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IMPROVING SOLDIER TRAINING:
AN APTITUDE-TREATMENT INTERACTION
APPROACH
BY
GARY W. BLOEDORN, LTCOL, U. S. ARMY
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An analysis of the theoretical and methodological concepts available to and needed by the U.S. Army in developing soldier profiles in learning is presented within a context of the Army training, classification, and assignment systems. Statistical analysis techniques appropriate for Aptitude-Treatment Interaction research are discussed in general terms.

Current views of cognitive processes are examined as they relate to individual differences in learning. A coordinated approach to the study of

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aptitudes as information processing constructs is correlated with instructional development strategies to capitalize on individual aptitudes in learning. Recommendations are provided as to those aptitude variables that might be included in training effectiveness analyses on developing and fielded weapons systems and equipments and what steps can be followed to use such data for instructional purposes.

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EXECUTIVE SUMMARY

Introduction

This research report describes the structure and functioning of the U.S. Army's training and classification system for enlisted personnel. The report is cast within the context of an all volunteer force characterized by large numbers of poorly educated accessions who are required to operate and maintain weapons and equipment of ever increasing complexity. The central issue is an analysis of the theoretical and methodological tools available to the training developers to individualize instruction so as to capitalize on individual soldier aptitudes for learning. The report identifies promising individual aptitude constructs and teaching strategies appropriate for these aptitudes and suggests a research methodology for service use.

Background

The advent of the all-volunteer Army has coincided with declining standards in civilian education and rising sophistication of military hardware to produce a severe personnel-equipment performance gap that the present Army training system is ill-prepared to close. The Congress, the Government Accounting Office, the Department of Defense, and numerous independent research organizations have focused their attention in recent years on the costs and effectiveness of Army training programs. The resulting pressure has caused the

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Army to make reductions in the time and money devoted to
enlisted training at the very time vast sums are being
spent to procure and deploy more complex systems. The result
is that few of the Army's most modern and important systems
are being operated to design capability. In effect, inade-
quately educated and trained soldiers are making it extremely
difficult and costly for the Army to take full advantage
of this technology. In effect the Army is in danger of buying
less battlefield capability for more money. The Army recog-
nizes this, and is working to reduce costs while simplifying
equipment operating and maintenance designs. However, real-
istic and challenging training will continue to be necessary
to ensure that individuals and units are prepared for the
demands of combat. To that end, the Army's Training and
Doctrine Command (TRADOC) has initiated a Training Effectiv'-
ness Analysis (TEA) program under the management of the
TRADOC Systems Analysis Activity (TRASANA), to develop
training programs and personnel classification procedures
with the same degree of scientific rigor as is used to
develop the weapon systems.

Purpose

The purpose of this research is to develop strategies
to apply educational technology in the development of instruc-
tional techniques and methods to capitalize on individual
soldier aptitudes. The report develops empirically derived

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training models to allow training effectiveness analysts
to use the complex variables that are present when trainers,
trainees, critical tasks, materials, and training objectives
come together as an instructional event.

Scope

The scope of the research includes the broad outlines
of the Army's training and personnel classification system
against a background of what is known about individual
differences in learning. The research centers around the
development of individual soldier profiles by investigating
promising aptitude and motivation constructs and the rela-
tion of these constructs to task specific learning strategies
designed to: (1) capitalize on individual aptitude strengths;
(2) compensate for lack of aptitude or; (3) remedy educational
deficiencies.

Current views of cognitive processes are examined as
they relate to individual differences in learning. A coor-
dinated approach to the study of aptitudes as information
processing constructs is correlated with instructional
development strategies. Recommendations are provided as
to those aptitude variables that might be included in train-
ing effectiveness analyses on developing and fielded weapon
systems and equipments and what steps can be followed to
use such data for instructional purposes. Statistical
analysis techniques appropriate for Aptitude-Treatment

Interaction research are discussed in general terms.

Aptitude-Treatment Interaction

One approach to the analysis of Instructional processes as they related to individuals is founded on the investigation of learner characteristics and educational treatments.

Aptitude-Treatment Interactions (ATI) entail much more than the differences in outcome of two alternative instructional treatments. Rather, ATI is oriented on the principle that learning is the result of neither individual differences nor specific instruction but rather the result of the interaction of the two to produce learning. Thus, if we tailor instruction to students of high aptitude for the task being taught, students of low aptitude do worse than if we were to teach them by methods for which they do have an aptitude. In other words, instructional techniques that may be well suited for one solider may be ill suited for others and may actually serve to degrade their learning.

The initial task for researchers is to develop a conceptual framework to describe individual learning traits Although the research literature does not now present a firm consensus as to the utility of these individual learner traits, it is rich in the formulation of testable treatments, and does identify certain combinations of aptitudes that show promise for predicting individual learner performance

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as a result of specific instructional treatments. These apti-
tude variables include: (1) General mental abilities measured
by standard tests on word knowledge, arithmetic and numerical
skills, specific spatial abilities and past academic achieve-
ment scores; (2) cognitive styles (patterns of information
processing) such as conceptual level and field-dependence
are measured by tests desig ed to quantify a person's ability
to conceptualize and to analyze complex situations. Conceptual
level is usually measured by essay and sentence completion
tests, while field-dependence is determined by results of the
embedded figures test in which people must detect simple geo-
metrical figures contained within more complex figures. Varia-
tions include tests in which the subject is required to locate
a true vertical position within a complex, separately tilted
environment. Subjects who can locate a true vertical are
said to be "field-independent". Those who cannot are said
to be "field-dependent". Lastly, (3) aptitude variable
composites are dependent on personality constructs derived
from motivation characteristics such as need for achieve-
ment, and anxiety traits, both of which can either positive-
ly motivate, or interfere with learning performance depend-
ing on the type task and the instructional strategy (treat-
ment) being used.

A Summary of the Literature

While no interactions are so well confirmed that they
can be used as guides to instructional developers without

a great deal of additional research, a pattern has emerged
suggesting that those aptitude constructs discussed above
can be employed to tailor instruction by thinking explicitly
about what is to be taught and to whom. The following
general rules seem to apply:

   ● Measures of high general ability combined with
field-independent cognitive style, high achievement thru
independence, and low anxiety identity, individuals who tend
to learn more rapidly, and to retain it longer if they
are exposed to a learning strategy emphasizing self-directed
instruction. Persons with this aptitude construct should
be allowed to organize and manipulate concepts as opposed
to learning task specific rules. These students are thought
to perform better under conditions of intrinsic motivation,
without performance feedback, as they need little externally
provided structure.

