# INDIVIDUAL DIFFERENCES IN MILITARY TRAINING ENVIRONMENTS: FOUR AREAS OF RESEARCH

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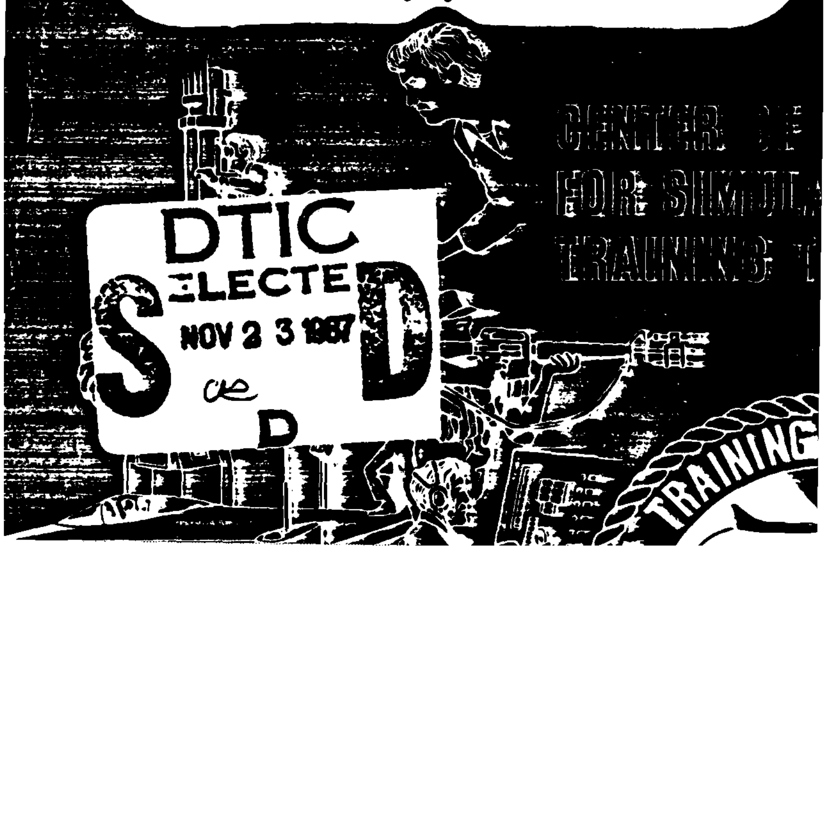


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April 6, 1987

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87 11 3 492

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SECURITY CLASSIFICATION OF THIS PAGE

AD-A187 463

**1a. REPORT SECURITY CLASSIFICATION**
UNCLASSIFIED

**1b. RESTRICTIVE MARKINGS**

**2a. SECURITY CLASSIFICATION AUTHORITY**

**2b. DECLASSIFICATION / DOWNGRADING SCHEDULE**

**3. DISTRIBUTION / AVAILABILITY OF REPORT**
UNLIMITED

**4. PERFORMING ORGANIZATION REPORT NUMBER(S)**

**5. MONITORING ORGANIZATION REPORT NUMBER(S)**
NAVTRASYSCEN TR87-003

**6a. NAME OF PERFORMING ORGANIZATION**
Hogan Assessment Systems under subcontract to:

**6b. OFFICE SYMBOL** *(If applicable)*

**7a. NAME OF MONITORING ORGANIZATION**
Naval Training Systems Center

**6c. ADDRESS** *(City, State, and ZIP Code)*
Battelle Columbus Laboratories
200 Park Drive, P.O. Box 12297
Research Triangle Park, NC 27709

**7b. ADDRESS** *(City, State, and ZIP Code)*
Orlando, FL 32813-7100
Attn: Code 712

**8a. NAME OF FUNDING / SPONSORING ORGANIZATION**
Naval Training Systems Center

**8b. OFFICE SYMBOL** *(If applicable)*

**9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER**
DAAG29-81-D-0100; D.O. 2000

**8c. ADDRESS** *(City, State, and ZIP Code)*
Orlando, FL 32813-7100
Attn: Code 712

**10. SOURCE OF FUNDING NUMBERS**

| PROGRAM ELEMENT NO. | PROJECT NO. | TASK NO. | WORK UNIT ACCESSION NO. |
|---|---|---|---|
| | | | |

**11. TITLE** *(Include Security Classification)*
(UNCLASSIFIED)
Individual Differences in Military Training Environments: Four Areas of Research

**12. PERSONAL AUTHOR(S)**
Joyce Hogan, Steve Arneson, and Eduardo Salas

| 13a. TYPE OF REPORT | 13b. TIME COVERED | 14. DATE OF REPORT (Year, Month, Day) | 15. PAGE COUNT |
|---|---|---|---|
| Final | FROM 12/31/85 TO 1/30/87 | | |

**16. SUPPLEMENTARY NOTATION**
This Scientific Services Program task was requested and funded by the sponsoring organization.

**17. COSATI CODES**

| FIELD | GROUP | SUB-GROUP |
|---|---|---|
| | | |
| | | |

**18. SUBJECT TERMS** *(Continue on reverse if necessary and identify by block number)*
ABILITY, APTITUDE, COGNITIVE, INDIVIDUAL DIFFERENCES, INSTRUCTION, LEARNING, TRAINING, TRAINING DEVICE.

**19. ABSTRACT** *(Continue on reverse if necessary and identify by block number)*

This review addresses the variety of learning and ability differences that individuals bring to the training environment. It is organized in terms of four content areas, which include: (1) trainees' cognitive strategies; (2) trainees' noncognitive characteristics; (3) aptitude-performance interactions; and (4) testing the individual differences hypothesis. Summarized findings are used to develop a decision model for training program design that involves classification of training tasks, selection of personnel for training, and specification of instructional strategies for optimal learning. The model provides a means for accomodating individual differences relevant to the training environment.

