. Barling et al 1996), career self-management training (e.g. Kossek et al 1998), workforce diversity training (e.g. Hanover & Cellar 1998) and approaches to computer training (e.g. Simon & Werner 1996). All suggest that training works. However, an examination of evaluations where training did not work is also needed (and we suspect there are many). Some important lessons can be learned from these types of evaluations as well.

Transfer of Training

Transfer of training is conceptualized as the extent to which KSAs acquired in a training program are applied, generalized, and maintained over some time in the job environment (Baldwin & Ford 1988). There has been a plethora of research and thinking in the transfer of training area (see Ford & Weissbein 1997). This emerging body of knowledge suggests a number of important propositions and conclusions. For example, (*a*) the organizational learning environment can be reliably measured and varies in meaningful ways across organizations (Tannenbaum

1997); (*b*) the context matters (Quinones 1997)—it sets motivations, expectations, and attitudes for transfer; (*c*) the transfer "climate" can have a powerful impact on the extent to which newly acquired KSAs are used back on the job (e.g. Tracey et al 1995, Thayer & Teachout 1995); (*d*) trainees need an opportunity to perform (Ford et al 1992, Quinones et al 1995); (*e*) delays between training and actual use on the job create significant skill decay (Arthur et al 1998); (*f*) situational cues and consequences predict the extent to which transfer occurs (Rouiller & Goldstein 1993); (*g*) social, peer, subordinate, and supervisor support all play a central role in transfer (e.g. Facteau et al 1995, Tracey et al 1995); (*h*) training can generalize from one context to another (e.g. Tesluk et al 1995); (*i*) intervention strategies can be designed to improve the probability of transfer (e.g. Brinkerhoff & Montesino 1995, Kraiger et al 1995); (*j*) team leaders can shape the degree of transfer through informal reinforcement (or punishment) of transfer activities (Smith-Jentsch et al 2000); (*k*) training transfer needs to be conceptualized as a multidimensional construct—it differs depending on the type of training and closeness of supervision on the job (Yelon & Ford 1999).

As noted by Ford & Weissbein (1997), much progress has been made in this area. There are more studies using complex tasks with diverse samples that actually measure transfer over time. However, much more is needed. Specifically, we need more studies that actually manipulate the transfer climate (e.g. Smith-Jentsch et al 2000). The measurement problems remain. Most studies still use surveys as the preferred method for measuring transfer. Other methods need to be developed and used. Finally, we need to assume that learning outcomes at the individual level will emerge to influence higher level outcomes. Vertical transfer of training is the next frontier. Vertical transfer may be a leverage point for strengthening the links between learning outcomes and organizational effectiveness (see Kozlowski et al 2000).

Taken together, these studies validate the importance of the organizational environment in training. In the future we need to continue to determine which factors affect transfer so that we can maximize it.

FINAL OBSERVATIONS, CONCLUSIONS, AND THE FUTURE

In closing, we draw on the extensive literature just reviewed to offer the following observations:

1. As Tannenbaum & Yukl (1992) predicted, the quality and quantity of research has increased. We truly have seen an explosion of theoretical, methodological, and empirical work in training research, and we do not see an end to this trend. This is very encouraging, and we believe this body of work will pay off as we learn more about how to design and deliver training systems. Therefore, we contend that training research is here to stay and prosper.

2. The progress in theoretical development, especially the attention given to cognitive and organizational concepts, is revolutionizing the field. These new developments promise to change how we conceptualize, design, implement, and institutionalize learning and training in organizations. In the future, we will need a deeper understanding of these concepts, we must strive for more precision and clarity of constructs, and our methods must be more rigorous.
3. The body of literature generated over the past decade suggests that the field does not belong to any single discipline anymore. In the past, industrial/organizational and educational psychologists primarily conducted training research. A closer look at the literature now suggests that cognitive, military, engineering, human factors, and instructional psychologists are involved in training research to an equal degree. In fact, computer scientists and industrial engineers are also researching learning, training technology, and training systems. As many others have observed, we need more cross-fertilization, collaboration, and dialogue among disciplines. To start, we need to read each other's work, and leverage each other's findings, ideas, and principles.
4. Technology has influenced—and will continue to do so for the foreseeable future—the design and delivery of training systems. Whether we like it or not, technology has been embraced in industrial, educational, and military institutions as a way to educate and train their workforces. Technology may, or may not, have instructional features because it is often employed without the benefit of findings from the science of training. However, as we learn more about intelligent tutoring systems, modeling and simulation, multimedia systems, learning agents, Web-based training, distance learning, and virtual environments, this state of affairs may change. It is encouraging that basic and applied research is currently going on to uncover how these technologies enhance learning and human performance (e.g. Cannon-Bowers et al 1998). More research is needed, and the prospects of it happening are very promising. Specifically we need to know more about how to best present knowledge over the Internet, how and when to provide feedback, which instructional strategies are best for Web-based applications, what role instructors and trainees play in these modern systems, and how effectiveness can best be evaluated.
5. The distinction between training effectiveness and training evaluation is much clearer. Kraiger et al (1993) provided the seed for this important distinction. Training effectiveness is concerned with why training works and it is much more "macro" in nature. That is, training effectiveness research looks at the training intervention from a systems perspective—where the success of training depends not only on the method used but on how training (and learning) is positioned, supported, and reinforced by the organization; the motivation and focus of trainees; and