   ● Individuals of low general ability, who seek
achievement through conformity to rules, who are field-
dependent and relatively high in anxiety are thought to
perform best under conditions in which the instruction is
broken into small steps and is highly structured with exten-
sive practice and feedback. These learners are dependent
on teacher or authority initiated structure and peer opin-
ion and appear liable to become disciplinary problems if
the instructional strategy is unstructured and includes
self-directed study components.

Various combinations of aptitude, i.e. average
mental ability, low or no desire for achievement, an average
level of anxiety, can be found to be combined in individuals
with either field-dependence, independence or high/low con-
ceptual level. Each of these combinations constitutes a
distinct aptitude construct which should be treated accord-
ing to the specific task to be mastered. Treatment vari-
ables include emphasis on spatial presentations, visually
dense presentations (sequenced from the simple to the com-
plex) and the need for practice sessions following visual
presentations.

The overall conclusion is that subjects should be
clustered by aptitude construct and the instructional
strategy employed should be specifically tailored to the
task and the learner aptitudes. Concepts of AIT can, with
additional research to more precisely focus and align apti-
tude with task and instructional strategy, improve the
terminal performance and skill retention of every student.

A Research Methodology

Because additional research is necessary and because
the Army is using the development of soldier learning styles
within the overall concept of TEA, this research report con-
centrated on the emerging research methodology as it should
logically be applied to the Army's needs. A research meth-
odology that appears to have promise is one which takes the

aptitude constructs of general mental abilities, personality
variables and cognitive style, adds a dimension of physical
ability and the appropriate techniques of statistical analy-
sis, and places them within an information processing model.
The components of this model include the coordination of
learning and abilities into a hierarchial arrangement
wherein learning is conceived of as a process of cognition,
production of data and evaluation of that data leading to
a behavior. This process may be hierarchially arranged
so that simple tasks are viewed as being mastered by less
complex abilities and more complex tasks dealing with con-
cept formation, principles, transformations and problem
solving are viewed as being mastered by highly complex cogni-
tive functions largely related to measures of general mental
ability. Figure 7 in Chapter V, p.71 presents this hier-
archy schematically.

The aptitude and learning hierarchy is best viewed
from the perspective of a stimulus-response-response pat-
tern wherein the researcher seeks to measure and identify
the process occurring within an individual during learning.
This may be accomplished through use of an information
processing model which makes useable distinctions between
short term memory (STM), intermediate term memory (ITM),
and long term memory (STM) and assumed subroutines to detect,

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analyze, and evaluate incoming data in order to recognize patterns of indivudal differences in information processing that are thought to be at the heart of observable differences in learning. Chapter V presents a complex analysis of these information processing variables and outlines a research model by which these differences can be related to the three instructional strategies (the preferential compensatory and remedial strategies introduced above).

A synthesis of these concepts is presented which allows the researcher to correlate the relationship between the aptitude constructs and the instructional treatments. The requirement to establish the validity of these constructs is acknowledged and an implementing strategy appropriate for use within the TEA process is provided.

An Implementing Strategy

A four phase approach to ATI testing is recommended.

- **Phase I** - consists of use of the Interservice Instructional Systems Development (ISD) model and the Armed Services Vocational Aptitude Battery to identify the tasks to be trained and the target population aptitude clusters. The development of initial instructional treatments and development of the combined S-R-R/information processing analysis models is also accomplished during Phase I.

- **Phase II** - this phase is devoted to refinement of the instructional strategies to better align them

with the aptitude clusters within target population.
This will probably include refinement/development of needed
aptitude tests for cognitive style, personality variables
and special measures of general intelligence that are likely
to be highly task specific, such as measures of perceptual
speed, memory span, closure speed, and visual memory.

● Phase III - is the actual conduct of the re-
search characterized by data collection using the combined
S-R-R/information processing model and multiple regression
analysis techniques to avoid masking the effects of indi-
vidual differences which may occur if analysis of the vari-
ance tehcniques are used.

● Phase IV - is devoted to the refinement of
data analysis and feedback into the instructional/aptitude
development programs necessary to both improve individual
instruction and to support improvement of the research
methodology of TEA.

Conclusions

1. Conclusion. Individual differences in learning
exist and become important upon situational demand. In-
structional strategies should be developed to exploit in-
dividual differences to ensure the best training for each
soldier within the reduced training resources available.

Recommendation. That TRASANA's TEA program be implemented as planned with TRASANA being the overall manager of ATI research as well as of the TEA program. Investigations should be integrated with ongoing instructional programs and should be started at SL2 task complexity.

2. Conclusion. Great strides have been made in Aptitude-Research Interaction research but much more needs to be accomplished before the results can be used by instructional developers in the field.

Recommendation. ATI research being conducted by TRASANA should be supplemented by the Army Research Institute (ARI) to develop and refine:

- Measures of general mental ability to include measures of perceptual speed, memory span, closure speed, and visual memory.

- Measures of personality variables with emphasis on measures of achievement motivation and trait anxiety. Basic research into the effects on learning of other personality variables such as self-confidence, need for affiliation, power, social approval and degree of dogmatism should be carried on separately from the basic TEA research program.

- Measures of cognitive style to include field-dependence and conceptual level.

3.   Conclusion.   The Army is correct in its assess-
ment of the training problem as reflected in the Army
training system and the evolving TEA system.   However, the
field of ATI research is incredibly complicated and dependent
on successful long range research.

Recommendation.   That the ATI aspects of TEA
remain a research concept until developed to the degree
that ATI results can be used by the instructional developer
without disruption of ongoing Army training activities.
This will take patience, money, people, and time.   These
resources should be provided as necessary and the specific,
detailed procedures of tailoring instructional strategies
to individuals should be implemented within the parameters
of present ISD model when perfected.