**20. DISTRIBUTION / AVAILABILITY OF ABSTRACT**
☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

**21. ABSTRACT SECURITY CLASSIFICATION**
UNCLASSIFIED

| 22a. NAME OF RESPONSIBLE INDIVIDUAL | 22b. TELEPHONE (Include Area Code) | 22c. OFFICE SYMBOL |
|---|---|---|
| EDUARDO SALAS | 305-646-5130 | Code 712 |

DD FORM 1473, 84 MAR

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SECURITY CLASSIFICATION OF THIS PAGE
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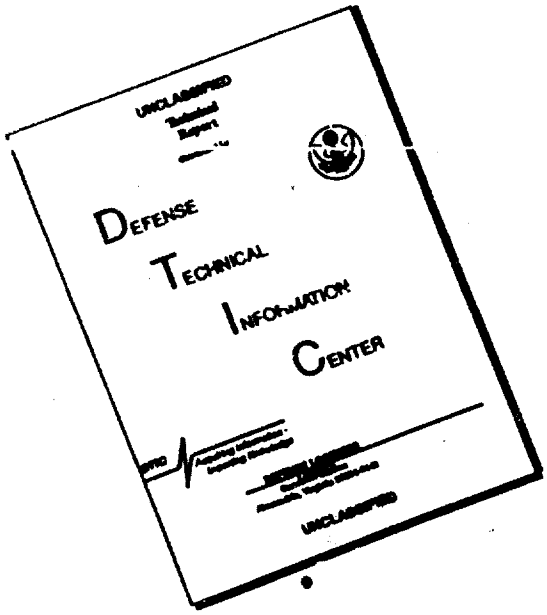


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# EXECUTIVE SUMMARY

This review describes the application of individual differences to four content areas of military personnel training. These address trainee cognitive strategies, non-cognitive characteristics that trainees bring to the training situation, aptitude-performance interactions, and the effects of instructional methods. Within each of these categories, the information presented supports the view that individuals are affected differentially by training, and that these differences need to be incorporated into the training process.

This report also provides a model for determining instructional strategies. Given the particular task to be trained, the model classifies the task according to a theory of occupational environments, and identifies personality characteristics that the successful trainee is likely to possess. Using these data, the model allows predictions of the most appropriate instructional strategy for that particular training task. That is, the training content or medium to be selected is one that will maximize levels of training acquisition, retention, and transfer of learning for all individuals.

# INDIVIDUAL DIFFERENCES IN MILITARY TRAINING ENVIRONMENTS: FOUR AREAS OF RESEARCH

How people differ in the rate, extent, style, and quality of their learning has become an important issue for military and personnel training specialists. If training is viewed as a transition from one level of knowledge and ability to another, it seems logical to incorporate individual differences into such a description of behavior change (Cascio, 1982). In fact, most practitioners would agree that maximum learning is not achieved by all participants in the typical training setting. Such factors as ability, skills, experience, intelligence, interests, personal characteristics (e.g., age) and motivation interact to produce performance differences within a particular training environment. There is a very large range of differences in human performance; the actual span, even in small groups, rarely falls below 200 percent (Rimland and Larson, 1984). Simple industrial tasks such as keypunching or typing have been shown to yield productivity differences in the range of 200 to 300 percent (Wechsler, 1952). For more complex jobs such as computer programming or electronics troubleshooting, differences of several thousand percent have been reported (Williams and Rimland, 1977).

Although individual learning and ability differences exist, occupational training is often guided by the premise that if people differ initially in performance, they may still attain the same level as a result of training. Unfortunately, this appears not to be the case because experience or training does not compensate for the range of individual differences. For example, in a study of military technicians, original differences in aptitude were reflected in the range of individual differences measured five years later (Vineberg, Sticht, Taylor, and Caylor, 1971). Flammer (1976) reported that the use of a mastery learning strategy did not decrease individual differences in learning time per mastery unit. Arlin (1984) reported similar results regarding mastery learning, concluding that the evidence did not support the mastery position of alterable differences as convincingly as it supported the position of persistent individual differences. Finally, Tiffin (1952) proposed that, depending on task complexity, industrial training may tend to increase individual differences in performance.

Because it is unlikely that training will reduce or remove individual performance differences substantially, it is necessary to acknowledge and incorporate the phenomenon of individual differences in the training design process. There are three areas of the design process where this approach might be fruitful and these include: (1) differences in learning ability (acquisition); (2) maintenance of training (retention); and (3) transfer of training. Historically, however, many training specialists have viewed individual differences as something of an inconvinence, and have focused instead on the hypothetical "average" learner (Tallmadge, 1968). For example, instruction in Army training centers has been characterized as a single track system with standard minimum requirements for graduation. Trainees enter together and receive the same program of instruction, but not all make it through the first time (McFann, 1969). As a result, the typical training course has been unable to accomodate slower learners who may have difficulty understanding the material, or more advanced learners who may find the training boring and unfulfilling.

With the advent of micro-computers, powerful software, and programmed instruction, training specialists are now recognizing the potential advantages of individualized training. Whatever the reasons for overlooking individual differences in the past, such technological and measurement advances provide a significant opportunity to train individuals more effectively and take advantage of their distinct differences.

This paper addresses the areas of military and personnel training research that focus on individual differences among trainees. The discussion is organized in terms of four content areas: (a) cognitive strategies, (b) non-cognitive characteristics, (c) aptitude-performance interactions, and (d) the effects of instructional methods. Based on this review, a model is suggested for training program design that accomodates individual differences relevant to the training environment.

## BACKGROUND

Despite the appeal for such research, there are relatively few published investigations documenting the effects of individual differences on military or personnel training. Most training studies use the main effect model which often fails to determine differential effects across individual trainees. This lack of research is evident in training literature reviews appearing in the Annual Review of Psychology (Campbell, 1971; Goldstein, 1980; Wexley, 1984). None of these reviews includes extensive coverage of the individual differences issue, and each suggests the need for more empirical research particularly where individual differences among learners are matched to various instructional strategies. Nevertheless, only a handful of aptitude-treatment interaction studies have been conducted, and many present only a theoretical or conceptual discussion of the consequences of individualized training (e.g., Cronbach and Snow, 1969; 1977).

As a prerequisite, consider the role of learning theory as it relates to individual differences and training. Gagne (1962) proposed that many learning psychologists would bring the following assumption to the design of training: " The best way to learn a task is to practice that task." However, this assumption may not always result in effective training designs (see Schneider, 1985). For instance, a number of studies have demonstrated that varying amounts of practice makes no significant difference in the proficiency of gunnery tasks (Melton, 1947; Rittenhouse and Goldstein, 1954). Instead, improved gunnery performance can be attributed to instructional cues regarding the correct sighting picture for ranging (Goldstein and Ellis, 1956). Other examples in which practice alone may be insufficient for learning are procedural tasks, where trainees may be expected to operate multiple controls of equipment. It seems obvious that simply practicing with the controls is inadequate; what contributes most to the performance of the task is the learning of the correct response sequence.