what mechanisms are in place to ensure the transfer of the newly acquired KSAs to the job. Training evaluation on the other hand, examines what works and is much more "micro" (i.e. focused on measurement). It looks at what was learned at different levels and is the basis for determining the training effectiveness of a particular intervention. This distinction has made some significant contributions to practice possible and, more importantly, is helping avoid the simplistic view of training (i.e. that training is just a program or curriculum rather than the complex interaction of many organizational factors). More research aimed at uncovering why training works is, of course, desirable.

6. Much more attention has been given to discussing training as a system embedded in an organizational context (e.g. Dipboye 1997, Kozlowski & Salas 1997, Kozlowski et al 2000, Tannenbaum & Yukl 1992). This is refreshing and welcome. For many decades, training researchers have ignored the fact that training cannot be isolated from the system it supports. In fact, the organizational context matters (e.g. Quinones 1997, Rouillier & Goldstein 1993) and matters in a significant way. Research aimed at studying how organizations implement training and why even the best-designed training systems can fail is encouraged.
7. Research has begun to impact practice in a more meaningful, and it is to be hoped, quantifiable way. We can offer principles and guidelines to organizations regarding how to analyze, design, develop, implement, and evaluate training functions. Much needs to be done, but it is only through mutual reciprocity—science and practice—that real progress will be made (see Salas et al 1997). As already stated, we have seen more evaluations conducted, there are more guidelines for designers and practitioners, and viable strategies that seem to impact organizational outcomes and the link between learning and performance are more tangible today (Bassi & Van Buren 1999).

A number of training issues need considerable attention in the next few years (in addition to the ones we have noted throughout this chapter). In particular, we need research that helps us get a better understanding of what, how, and when on-the-job training works. On-the-job training is a common practice in organizations, but few principles and guidelines exist on how to optimize this strategy. We need a deeper understanding of how to build expertise and adaptability through training. Although some work has started (e.g. Kozlowski 1998, Smith et al 1997), longitudinal studies in the field are desirable. How learning environments are created and maintained in organizations needs to be researched and better understood. A related issue is how, and under what circumstances, individuals and teams learn from informal organizational activities. In addition, as organizations become older and more diverse, more attention must be paid to the special training needs of nontraditional workers (especially given the anticipated reliance on high-tech systems). Moreover, as organizations allow more flexibility in how work is accomplished (e.g. telecommuting), training practices must keep pace. In fact,

organizations will increasingly depend on workers who can develop, maintain, and manage their own skills, requiring attention to the challenge of how to develop and attract self-directed learners. Finally, as noted, training researchers need to embrace and investigate new technologies. We know that organizations will; we hope that new developments in training are driven by scientific findings rather than the band wagon.

In conclusion, we are happy to report that, contrary to charges made by our predecessors over the years, training research is no longer atheoretical, irrelevant, or dull. Exciting advances in all areas of the training enterprise have been realized. Training research has also been called faddish, a characteristic we hope is beginning to fade as well. However, we wonder whether there is compelling evidence to suggest that training practitioners in organizations are actually applying what has been learned from the research. This brings us back to a question we raised at the beginning of this chapter; namely, to what degree does the science of training affect organizational training practices? In other words, can we find evidence that organizations are implementing the lessons being learned from training research (especially the work reviewed here), or are practitioners still prone to latch on to the latest training craze? The answer is, quite simply, that we just do not know. This is due, at least in part, to the fact that detailed records documenting training practices (and more importantly, the rationale that went into developing them) are not typically available. However, one thing seems clear: The stage for the application of training research is set. We say this because, as noted, organizations are beginning to question the value-added of human resource activities (including training), and to pay more attention to human capital. Simply put, organizations want to know what the return is on their training investment.

Assuming this trend continues, it should force training professionals to turn to the science of training for empirically verified guidelines regarding how to optimize training outcomes (including transfer), and how to evaluate whether training has been effective in reaching organizational goals. As the pressure grows to show an impact on the bottom line, training practitioners will do well to employ sound principles, guidelines, specifications, and lessons learned from the literature, rather than relying on a trial-and-error approach. For this reason, we believe a new era of training has begun—one in which a truly reciprocal relationship between training research and practice will be realized.

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