PREFACE

This research was initiated at the suggestion of the Chief, Training Effectiveness Analysis (TEA) Division, U.S. Army Training and Doctrine Command (TRADOC), Systems Analysis Activity (TRASANA), White Sands Missile Range, New Mexico. The Center for Advanced Research of the Naval War College agreed to sponsor the research as being applicable to military training in general.

Many of the sources listed in the bibliography are of recent origin, authored by a select few innovative psychologists who are just now expanding the known limits of the role of human aptitude in learning and performance. This is a literature of specialists who do not always agree simply because they are employing imprecise research tools to study an incredibly complex subject. The reader should be aware that this paper does not represent the views of any one body of opinion. Rather extensive use has been made of the work of a few authors who have focused their research on developing a cohesive theory out of many conflicting, often confusing, studies. While the theory is not yet complete--much research is necessary to develop a useable body of principles and rules--a method for the conduct of research has been developed that can serve to point us in the right direction. Extensive use of this methodology has been made

in this paper in order to synthesize advances in individual

differences in learning with the evolving Army training

system.

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AN APTITUDE-TREATMENT INTERACTION APPROACH

CHAPTER I

INTRODUCTION

The Problem

A military educational conference was held at College
Park, Maryland, in April of 1979 to discuss the problem of
declining literacy in the United States. Dr. James Flood,
Assistant Professor in Boston University's department of
reading and language, told the conference that 30% of high
school seniors are not able to read their textbooks or news
magazines. Eighteen percent of American adults lack basic
literacy skills to the point where they cannot even fill
out basic forms. Dr. Food emphasized that "certain" mili-
tary personnel cannot even read field and technical manuals.
This is not surprising. A 1975 U.S. Office of Education
study found 42% of adult Americans to be poor readers or to
be barely able to read well enough to cope with the problems
of everyday living.

An example of how this decline in basic reading
ability within the general population impacts on the Army
is to be found in a recent study of reading abilities in
the infantry conducted by the U.S. Army Infantry School
(USAIS). The Infantry School became involved in the reading

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problem when it was found that an inordinate number of
enlisted men were failing the written portion of the infan-
try Skill Qualification Tests (SQT). One of the suggested
causes of this failure was that infantrymen could not read
well enough to comprehend written tests. Evaluation of
the reading level of the SQT and supporting field manuals,
indicated that the SQT were written at approximately the 10th
grade level and the field manuals were written at about the
12th grade level.[1]

The Infantry School surveyed 189 junior officers and
1525 enlisted men selected so as to be representative of
the infantry population, to measure reading levels. The
survey used established reading tests to determine vocabu-
lary, comprehension, and accuracy. Test results were corre-
lated with rank, race, education, and scores on the Armed
Forces Qualification Test (AFQT) (the AFQT measures an appli-
cant's word knowledge, arithmetic reasoning, and spatial
abilities). Results of this testing revealed that almost
100% of the officers read above the 12th grade level. How-
ever, a large percentage (56%) of the enlisted men in the
grade E1 thru E3 read at the 5th grade or lower. A smaller
percentage (about 15%) read at the 12th grade or higher,
while the remainder of the enlisted sample, about 32%
spread across seven enlisted ranks, read between grades 5
thru 1... Significantly, of approximately 1000 high school
graduates between 300 and 400 read at between the 2nd and

4th grade levels.[2] Equally serious was the finding that good scores on the Armed Forces Qualification Test (AFQT) did not reliably predict reading ability. A large group (N=300) with relatively high AFQT scores read at less than the 5th grade level.[3]

In summary, the USAIS study tends to support Dr. Flood's gloomy picture of a school system that often fails to develop student literacy, and that certain soldiers cannot now read their training and maintenance literature. Virtually all infantry publications have been written for soldiers who could read at the high school level, while the majority of enlisted men in the infantry read at a level well below high school. This situation is particularly worrisome because, as will be seen, the Army's training system is heavily dependent on use of written texts by enlisted men.

Data from the Army's Recruiting Command indicates that during CY 1978, 86.9% of the applicants accepted for enlistment were placed in the lower two of four mental categories (CAT III and IV) on the basis of AFQT tests.*

In a recent survey at the Army's Armor School the distribution of 436 recruits across mental categories was:

CAT I - 3.1%

CAT II - 13.4%

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* See Chapter II for a discussion of the Armed Services Vocational Aptitude Battery (ASVAB) and personnel selection criteria.

CAT III - 75.1%

CAT IV - 8.3% [4]

This high percentage of lower mental category people included 66% high school graduates. These findings are consistent with the infantry school study and appear to be representative of the educational quality of people joining the force. Keeping in mind that these mental categories are based largely on word knowledge and arithmetic abilities, the impact of the situation described by Dr. Flood on the military is clear. It is already difficult and costly to train soldiers on the complex equipment of today and so it may be even more difficult to train them on the increasingly complex equipment entering the inventory in the 1980s.

The problem of declining literacy has already impacted on the military in numerous ways. Millions are being spent to develop illustrated technical manuals to assist soldiers with reading deficiencies; remedial training is being given potential enlistees by the Department of Health, Education and Welfare's Office of Education to enable those who fail the AFQT to qualify for enlistment; and the Army's Basic Skills Education Programs are designed to upgrade the literacy and computational skills of Army personnel found deficient.

The magnitude of the problem is such, however, that the services may be unable to adequately man the equipment

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needed to defeat the powerful and growing threat posed by
the sophisticated forces of the Warsaw Pact.

Concerned about this large and probably growing gap
between personnel performance capabilities and operational
requirements, the Commander of the Training and Doctrine
Command (TRADOC) obtained Chief of Staff of the Army approval
in late 1977 to initiate a comprehensive study of Army
training programs required to optimize the capabilities of
major new weapon systems programmed for delivery to the
force in the 1980s. The resultant Army Training Study (ARTS)
report was presented in August 1978. While it is beyond the
scope of this paper to review the data, conclusions, and
recommendations of the ARTS report, it is appropriate to
note that the study group concluded that training now
being conducted in Army units was not achieving the estab-
lished standard of individual and collective proficiency.
In effect, soldiers were not trained sufficiently well to
enable them to consistently operate their weapons and equip-
ment to the level of capability for which they were designed.
Further, evidence was found that inadequate training con-
tributes substantially to morale, discipline, and retention
problems.[5]

Given the declining quality of the available manpower
pool it is clear that the Army's ability to take advantage

of developing technology is limited. These conditions suggest that advances in educational technology must be exploited apace with the hard sciences. To do otherwise is to risk the possibility that the Army will be denied the skilled manpower required for the battlefield of the future.