This is not to say that performance should never be practiced. In fact, recent research suggests that there may be an optimum number of task repetitions necessary which vary depending on individual aptitudes, task characteristics, and training conditions (Schneider, 1985). Hagman (1980) examined the effects of task repetition on transfer of training and retention for fuel and electrical repairmen. Retention improved after three task repetitions, but was not aided by additional repetitions. Also, transfer of training was better after minimal task repetition than after familiarization alone. Hagman and Rose (1983) call for additional research to determine the most cost-effective number of repetitions to use for different kinds of tasks. The authors concluded that retention can be improved through the use of training methods tailored for specific training environments. Therefore, although task repetition may be a necessary component of training, something other than direct or continuous practice of the final task is also contributing to the learning process.

With this in mind, Gagne (1962) specified three psychological principles that are useful for the design of training programs. First, any human task may be analyzed into a set of component tasks. Second, these component tasks are mediators of the final task performance. Finally, the basic design of training should follow these principles: a) identify the component tasks of a final performance; b) insure that each of the component tasks is fully achieved; and c) arrange the total training situation in a sequence to insure optimal effects from one component to another.

In such a framework of component or sequential learning, it is easy to see the application of individualized instruction. Individuals differ in their ability to learn certain tasks; dividing the training material into components allows trainees to master the sequence at their own rate. Unfortunately, the collection of empirical evidence to refute or support the notion of individualized instruction has been slow to accumulate. The remainder of this paper presents research investigating individual differences in training.

## REVIEW

Literature addressing individual differences in training environments appears in four general research areas. These include the study of: (1) trainee cognitive strategies, learning styles, and sensory modalities; (2) non-cognitive characteristics of trainees; (3) aptitude-performance interactions; and (4) instructional methods. Although there is some overlap among these areas, the major distinction is that the first two are concerned with variables or factors that individuals bring to the training environment, while the final two address the issue of how to accomodate the training process to individual trainees.

### Using learning styles and cognitive strategies in the training process

Ideally, "custom-tailored" instruction should take account of all facets of individual differences. However, among factors least likely to be given serious attention are the learning styles, cognitive strategies, and sensory modalities of individual trainees (Goodman, 1978). Indeed, there appear to be several major classes of training activities in which cognitive mapping behaviors, learning styles, and media preferences could prove to be useful determinants of individual performance. As a result, the body of research concerned with individual learning abilities in training is growing rapidly.

This literature is grounded in the assumption that individuals bring various strategies or styles of learning to the training environment. "Cognitive structuring" or "information mapping" is a systematic procedure for organizing verbal and/or pictorial information into practical knowledge. Cognitive or learning styles then, represent one's preferred method of collecting and organizing information, and this is closely associated with one's interests, abilities, aptitudes, and self-concept (Goodman, 1978). In the training context, the learner's attention and motivation are likely to be focused upon information that he or she deems relevant to understanding possible and appropriate behaviors. Thus, the particular learning style and the type of training offered may either inhibit or facilitate the individual learning process.

The concept of adapting instruction based on learning styles or cognitive abilities is receiving attention within the training community. In a review of training simulators, Su (1984) states that "there is an increasing awareness that training devices are most successful when tailored to the particular cognitive style and capabilities of the trainee" (p. 64). Su cites the Adaptive Computer Training Systems (ACTS) reported by Freedy and Lucaccini (1981) as a method to determine these capabilities. The ACTS is used in electronics maintenance training to evaluate the quality of repair decisions and the process of generating and choosing from among alternatives. The student's task is to troubleshoot a complex circuit by performing various test measurements, replace the malfunctioning parts, and take final verification measurements. A computer model is prepared which reflects the student's selection of measurements and replacement of circuit modules. This model is then analyzed by the ACTS, which compares the student's diagnostic and decision value structure to that of an expert and adapts the instructional sequence accordingly (Freedy and Luciccini, 1981). Thus, the ACTS uses a decision model to examine an individual's cognitive ability; it then suggests the appropriate procedural instructions to channel that ability into effective troubleshooting performance. Another computer-based method for determining instructional sequences from cognitive abilities is described by Tennyson (1978), who used differential pretraining ability to design an adaptive instructional system. After the effectiveness of a single best treatment is identified and maximized, micro-treatment variables are applied based on the individual student's prior knowledge. The computer system provides a dynamic environment which updates each student's on-task learning progress and modifies the instructional sequence accordingly. This adaptive strategy is characterized as an iterative algorithmic model with the capability to decide amount and sequence of individualized instruction. This instruction proceeds according to student needs for learning concepts at a given level of the criterion.

The individual learning styles approach has other proponents. One source is the cognitive styles literature which is based in part on the distinction between field independent and field dependent types. Field independent people seem better able to achieve a different percept - when required to do so by situational demands or inner needs - through the restructuring of their initial perceptual experiences. In contrast, among field dependent people the prevailing organization of the perceptual field is likely to be adhered to as given (Witkin and Goodenough, 1981). A difference in restructuring ability between field independent and field dependent persons is also evident in their intellectual functioning. Based on an extensive review of the cognitive styles literature (especially field dependence/field independence), Mezoff (1982) suggested that persons with different cognitive styles respond differently to structured (e.g., role-playing, simulation) and unstructured (e.g., T-groups) human relations training (Wexley, 1984, p. 531). For example, field dependent persons, compared with field independent persons, are more likely to display interpersonal competencies; in contrast, field independent persons have greater skill in cognitive restructuring (Witkin and Goodenough, 1981). Extensive research on the relation between field dependence-independence and educational/vocational preferences and performance shows that people are likely to favor and succeed in educational settings that suit their cognitive styles (Witkin, Moore, Goodenough and Cox, 1977; Quinlin and Blatt, 1972). Thus, the greater openness of field dependent persons to external stimuli sources may facilitate their training in unstructured exercises such as T-groups or leaderless discussions, while the field independent person may benefit most from structured exercises such as in-baskets, business games, or work simulation. Given verification of Mezoff's hypothesis, trainers will be able to determine participant cognitive styles and provide the appropriate individualized training.

The cognitive approach to individualized training also makes use of instruments such as the Learning Styles Inventory (LSI; Kolb, 1981). The LSI measures a person's self-description of how he or she learns in relation to four learning modes and abilities. These include: Concrete Experience (feeling), Reflective Observation (watching), Abstract Conceptualization (thinking), and Active Experimentation (doing). Kolb and his associates use the LSI as a tool to determine an individual's approach to learning; knowledge of particular learning styles can then be used to structure and organize training. Unfortunately, there are some reservations about the reliability and construct validity of the LSI (Stumpf and Freedman, 1981). Additional research may demonstrate the range of inferences that can be made on the basis of LSI scores.

Another cognitive approach to individualized instruction is the Learning Activities Questionnaire (LAQ; Weinstein, Wicker, Cubberly, Roney, and Underwood, 1980). The LAQ identifies various types of learning strategies (i.e., rote, physical, grouping, imagery) used by persons in a variety of training and academic tasks (i.e., paired association, free recall, reading comprehension). LAQ results provide a means for tailoring training programs to account for differences in learning strategies, and point out the need to facilitate the learning strategies of trainees, particulary at lower educational levels (Wexley, 1984, p. 531). For this facilitative process, Weinstein and her colleagues suggest that practice, feedback, and ordering material from easy to difficult allow trainees to acquire new learning strategies. But like the Learning Styles Inventory, the LAQ requires additional research and particularly evidence of construct validity. For example, when the Cognitive Learning Strategies Training Program was administered to Army personnel, no significant differences were found between training, control, and posttest only groups.

In response to advocates of mastery learning, who propose that individual differences in performance (i.e., achievement and learning rate) disappear when instruction to mastery is used, Federico (1984a) defends the concept of individual learning rate as a differential performance variable. Navy trainees who completed a computer-managed course in basic electronics were cluster-analyzed into groups using 24 measures of cognitive characteristics. After discarding data for subjects who were outliers and who formed a group with a small sample, a stepwise discriminant analysis was performed on the two remaining groups. Subjects in these two groups differed primarily on dimensions of verbal comprehension, general reasoning, mechanical comprehension, reflectiveness-impulsiveness, and tolerance of ambiguity. Multiple discriminant analyses were then computed between the two groups using training module test scores and completion times. Results showed that the groups differed significantly in test scores for four of the 11 modules and in time of completion for one module. Neither group demonstrated a progressive decrease in the variability of their achievement and learning rate throughout the sequential modules. These results suggest that computer-managed mastery learning does not eliminate the effect of incoming cognitive characteristics entirely (Federico, 1982). This emphasizes the need for careful selection of students for a specific course of study. Although variation in cognitive styles, abilities and aptitudes may exist, the selection process for, and mastery of learning in, computer-managed instruction does not completely homogenize individual differences in student achievement and learning rate.

Further hypotheses suggest that learning rates may be better predictors of training achievement than conventional cognitive ability tests. Payne and Tirre (1983) presented findings that support this hypothesis. They reported that initial learning rates were a better predictor of retention and relearning among Air Force recruits than were intelligence scores; fast learners retained more and relearned more quickly than slow learners. This suggests that if the goal is to predict learning criteria, direct measures of learning ability are appropriate selection devices. Given the Air Force policy of assigning individuals to an occupational area on the basis of that area's rated learning difficulty, direct measures of learning rate could have great utility for future selection and classification procedures (Payne and Tirre, 1983). Obviously, cognitive abilities are a critical determinant of training performance. Given that these abilities vary according to each individual, it seems logical to propose different learning styles for different trainees in order to facilitate their acquisition, retention and transfer of training.

Non-cognitive training characteristics

In addition to learning styles, non-cognitive characteristics may also be associated with differences in training performance. Individual differences in personality, affective adjustment, or physical ability are dimensions that have been largely neglected in the training performance literature. It is possible in some settings that differences within these dimensions account for as much variance in performance as cognitive determinants.

Individuals bring different aptitudes, interests, and attitudes to the training environment; they differ in terms of ambition, motivation, anxiety, prudence, and interest in ideas, all of which may account for the diversity of training accomplishment. Such personality factors are often quite useful for predicting training success, particularly when technical competence needs are minimal or assured through other selection standards, or where cognitive test scores fail to predict training performance.

Hogan and Hogan (1985) report several studies of psychological and physical performance factors associated with successful completion of bomb disposal technician training. In a longitudinal analysis of Navy explosive ordnance disposal (EOD) divers, students (N=97) completed a comprehensive battery of personality, vocational, and physical performance tests prior to matriculation into a 42-week training program. Training performance data were gathered on all students until a final disposition was available for the complete sample. Individuals most likely to complete the course were characterized by realistic occupational interests (Self-Directed Search: Holland, 1985); they liked working on technical problems and they did not mind working alone. Personality correlates (Hogan Personality Inventory:

Hogan, 1986) associated with successful course completion were self-confidence, good adjustment, and risk taking. Cardiovascular endurance, lifting strength, and muscular endurance test scores predicted both completion of the diving phase and overall training performance. Cognitive measures (ASVAB: U.S. Department of Defense, 1980) were unrelated to training performance outcome. These results generally corroborate findings from an earlier cross-sectional study of EOD trainees (N=196) from all services (Hogan, Hogan and Briggs, 1984).

Hogan, Jacobson, and Thompson (1985) investigated personality characteristics associates with successful completion of Army EOD apprentice training. Army students (N=179) were administered the Hogan Personality Inventory prior to a twelve-week training program and were followed-up until course completion status was available. Training success was associated with personality dimensions of curiousity, good-adjustment, autonomy, and lack of ambition. Successful students also displayed an interesting personality syndrome of excitment seeking and at the same time a lack of impulsivity and delinquency. Again, ASVAB scores did not predict successful training completion.

Where cognitive ability tests do offer some insight regarding training success, the addition of non-cognitive measures may enhance this prediction. Hoskin, Driskell, and Salas (1986) reported findings that emphasize the utility of personality assessment for this purpose. Trainees (N=155) at the Navy Basic Electricity and Electronics School were administered both the ASVAB cognitive ability tests and the Hogan Personality Inventory (HPI). Personality dimensions were found to increase the predictive power of the ASVAB tests for the four training criterion. The combination of HPI and ASVAB scores was a better predictor of: (a) final academic standing; (b) final student grade; (c) computer-aided instructional performance; and (d) student delinquency than the cognitive ability tests alone. The authors concluded that the predictive gain provided by noncognitive measures could result in incremental gains in training efficiency and cost savings.