The Purpose

The purpose of this research is to determine strategies to apply educational technology in the development of instructional techniques and methods to capitalize on individual soldier aptitudes. The fundamental premise of this research is the notion that all of what may be best for PVT Jones may not be best for everyone else in PVT Jones' unit. What is needed are empirically derived training models, which will allow commanders to use the complex variables present when trainers, trainees, critical tasks, materials, and training objectives come together as an instructional event. While this research emphasizes the soldier component of the training problem, much of what is presented can and must be applied to the trainer as well.

Organization

This paper will investigate what is known about differences in individual learning against a background of the current Army training system and the Training Effectiveness

Analysis (TEA) Methodology being developed by the Army to improve training. The objective of this approach is to synthesize the proposed TEA methodology (and thus the Army training system) with the applicable research in order to develop a guide to future research. The paper addresses the following areas:

- An introduction to individual differences in learning within the context of modern psychological concepts of aptitudes, instructional treatments, and the interaction between aptitude and treatment. This interaction is referred to as an Aptitude-Treatment interaction (ATI).

- An appropriate military perspective as regards ATI.

- A review of the literature to include:
  - testing hypotheses and statistical analysis
  - effects of general abilities
  - effects of specialized abilities
  - effects of individual personality traits
  - instructional strategy development

- A research methodology that provides an initial framework for the identification of aptitude and treatment constructs.

- An implementing strategy.

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Current Army Training System

The Solution. The reader should note that the Army
has not been unaware of these trends and in fact has formu-
lated concepts and programs to solve the problem. The
existence of the TRADOC, which provides centralized control
of the Army's school system and doctrinal development, under
the command of a four star general, is evidence of the
priority given training. TRADOC has been both aggressive
and innovative in promoting change and in implementing
modern educational developments. At the heart of the Army's
solution to the problem is the school system which is organ-
ized by function/branch. Each branch school (Infantry,
Armor, Ordnance, etc.) is responsible for developing branch-
unique programs of instruction and the necessary field and
technical manuals for its community. All TRADOC branch
schools use the Interservice procedures for Instructional
System Design Model (ISD), (TRADOC PAM 350-30) incorporating
five phases (analysis, development, design, implementation,
and control) in the development of training programs. They
also use criterion referenced instruction (CRI) by which
satisfactory job performance is identified and measured.
Tasks, conditions, and standards are developed for each job
as the basis for development of resident and non-resident
programs of instruction. Training assistance to units in
the field is provided by development of exportable training

packages for individual Military Occupational Specialties
(MOS) and collective training tasks for units. This assis-
tance takes the form of instructional texts and:

- Soldiers's Manuals (SM) which contain a list-
ing of the critical tasks the soldier is expected to perform
and the cues, conditions and standards for each task.

- Commander's Manuals (CM) which provide a list-
ing of critical tasks for each MOS. This manual informs
commanders what each soldier is responsible for knowing,
who is responsible for training the soldier to criterion
for each task and the references required.

- Skill Qualification Tests (SQT) which are
designed to verify enlisted proficiency and eligibility for
promotion on a periodic basis. Each SQT has three components;
written tests, hands-on performance tests, and a certification
component.

- Army Training and Evaluation Programs (ARTEP)
are used to establish the tasks, conditions, and standards
of performance for each company and battalion sized unit.
ARTEP include common tasks such as chemical defense and
first aid as well as branch unique missions.

- Combined arms tactical doctrine, i.e.,
combined infantry, armor, and artillery employment, is the
responsibility of the Combined Arms Center (CAC) at Ft.
Leavenworth, Kansas. CAC develops tactical doctrine for the

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brigade, divisions, and corps, and operates the Command and
General Staff College which trains officers from all
branches.

● The TRADOC school system is supported by a
scientific community consisting of combat development cen-
ters, operational test agencies and systems analysis organ-
izations.

● Unit training is decentralized so that the
battalion commander has the primary responsibility for the
individual and collective training of his unit. The commander
uses the SM, CM, ARTEP and unit-unique maintenance and
mission training requirements to formulate quarterly train-
ing programs as the basis for his weekly training schedule.
Standards are maintained by higher headquarters through
use of SQT evaluations of each individual for each MOS and
by periodic ARTEP exercises in the field, as well as by
periodic maintenance , administration and weapon qualification
evaluations of each unit.

Training Effectiveness Analysis

In support of this sytem, TRADOC has instituted a
Training Effectiveness Analysis (TEA) program. This program
is fundamental to sound combat and training developments as it
serves to not only develop training programs apace with
equipment and weapons, but it also provides data to enable
the Army to determine if performance shortfalls are caused
by training or equipment design error.

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TEA are conducted during the equipment acquisition process to ensure that a training subsystem is developed with the same degree of scientific rigor as is the hardware subsystem. Central to this is an analysis of all feasible training subsystem alternatives to reduce training problems to a minimum. By definition, this entails testing to evaluate whether or not available manpower can be trained on equipment designs and if so, to determine the most cost effective way to do so. TEA are also conducted after a system had been fielded in order to verify the degree to which actual effectiveness matches design or to determine if a significant performance gap exists. Figure 1 depicts the role of TEA within the overall training and support system.[6]

TRADOC has established the objectives of the TEA system to be the use of interdisciplinary approaches in order to develop methods and techniques which: (not inclusive):

● best align equipment design (human engineering) and the training subsystem with the soldiers abilities.

● enhance the effectiveness of the training subsystem development process.

● establish equipment/weapons development and training development interface early in and throughout the acquisition cycle.

● increase assurance that anal_sis, design, and development phases of ISD are accomplished in a timely manner prior to fielding the equipment.