In similar research conducted by Biersner and Ryman (1974) with Navy scuba trainees (N=296), a demographic questionnaire, health inventory, and attitude survey were administered at the start of training. Results indicated that trainees who were less concerned with possible physical injury performed better during training. This relationship corroborated the results of the health inventory which found that those trainees who reported fewer emotional symptoms or visual problems were more likely to succeed in training. Also, results of the attitude survey indicated that trainees who were not apprehensive about being injured had the highest ratings of training effectiveness. From the demographic questionnaire, trainees who reported frequent criticism as youngsters were more likely to succeed in training. The authors suggest that criticism (primarily from the mother) was important in adjusting to hazardous situations encountered years later (Biersner and Ryman, 1974).

Ryman and Biersner (1975) reported that attitudes of confidence and concern about training were valid predictors of success in Diver Second Class (DSC), Preliminary Underwater Demolition Team (PUDT), and Full Underwater Demolition Team (FUDT) training. A 25-item questionnaire measuring attitudes about training motivation, leadership, and course expectations was administered to a total of 548 trainees enrolled in the diving courses. Graduation from the DSC, PUDT, and FUDT training programs was used as the criterion variable and results suggested that specific attitudes toward training can be used to select those who will most likely succeed from those who will most likely fail. Trainees who graduated from all three programs expressed significantly higher training confidence attitudes than those who voluntarily dropped. Also, those who passed DSC training scored significantly lower on scales which measured fearful attitudes (e.g., family's fear of injury) than those who failed (Ryman and Biersner, 1975).

Individual differences in PUDT training success was examined further by Biersner, Ryman, and Rahe (1977) in a study of PUDT trainees (N=148) who completed physical tests, the Schedule of Recent Experience (SRE) Questionnaire, an attitude survey, the Cornell Medical Index (CMI) Health Questionnaire, and the Mood Questionnaire prior to training. A measure of physical fitness, pull-ups, differentiated between men who passed the course and those who failed. This predictor also appeared to identify those men likely to escape incapacitating illness or injuries during stressful training. Among the psychological predictors, only motivation proved helpful; trainees in the pass group showed higher motivation scores than the voluntary fail group. Also, a tendency was seen for men who involuntarily dropped from training to have reported more recent life changes and higher CMI scores than did those who passed or voluntarily dropped from the program (Biersner, Ryman, and Rahe, 1977). The authors concluded that significant correlations between subjects' scores on the motivation scale (from the attitude survey) in conjunction with moods of Happiness and Activity suggested a single personality syndrome, such as personal effectiveness or confidence. Together with physical ability, this measure of psychological "preparedness" was predictive of PUDT trainee effectiveness.

In another study, the CMI and SRE were found to be useful predictors of UDT training success. The SRE identified subjects with a high likelihood of failing UDT due to disabling illness or injury experienced early in the training, whereas the CMI, which measures subjects' illness symptom recognition, identified voluntary drop-outs from the course primarily due to a lack of motivation (Rahe, Biersner, Ryman and Arthur, 1972). These studies of Navy divers suggest that attitudes toward training and past life experiences may result in a propensity for illness and injury; together with actual physical fitness, these affective individual differences are an important determinant of training success.

The effect of noncognitive characteristics on training performance is not restricted to physically demanding courses. In the context of social skills training, Pentz (1981) suggests that individual differences, particularly ability for verbal reasoning, state anxiety level, and pre-training unassertive or aggressive behavior may render students differentially able to use social skills or resources. To test this hypothesis, Pentz evaluated the relative contribution of training variables (modeling mode and training stimuli) and individual differences to an assessment of self-efficacy and assertive behavior in adolescents (N=61) selected for their unassertive or aggressive behavior with teachers. Results indicated that individual difference variables, particularly verbal reasoning and state anxiety, accounted for substantially more variance in cognitive and behavioral measures of assertiveness than did the training variables. Correlational analyses indicated that low anxiety and high verbal reasoning produced higher levels of self-efficacy and assertive behavior. The author suggested that further study is needed to assess whether high anxious and low verbal reasoning students might benefit from certain forms of pretraining preparation, such as systematic desensitization or concentrated practice involving verbal reasoning skills (Pentz, 1981).

Finally, the effectiveness of alternative presentations of technical material may depend on non-cognitive trainee characteristics. Githens, Shennum, and Nugent (1975) suggested that personnel characteristics be grouped according to aptitudes, background factors, and attitudes, that can be used to study reading comprehension and job performance. The authors describe a process that will enable technical manual writers to determine the characteristics of the group of probable users for a specific training manual (TM). This process involves the following steps: (1) determine the extent of the reading ability/TM readability mismatch; (2) develop an initial matrix table that includes personnel characteristics, TM comprehension levels, and potential TM user groups; (3) generate vocabulary knowledge tests for TM user groups; (4) develop tests of operational comprehension; (5) relate personnel characteristics to operational comprehension; (6) develop a procedure for revising the matrix table of personnel characteristics and potential TM user groups; and (7) determine the relationship between writing characteristics and personnel characteristics (Githens, Shennum and Nugent, 1975). Hopefully, the development of procedures for adapting technical manuals and other training materials to the appropriate user groups will continue. Research in this area may be the key to accomodating individual differences in the training environment.

The previous two sections have illustrated that individual trainees bring various cognitive styles and non-cognitive characteristics to the training environment, depending on content and presentation of material, these differences enable some trainees to acquire, retain and transfer learning *much* more readily than others. Only recently, however, have training specialists begun to incorporate these individual differences into the training process. The next two sections address research evidence that pertains to the process of accommodating individual trainees.

## Aptitude-performance interactions

The first step for developing flexible instructional strategies is to acknowledge and understand the interaction between individual aptitude and training performance. In this context, aptitude is "any characteristic of the individual that increases or impairs his or her probability of success in a given treatment" (Cronbach and Snow, 1969). Because individuals possess different learning potential, it is necessary to determine the level of training at which each person can be successful. This match of individual aptitudes and optimal performance is the critical issue facing training specialists today.

The most frequently used method of instruction in most training environments is the lecture-demonstration-practice paradigm. However, as McFann (1969) reported, sufficient data exist to raise questions concerning the appropriateness of this practice for training lower aptitude personnel. From an examination of both Basic Combat Training and Combat Support Training (initial individual training courses included at Army training centers), results suggest a significant relationship between aptitude as measured by Armed Forces Qualification Test (AFQT) scores and success in training. Successful completion of course standards was highly related to AFQT scores, indicating high aptitude subjects were more likely to complete the course requirements on the first enrollment. Although the majority of trainees eventually make it through a course, the degree to which they successfully meet minimal standards the first time through is a function of AFQT scores (McFann, 1969).

Fox, Taylor and Caylor (1969) evaluated the relationship between aptitude level and training performance in a study of ability to acquire military skills and knowledges. Groups of high (AFQT 90-99), middle (AFQT 45-55), and low (AFQT 10-21) aptitude subjects were trained on eight tasks of varying levels of complexity. Instructional methods were selected to maximize the low aptitude subjects' opportunity to learn. Results of the study demonstrated large differences among the three aptitude levels. In general, the low AFQT subjects were slower to respond, required more time to attain a specified criterion, and were decidedly more variable as a group than either middle or high aptitude subjects. The authors concluded that efficient training of men at all levels of aptitude will depend upon the recognition of individual differences, and the design of instructional programs compatible with differences in learning rate and final performance capability (Fox, Taylor, and Caylor, 1969).

McCombs and McDaniel (1983) addressed the aptitude-performance issue by investigating the effects of various alternative training modules on student differences in precourse memory abilities (processing and retrieval skills) and motivation (anxiety and curiosity). Five lessons selected from the Inventory Management course taught as part of the Air Force Advanced Instructional System varied according to content and task requirements. Time-to-completion and test scores for each alternative module were compared to performances on the original instructional module for Air Force trainees. Results indicated that the treatment modules compensated for low memory/processing ability in two of the five lessons. However, compensatory treatments designed for high anxiety/low curiosity students did not produce the desired beneficial effects.

Although the alternative compensatory modules produced performance that was, in general, comparable to original module performance, in several instances the effectiveness of a module differed as a function of memory ability and/or motivational level of the learner. Imbedded questions in a lesson seem to compensate for students with less ability to read and extract information from technical text; spaced review seems to compensate for students with average to low memory spans; and feedback to embedded questions or organizational aids may help students with high learning anxiety (McCombs and McDaniel, 1983).

However, not all research reviewed has shown a positive linear relationship between aptitudes and performance. Tallmadge and Shearer (1967) designed a study involving a standard control and two experimental versions of the 1-week maneuvering board training course given to Class A Navy radar personnel. The two experimental training methods were designed to emphasize Gagne's (1965) Type 3 (rote memorization) and Type 7 (problem-solving procedures, and underlying principles, concepts and rational) learning strategies. Navy Basic Battery aptitude test scores were obtained for 166 subjects; the Spatial Orientation and Spatial Visualization subtests of the Guilford-Zimmerman Aptitude Survey and the Kuder Preference Record (Vocational Form B) were also administered to the subjects. The purpose of the study was to investigate possible interactions between learner characteristics and method of instruction. Large achievement differences resulted from the three methods of instruction; however, no interactions between training methods and learner characteristics were found, either with single or combined aptitude measures (Tallmadge, 1968).

In view of other reported studies, these negative findings are surprising. The authors concluded that the specific interaction between subject matter content and training methods were responsible for the negative findings, and that it is possible other aptitude, interest, or personality factors might have produced a positive relationship with training methods.

Most practitioners would agree that in all likelihood, pre-training aptitude differences will remain as performance discrepancies if only one method of training is used. Thus, the question again is raised: would not training performance improve if the learning process were applied to individual needs? The best answer to this question may rest with empirical studies which implement various training strategies to test the individual differences hypothesis.

## Testing the individual differences hypothesis

More generally known as aptitude - treatment interactions, the body of research that actually tests the individual differences hypothesis is the heart of the individualized instruction literature. Nearly twenty years ago, Cronbach (1967) discussed three models for accommodating instruction to individual students. These include: (1) manipulate the pace of teaching, i.e., alter the duration or sequential selection of training material; (2) determine for each trainee his or her prospective role and provide a curriculum preparing for that role; and (3) provide remedial adjuncts to fixed "main track" instruction, i.e., teach different trainees with different methods. Thus, Cronbach was largely stressing the adaptation of training according to pre-training student differences.

McFann (1969) expanded this approach and proposed an individual-treatment interaction process that is still being applied in military training research. McFann suggested procedures for investigating the relationships among three broad classes of training variables. First, individual difference variables such as aptitude levels, reading and arithmetic skills, demographic data, Army Classification Battery Test scores, and non-verbal mental abilities should be considered as recruit input predictors. Second, the relationship between these predictors and task variables such as complexity or level of abstraction are examined. Third, a variety of training method variables are considered, including; knowledge of results, pace of presentation, and selected human, material, and physical facility resources.

The basic research approach involves selecting training method variables and studying their interaction with the individual difference variables while holding task variables constant. The goal is to determine the potency of various combinations of individual, task, and training method variables for optimal training performance. McFann (1971) distinguishes between types of training strategies that would allow for efficient training of subjects at all aptitude levels. He constructs a model that consists of three training methods (curriculum, time, and standards) and then crosses them with format (fixed or variable). Training situations using fixed curricula and time for completion largely ignore the concept of individual differences. By contrast, programs that use variable standards, different completion schedules, and individualized curricula are most adaptive to individual trainee needs. Therefore, successful treatment of individual differences will occur when trainees are allowed to complete various levels of course requirements at their own pace (McFann, 1971).

Completion time when training is individually paced can be influenced by prior familiarity (Tobias, 1976). Prior familiarity may be defined as the amount of exposure one has had to training content or tasks. A consistent finding among aptitude-treatment interaction studies is that students' prior familiarity with the subject matter seems a better determinant for adjusting instruction than attributes such as associative novelty, anxiety, or preferences. Thus, the higher the level of prior achievement, the lower the instructional support required to accomplish instructional objectives. Abramson and Kagen (1975) provide experimental support for this hypothesis. The authors prefamiliarized half of their research group with both verbal and pictorial program content, and then randomly assigned subjects to high (constructed responses and reinforcement) and low (reading groups) instructional support conditions. Results indicated that, as expected, familiarization improved the posttest retention scores of the low instructional support group to a greater extent than it aided the maximal instructional support group (Tobias, 1976; p. 68). If this hypothesis is supported further by additional data, it may prove useful to assign students with high prior familiarity in a given area to an instructional treatment with minimal support, or to an advanced sequence of the training course.