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FIGURE 1

TEA SYSTEM FLOW CHART

EA= Actual Effectiveness
(Soldier capability)
ED= Design Effectiveness
(Equipment capability)
ISTEA= Initial Screening TES
TSEA= Training subsystem TEA
TSE= Total System Evaluation
TDS= Training Development Study

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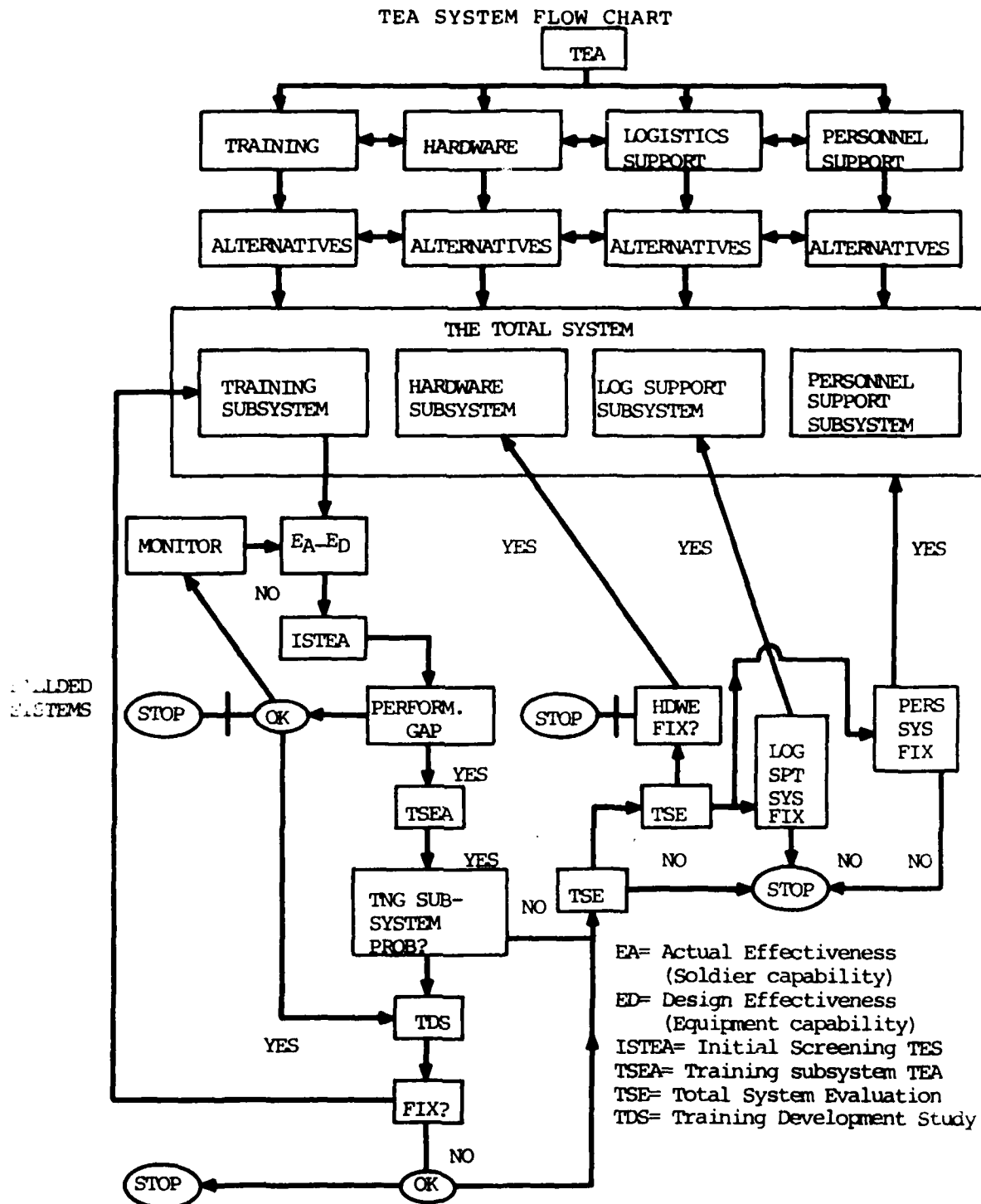
- provide training related baseline data about generically similar fielded systems for inclusion in consideration of developing systems.

The TEA analyst is primarily interested in the determination as to whether a causal relationship exists between demonstrated soldier proficiency and attitudes and the training he has received. If a significant performance gap is found to be caused all, or in part, by the training subsystem, the TEA team must:

- examine the training subsystem in detail to relate the soldier, trainer, training environment, training subsystem and hardware subsystem factors/variables, to obtain precise definitions of training problem areas.

- identify, by excursion, related personnel and logistic support subsystems that cause gaps which may exist. The Training Effectiveness Analysis (TEA) then looks at the training subsystem as complete packages put together by training developers using Phases I-III (analyze, design, develop) of the ISD model. These packages contain all media, materials, materiels, combinations and sequences needed by the trainer to implement phase IV of ISD, which is to conduct effective training.

The problem is that no one knows how to do all this consistently well. TRADOC has had no established TEA management system and past efforts have suffered from inconsistent methodology and quality. As a result, the Army has been unable to close the gap as performance of fielded

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and emerging systems continues to fall short of design

effectiveness in direct proportion to the decline

in soldier quality and the rise in equipment/task complexity.

Basic TEA Considerations

In late 1978 Commander, TRADOC, designated the Director,
TRADOC Systems Analysis Activity (TRASANA) at White Sands
Missile Range in New Mexico as TRADOC Management Agent for
the TEA as it applies to hardware systems. TRASANA has been
authorized the necessary manpower spaces to develop the TEA
methodology and to assist in the conduct of TEA done by
other Army agencies such as the service schools. In addition,
TRASANA is developing a TEA handbook, a management system
and a priority system. In concept, the TEA methodology being
developed by TRASANA provides for developing alternative
training subsystems early in the developmental cycle so as
to compare the effectiveness of each alternative in terms of
demonstrated soldier performance and cost. The best alter-
native(s) is/are selected for implementation. Basic TEA
considerations are outlined in Figure 2.

The TEA process being developed to harmonize these
basic considerations includes research to develop a "soldier
profile" through identification of individual learning styles,
best expressed in terms of psychological processes as to how
the individual soldier learns best. In other words, TRASANA
is seeking a conceptual construct to describe how trainees

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FIGURE 2

BASIC TEA CONSIDERATIONS

are alike and how they differ from one another. Once this

has been established the TEA process seeks to develop an

understanding of the instructional methods and techniques

best suited to individual learning styles to facilitate learn-

ing and skill retention. The final phase is to determine

if the available soldier capabilities match the demands

of the equipment. If they do, then the researchers must

develop the personnel selection criteria and assist the

appropriate branch school to design (Phase II, ISD) and

develop (Phase III, ISD) the training subsystem. If soldier

capabilities do not match the demands of the equipment then
the hardware should be redesigned until the selection crit-
eria and training subsystems provide the appropriate quality
crews who can operate the equipment to design capabilities.

CHAPTER II

AN INTRODUCTION TO APTITUDE-TREATMENT INTERACTION (ATI)

General Perspective

For years it has been believed by educators and
instructors alike that psychologists have been making sub-
stantial progress towards developing rules, laws, principles,
and techniques of learning that would, if understood by
all, guarantee student performance. Recently, however, both
psychologists and educators have begun to have doubts.
McKeachie[1] believes that Thorndike's principles of learning
appear to be "crumbling ": that at least for significant
numbers of people, defining objectives may not result in
better learning; that learning by small steps may be less
effective than by big steps; that delayed knowledge of
learning/training results may actually be a better measure
of the effects of instruction than immediate knowledge;and
that rewards may not motivate all students to do better.
Cronbach and Snow go even further and state categorically
that "there is no such thing as a homogenous group of stu-
dents or a specifiable method of instruction."[2] In other
words, for many soldiers the standard course of instruction
is not the best course of instruction. If this is true,
and the literature provides impressive evidence that it is,
it suggests the need to capitalize on individual differences

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to narrow the growing gap between soldier capabilities and
equipment-job requirements. While some may hold that simply
by training soldiers to criterion we can erase the effects
of individual differences (ID's), a strong case is emerging
that we cannot in fact erase them so much as mask them.
In masking the effects of ID's it is likely that the Army
is merely deferring payment, payment ultimately to be made
in the form of increased time to train, accelerated decay
of individual skills and, ultimately, degradation of unit
readiness. "What lies before us is the task of accumulating
knowledge about how a person's characteristics influence his
or her response to the alternatives educators can offer or
invent."[3]

The Concept of Interaction Research

One approach to the analysis of instructional processes
as they relate to individuals is founded on the investiga-
tion of learner characteristics and educational treatments.
The initial task for researchers is to develop a conceptual
framework to describe individual learner traits. Cronbach
and Snow (1977) do so in terms of aptitudes. They define
an aptitude as "any characteristic of a person that fore-
casts his or her probability of success under a given treat-
ment."[4] Obviously, in addition to our present assessments
of mental ability and aptitude areas, this definition may
include prior achievements, sex, physical condition, in-
terests, ethnic background, information-processing

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capabilities and styles and a host of other, non-test varia-
bles. Many of the implications of this aptitude definition
remain to be developed, but, as will be shown, some initial
directions have been formulated and proven useful. Treat-
ment is defined as "any manipulable variable."[5] A treatment
variable consists of one or more tasks plus the manner of
delivering the instruction, such as curriculum structure,
directions, feedback, step size, program versus lecture
instruction, etc. Unfortunately, at present there is no
firm consensus as to the utility of major constructs of
instructional treatments as they relate to target population
learning styles. However, the literature is rich in the
formulation of testable treatments, many of which will be
discussed in following chapters in a context relating their
appropriateness for use with different aptitudes.

Learning outcomes are best viewed as "interactions."
"Interaction research concerns itself not with interactions
of aptitudes and treatments in isolation, but as they relate
to learning outcomes. Lewin's interaction formula...states
this relationship: $B=f(P,E)$, or behavior is a function of
person and environment."[6] If we view the problem of inter-
action as an equation, as Lewin has done, then we must ask
not only what skills should be learned and in what manner
can they best be taught but we must also ask in what different
ways are evidences of learning behavior to be measured? Do
we demand demonstrated mastery, familiarity, or merely the

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ability to transfer the knowledge to different situations?

Three aspects about the relationship of individual differences (ID's) in learning from instruction seem clear: (1) ID's are far more complex than can be accounted for in a rank order conception of intelligence and they are more fundamental to human learning than most curriculum's recognize, and (2) ID's not only predict individual differences in learning outcome;they also interact with alternative instructional strategies, and finally (3) ID's can be used by the instructional developer, thru the medium of interaction research, to improve instruction for almost everyone. To illustrate the interaction between an aptitude and an instructional treatment refer to Figure 3 and the explanatory paragraph.[7]

Figure 3 (a) simply portrays the differences in outcome of two alternative instructional treatments. Treatment A is considered better than B because average student gain scores are higher after A than after B. Individual student differences of learning styles were not considered here-- rather teaching strategies were the central concern, and learning outcomes were measured by post te ....'c or averages. The addition of learner aptitudes changes Figure (a) to Figure (b) by adding an abscissa representing student aptitudes. A regression line, for the tasks being taught, is determined by measuring individual aptitudes

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FIGURE 3

Hypothetical results of: (a) traditional instructional
comparisons; (b) studies including an aptitude variable;
and (c) studies testing for aptitude-treatment interaction.

By tailoring instruction to Hi-
aptitude students Hi's improve--
but Lo's do worse than before.

By changing Treatment A to
Treatment B Lo's improve but
Hi's decline. To keep all
students at a Hi level it may
be necessary to use two instruction-
al strategies