In a large scale evaluation of individualized training, Hall and Freda (1972) assessed the effectiveness and efficiency of individualized instruction (II) and conventional instruction (CI). Measures of training effectiveness and efficiency were examined from over 5,000 graduates of Navy technical schools. Individualized instruction (self-paced and computer managed) and conventional (group-paced) instruction were found to be equally effective in training personnel. Further results indicated that

II benefited higher ability students more than lower ability students. Higher ability personnel mastered more course content and completed training in less time. Conversely, CI did not benefit one ability level over another during training. When course content was classified into generic training tasks, II was found to be more effective than CI for primarily procedural tasks. Conventional instruction was more effective than II in courses that taught primarily rule or principle tasks. Finally, no one method of instruction was found universally effective for training all of the different types of tasks to different ability level students. This suggests that a combination of methods used within a given course would likely be more effective than use of a single method for an entire course.

These same findings were confirmed in a review of individualized instruction as it relates to Basic Rifle Marksmanship (Maxey and Swezey, 1985). The authors concluded that certain training strategies are appropriate for various steps in BRM training. Structured, group-based, instructional methods should be used for teaching cognitive aspects of rifle marksmanship, while individualized, hands-on learning sequences should be used to teach trainees how to actually hold, sight, aim, and fire on targets in both simple and complex situations.

These two studies point out that instruction should vary according to trainee differences as well as the specific task to be learned. Consequently, if training is to be divided into alternative modules or procedures, those alternatives should be chosen to maximize the particular characteristics of the learner and the task. Sorensen and Pennell (1982) provided a suitable methodology to determine appropriate alternative procedures, identifying three variables which must be included in the individual-treatment assessment. The author reported that effective diagnosis of instructional modules depends on the relevant and reliable measurement of: (1) personal descriptors such as sex, age, length of service, prior duty, and test scores; (2) treatment variables such as instructor assignment, group size, individual coaching, and instructional materials and procedures; and (3) achievement variables such as achievement in prior lessons, measured time to criterion, number of attempts to criterion, and other performance outcomes. The goal then, is to develop the best possible instructional module from a careful consideration of these three factors.

Unfortunately, adaptive decision strategies such as Sorensen's are not always feasible. Although individual needs may be served by adaptive instruction, individualized training may not be cost-effective for certain tasks. For instance, Riedel, Abram, and Post (1975) compared adaptive and non-adaptive training strategies for the acquisition of a physically complex psychomotor skill. In the adaptive condition, the student's level of performance determined the difficulty of a self-adjusting arc welding simulator; that is, as an individual's performance improved the task became more difficult. The task was unaffected by performance in the non-adaptive condition. Six levels of task difficulty were examined and no significant differences were reported; adaptive and fixed strategies were equally effective in training the skill required. Overall, subjects demonstrated substantial learning of the task, and the different task difficulty levels had no systematic effect on acquisition in either the adaptive or non-adaptive groups. Because the fixed training strategy takes considerably less investment in terms of development and implementation, the authors recommended it as the most cost-effective method for training this particular skill (Riedel, Abram, and Post, 1975).

The development and implementation of training devices is also a costly venture for training specialists. To what degree should trainee characteristics impact the use of simulators as a training device? Buffardi and Allen (1986) examined the interaction of individual differences and simulator fidelity on electromechanical troubleshooting performance. Ninety undergraduate college students were given a battery of analytical ability, mechanical aptitude, and vocational interest tests prior to performing a troubleshooting exercise with a simulator and with actual electronic equipment. Three levels of physical and functional fidelity were manipulated using three simulators. Subjects were randomly assigned to one of the nine (3 physical x 3 functional) training conditions. Two significant interactions were reported. Simulators high in physical fidelity seem to aid low ability subjects to a greater degree than high ability subjects, whereas a more cognitive schema (low physical fidelity) facilitates the performance of those with higher abilities more than those with low ability levels (Buffardi and Allen, 1986). The implications of this study are important for training situations that rely on a variety of simulators. High ability trainees may use training simulators low in physical fidelity (at presumably a lower cost), while the use of more expensive simulators (high in physical fidelity) may be limited to lower ability students.

Finally, in a effort to account for the varied aptitude across trainees, Weingarten, Hungerland, and Brennan (1972) introduced two types of media instruction to Army field wireman course training. Using either written programmed manuals or such alternatives as audio and video tapes, the authors reported that brighter and better educated men learned fairly well regardless of the medium used. However, lower aptitude personnel did not learn well even with those media thought to be most suited to their needs. An alternative strategy investigated ultimately led to effective training for men of all aptitudes. A number of content experts were used to teach two trainees each on the field wireman tasks. As these men passed a performance test, they would train two men each, and so on. The research staff carried out the experiment for four generations, and every trainee, regardless of aptitude, passed the test. This peer-instructional model demanded 100 percent mastery, yet it resulted in a reduction in academic attrition from 19 to 12.5 percent, and a decrease in academic recycles from 30 to 0 percent. The method was found to be cost-effective as well, and remains an interesting alternative for training personnel of all aptitude levels (Weingarten, et. al., 1972).

## DISCUSSION

In contrast to the more developed body of knowledge regarding cognitive styles in general (Witkin and Goodenough, 1981), the application of learning styles and cognitive strategies to personnel training is relatively new. However, the literature indicates that individuals bring a variety of cognitive styles to the training environment, and that the interaction between these styles and the type of training offered may inhibit or facilitate the individual learning process. A student's difficulty in mastering certain material or in performing a particular task may be due to his or her inability to adopt the appropriate mode of information processing. It may be feasible to train students whose predominant cognitive style is verbal-analytic to adopt a spatial-synthetic orientation when appropriate and vice-versa. Alternatively, instructional strategies themselves could conform to a learner's preferred cognitive style (Federico, 1984b). Procedures such as the Learning Styles Inventory and the Learning Activities Questionnaire provide a means for determining an individual's approach to learning; as the psychometric properties of these assessment techniques are developed more extensively, it might become possible for training specialists to adapt their programs to accomodate individual learning styles identified.

In those cases where cognitive assessment fails to predict training performance, it becomes necessary to look for other individual difference measures that could be used to augment cognitive prediction. Non-congnitive or affective measures such as personality inventories or attitude surveys are particularly useful for selecting individuals for training programs that have important pyschological components. Likewise, physical tests or technical aptitude measures are useful predictors of training success for tasks that require physical or mechanical manipulation.