(a)   (b)   (c)
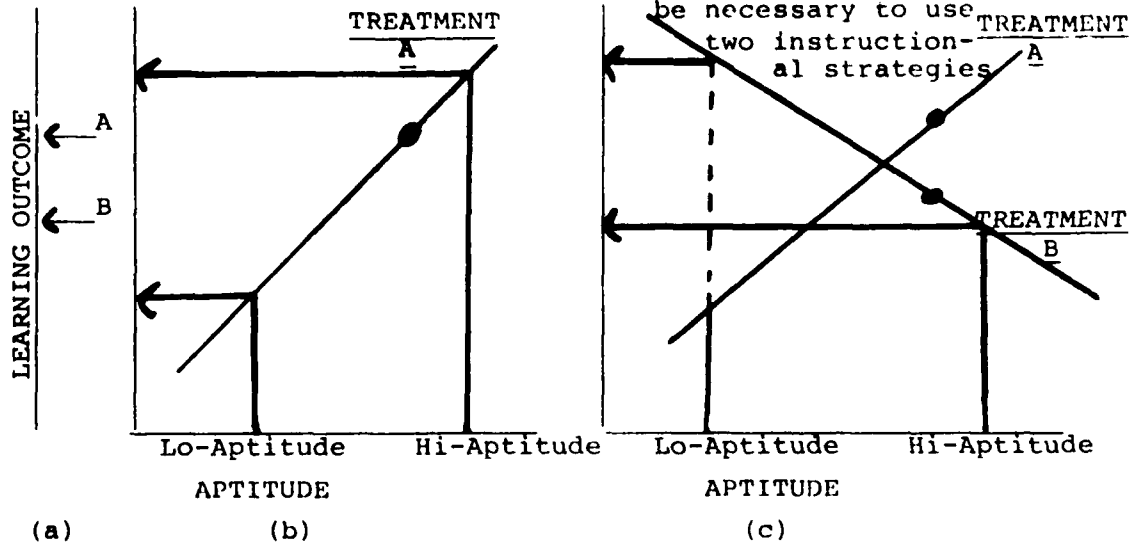
before instruction and then plotting each student as a point

on the graph by connecting the aptitude score to the post

instruction achievement score. The resulting regression slope

can be viewed as a sort of running average across varying

aptitude levels. Naturally, when results look like this,

instructional developers attempt to change the instruction

to benefit the low achievers, while hoping that the high

achievers will continue to perform at a high level despite

changes in the instructional media or methods. However an

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impressive body of research now suggests that Figure (c)
is the more likely result. By improving instruction for
students with one type of aptitude (or lack of aptitude)
instructional effectiveness is likely to be reduced for
others. In this type of situation the proper course of
action may be to assign higher aptitude students to treatment
A and lower aptitude students to treatment B. Results of
this sort indicate the presence of an aptitude-treatment
interaction and it is exactly this capability the Army seeks
to attain through use of ATI research in the TEA process.
Hopefully, instructional theories can be built on such co-
relations if research results lead to full understanding of
aptitude-treatment interactions.[8]

Result (c) in Figure 3 is an example of a "disordinal
interaction," one in which the regression slopes cross.
Traditionally, disordinal interactions have been interpreted
as being "significant," in that this definitely shows a
specific treatment to be best for specific aptitudes, while
ordinal interactions, a situation wherein treatment regression
slopes do not cross, have been dismissed as not "significant"
or as indicating that no interaction is present. Modern
researchers however, do take ordinal interactions seriously
because experience has shown that the aptitude x treatment
interaction regression slopes need not be so pronounced as
to cross to contain useful information for instructional

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developers seeking to improve individual terminal performance by manipulating the manner in which the instruction is presented.

Present State of the Art

Over the past 20 years research into aptitude-treatment interactions has grown substantially. This growth has been characterized by interest in analysis of human information processing in perceptual, cognitive, learning and problem solving tasks. Of major interest in this work is the analysis of the complex learning that is relevant to the real world. While there are literally thousands of individual differences which can never be included in theory, psychologists have recently managed to impose a cohesive structure on a confusing and often contradictory field of research. In particular, Cronbach and Snow have contributed immeasureably to the sum of our knowledge with their recently completed (1977) Aptitudes and Instructional Methods.[9] Some 12 years in preparation, this "handbook" for researchers defines relevant concepts in a mosaic which portrays the central concerns and contributions that have been made in the discipline. It instructs the novice and guides the seasoned researcher to avoid the pitfals of the past. In so doing Cronbach and Snow have prepared a road map by which the researcher can produce data that are of practical use to the instructional developer. This road map is oriented on the principle that learning is the result of neither individual

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aptitudes nor specific instruction but rather the result
of the interaction of the two to produce learning.

If one accepts this view of learning it is evident
that researchers must seek a combination or interdependence
of aptitudes and instruction to better develop optimal
balances of the best educational program for the individual
learner. The Army's long range need is for understanding
of the causative factors that lead a soldier to learn more
and to retain it longer as a result of one instructional
experience rather than another.

The reader is well advised at this point to realize
that to "categorize substantive findings on Aptitude-Treat-
ment Interactions presents an insuperable problem. Dozens
of abilities and dozens of personality traits are used as
aptitude variables (along with sex, age and social class).
Treatments are likewise heterogeneous, and there is no
conventional basis for classifying them."[10] Thus, no magic
formula will be presented. Rather the contribution of this
paper will be to focus future research efforts to improve
soldier training within a framework of the existing organ-
ization, methodology and the Army training and classification
systems, so that we may find out what has happened in a
training experience and what has not happened. This knowl-
edge will hopefully allow us to capitalize on individual
differences by developing an individual soldier profile
relative to learning performance; by refining our personnel

selection criteria; by more precisely defining critical
tasks; and by modifying our instructional alternatives to
enhance performance and skill retention.

CHAPTER III

A MILITARY PERSPECTIVE

Having discussed the present and growing personnel
performance gap, the Army training system, the need for and
c cept of TEA, and defined Aptitude-Treatment Interaction
research, it is necessary to briefly look at past and
present attempts by the military to address the problem and
by so doing to more precisely focus on Army needs

Current Personnel Classification Procedures

Armed Services Vocational Aptitude Battery (ASVAB) and
Career Management Field (CMC) Personnel Selection Criteria.
The basic objectives of the ASVAB are: (1) Established
mental qualifications for enlistment for use by all services;
(2) Selection of enlistment applicants for a particular
military occupation or training course; (3) Classification
and assignment; and (4) To test high school seniors. ASVAB
Forms 6 and 7 are parallel forms of ASVAB 5, administered
at the Armed forces examining station, along with a short
interest inventory (The Army Classification Inventory).

Information about aptitudes is then provided by the
ASVAB; Army requirements are established in quotas set for
each military occupational specialty (MOS) which are grouped

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by Career Management Fields (CMF). There are nine broad

CMF used by the Army. These are: Combat (CO), Field

Artillery (FA), Electronics (EL), Surveillance and Communica-

tions (SC), Operators and Food Handlers (OF), Mechanical

Maintenance (MM), General Maintenance (GM), Clerical (CL)

and Technical Skills (ST).