Whatever the task, it is likely that both cognitive and non-cognitive characteristics will impact an individual's performance. Given differences among individuals, it is necessary to determine that level of training at which each person can be successful. A handful of studies have shown that certain training strategies are more effective than others for particular groups of trainees; lower ability personnel may benefit from more individualized instruction, high ability trainees may require faster-paced instruction, and so on. Such aptitude-performance interactions are the link between individual differences and training success; how best to maximize these interactions is the most important issue facing training specialists today.

To best use the knowledge of individual differences, it is suggested that an optimal training program include the following prerequisites. First, the training content should be classified to determine exactly what type of task is being trained. Second, it is important to select those individuals that are best suited for this particular training. Finally, the training must include the appropriate instructional strategy to enhance the task-trainee relationship. This three part decision model for training program design is summarized in Figure 1. As anchors for the model, six tasks were chosen that are the focus of extensive training in the U.S. Navy. Next, the process of classifying tasks and selecting personnel is encountered. In his theory of vocational choice, Holland (1985) proposed six types of occupational interests and a measurement base through which these types can be assessed. Therefore, training tasks may be classified in terms of their respective vocational categories. Holland has labeled these categories Realistic, Investigative, Artistic, Social, Enterprising, and Conventional; they appear in the second row of the model under the title of Occupational Task Type. Holland also contends that individuals' personalities can be classified in terms of the six vocational categories. That is, certain individuals are likely to be Realistic types, Social types, and so on. Similarly, a number of researchers have concluded that personality can be assessed in terms of five basic dimensions (McCrae and Costa, 1986; Digman and Inouye, 1986; Digman and Takemoto-Chock, 1981; Driskell, Hogan & Salas, in press; Norman, 1963; Hogan, 1983, 1986). These dimensions are represented by scales from the Hogan Personality Inventory (HPI; Hogan, 1986) presented in Figure 1; for a complete interpretation of these scales, see Hogan (1986). Selection decisions then, are a product of matching the individual's personality type with the

## Figure 1

### PROPOSED TRAINING DESIGN INTEGRATING TASK TYPE, PERSONALITY, AND INSTRUCTIONAL STRATEGY

| Training Task | | Operating Propulsion Boiler | Maneuvering Board Training | Interpreting Aerial Photos | Counseling Drug & Alcohol Abusers | Acquiring Leadership Skills | Dispensing Supplies |
|---|---|---|---|---|---|---|---|
| Occupational Task Type[a] | | Realistic | Investigative | Artistic | Social | Enterprising | Conventional |
| Personality Factors | INT[b] | AVG | HIGH | HIGH | AVG | AVG | AVG |
| | ADJ | HIGH | AVG | AVG | HIGH | HIGH | HIGH |
| | PRU | HIGH | AVG | LOW | AVG | AVG | HIGH |
| | AMB | HIGH | HIGH | AVG | AVG | HIGH | HIGH |
| | SOC | AVG | AVG | HIGH | HIGH | AVG | LOW |
| | LIK | AVG | AVG | AVG | HIGH | HIGH | AVG |
| Instructional Strategy | | Simulator<br>Group Procedural Training | Computer-Aided Instruction | Video Discs Graphics<br>Apprenticeship Training | Small Group Discussions<br>Role-playing | Behavior Modeling<br>Small Group Discussions | Computer-Aided Instruction<br>Part-task Training |

[a] From: Gottfredson, Holland, & Ogawa (1982).

**Realistic** - tasks involve concrete and practical activity involving machines, tools, or materials.

**Investigative** - tasks involve analytical or intellectual activity aimed at problem solving, trouble shooting or the creation and use of knowledge.

**Artistic** - tasks involve creative work in the arts or other unstructured and intellectual endeavors.

**Social** - tasks involve working with people in a helpful or facilitative way.

**Enterprising** - tasks involve working with people in a supervisory or persuasive manner.

**Conventional** - tasks involve working with things, numbers, or machines in an orderly manner.

[b] From: Hogan (1986).

**Intellectance** - the degree to which a person is seen as intelligent, well educated, and creative.

**Adjustment** - the degree to which a person seems free from the everyday symptoms of maladjustment.

**Prudence** - the degree to which a person seems dependable, conscientious, and reliable.

**Ambition** - the degree to which a person seems hard working, energetic, and leaderlike.

**Sociability** - the degree to which a person seems gregarious, affiliative.

**Likability** - the degree to which a person seems agreeable and pleasant.

appropriate vocational interest. Support for this relationship between vocational interests and personality is overwhelming (cf. Digman and Inouye, 1986; Digman and Takemoto-Chock, 1981; Holland, 1985; McCrae and Costa, 1986).

Classifying tasks and selecting appropriate trainees provide the basis for insuring effective training performance. However, of equal importance is the instructional strategy chosen to disseminate the training content. Just as trainees are selected for their predisposition towards a particular task, so to must the mode of instruction be chosen to meet the particular learning abilities of the individual. Thus, given the type of task in question, the appropriate instructional strategy or medium recommended for the training program is presented in Figure 1.

The relationship between task type, personality type, and appropriate instructional strategy is best summarized by Holland (1966) in a discussion of the six work environments. Regarding the Realistic type, Holland states that "typically the problems are mechanical, demanding the use of tools and machines. Work tasks often require medium to great capacity for such physical activities as reaching, handling, fingering, feeling, and seeing." From this definition, it follows that the most appropriate means for learning Realistic tasks will be hands-on simulator and procedural training. This same selection strategy is true for the other training recommendations; instructional techniques presented in Figure 1 are theoretically derived from the type of task and individual to be trained. As discussed throughout this review, certain individuals will benefit more than others from specific instructional strategies. By adapting the instructional strategy to the particular needs of the task and trainee, it is possible to achieve optimal levels for the acquisition, retention and transfer of training.

When correlates of training performance across a number of individual difference variables are examined, it is clear that predictions from cognitive measures are consistent and positive; higher ability individuals perform better in training regardless of how training success is defined (Christal, 1976). However, no systematic training investigation of noncognitive individual difference variables has been pursued. In part, this may be due to the belief that little incremental prediction could be achieved with these measures and the conception that only weak theoretical grounds could justify the inclusion of such assessments (Guion and Gottier, 1965). However, taxonomic advances within the non-cognitive domain allow us to understand the structure of vocational interests and personality dimensions and that knowledge leads to a systematic way of thinking about individual differences (e.g., Driskell, Hogan & Salas, in press). A decision model approach to the design of training programs is the best way to incorporate this knowledge of individual differences into the training environment.

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