Research on matching aptitudes to military training

has shown that various combinations of aptitudes and abilities

are of value in predicting success in given career fields.

In the classification process, the aptitudes of individuals

are matched to the demands of the MOS. The current battery

consists of a series of subtests that are combined into 6

aptitude area composite scores for high school students

and 9 aptitude area composites for the active Army. These

aptitude area scores are a primary basis for assignment.

Each entry level training course has a prerequisite score

in the appropriate aptitude area.

Aptitude area composites, subtests, and their correlation

with the CMF are portrayed in Table 1 on the following page.

A summary discussion of subtest and aptitude area composite

composition is at Appendix I.

TABLE 1

APTITUDE AREA COMPOSITES

TEST	APTITUDE AREA COMPOSITES									
	GT	ST	CO	FA	EL	OF	SC	MM	GM	CL
GENERAL INFORMATION (GI)			GI	GI			GI			
NUMERICAL OPERATIONAL (NO)										
ATTENTION TO DETAIL (AD)			AD							AD
WORD KNOWLEDGE (WK)	WK						WK			WK
SPACE PERCEPTION (SP)			SP				SP			
MATHEMATICAL KNOWLEDGE (MK)		MK		MK				MK		
ELECTRONIC INFORMATION (EI)				EI	EI			EI		
MECHANICAL COMPREHENSION (MC)					MC		MC		MC	
GENERAL SCIENCE (GS)		GS							GS	
SHIP INFORMATION (SI)					SI			SI		
AUTOMATIVE INFORMATION (AI)						AI		AI	AI	
ARITHMETIC REASONING (AR)	AR	AR	AR	AR	AR		AR		AR	AR

SYMBOLS: APTITUDE AREA COMPOSITES

FA = Field Artillery   MM = Mechanical Maintenance
EL = Electronics Repair   GM = General Maintenance
OF = Operators and Food   CL = Clerical
SC = Surveillance and   ST = Skilled Technical
       Communications
CO = Combat

Table 2 portrays the correlation between mental category
(a function of individual achievement on the AFQT) and
the GT score, i.e., mental score with spatial perception
factors removed.

TABLE 2

MENTAL CATEGORY AND GT SCORE CORRELATION

MENTAL CATEGORY	GT SCORE
I	130-160
II	110-129
IIIa	100-109 (Avg Percentile)
IIIb	90-99
IVa	80-89
IVb	65-79
V	50-64

Discussion

While the ASVAB has demonstrated a good reliability
coefficient (range for the composites is between .88 and
.92) the validity coefficients have not been established.[1]
Correlation of the subtests against MOS specific critical
tasks is being undertaken by the Army Research Institute;
(ARI) but, to date, the tests have been validated against
only supervisor/survey opinion. While the ASVAB depends

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heavily on cognitive factors for aptitude classification, the Army has turned increasingly to hands-on performance training that places few cognitive demands on the entry level soldier. There are however, many cognitive demands remaining for high skill level training tasks. This said use of the ASVAB is a defacto recognition that people differ not only in size and shape but in their aptitude for specific types of jobs. More importantly, by the existence of the ASVAB the military acknowledges that an aptitude for learning a skill can be measured and applied in an operational selection situation. People who are high on the measure are likely to be successful in jobs involving that skill, while people low on the measure are likely to perform inadequately. Because this is true, it is reasonable and logical to hypothesize that people can also be high in aptitude on specific instructional treatments and will be more successful learners in instructional situations involving that aptitude. Unfortunately, the ASVAB does not make this connection. Yet it is true that the services have made numerous attempts to predict success in training, and in the military overall, based on individual differences. They have also attempted to tailor instruction to individuals so as to remedy learning deficiencies uncovered by the ASVAB and individual performance evaluations. Several of these studies appear to have been well done and are worth reviewing.

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Profile of a Successful Marine[2]

In this study men who joined the Corps during the first year of the all-volunteer force were followed through two years of service. Background and test selection data were related to early discharge to produce a profile of a successful Marine. When reviewing these data the reader is cautioned that not only do people vary between one another but they also vary within themselves from day to day. A person may not behave tomorrow as he did today. This tends to make predictions based on profiles actuarial rather than absolute. With this in mind, let us turn to the profiles of success and failure developed in this study.

The analysis considered only age, race, educational level, number of dependents and aptitude and attitudinal test scores. Three separate profiles were developed:[3]

- Profile 1. based on:

    -- educational level. age and an attrition composite developed from the ASVAB scores and an attitudinal survey.

    -- 14 months of service

    -- N = 3.000

- Profile 2, based on:

    -- educational level (HSG vs. NHSG), age and mental group.

    -- 14 months of service

    -- N = 3,000

- Profile 3, based on:

  -- educational level as a function of number
of grades completed, age, mental group

  -- 24 months of service

  -- N = approximately 46,000

Results

- Most discharges occur in the early months of train-
ing. Unsuitable troops are identified easily and quickly.[4]

- Profile 1 is the best predictor of early attri-
tion. Non-high school graduates (NHSG) and low ASVAB scores,
particularly low AFQT/GT scores, are important predictors
of attrition. However, the "attrition composite" in profile
1 is based heavily on a non-standard attitudinal test whose
transparent nature is such that it cannot be recommended for
implementation. Profile 1 does however, serve to illustrate
the value of such an approach if a non-transparent attitud-
inal test were available for inclusion in the ASVAB.[5]

- Profile 2 and 3 were successful at predicting
attrition with Profile 3 being the more useful as it better
predicts success for non-high school graduates.[6]

- The most successful Marines are most often those
who have completed high school, enlisted at an early age
and scored high on the ASVAB mental group composites.[7]
(CAT I through IIIa.)

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• Race and number of dependents were not found to be significant. Once educational level, mental category and age are known both minority and majority racial groups were shown to have identical chances of success. Figure 4 portrays the premature discharge rates as a function of education, age, and mental group.[9]

FIGURE 4

ILLUSTRATIONS OF DISCHARGE RATE AS A FUNCTION OF
EDUCATION, AGE, AND MENTAL GROUP
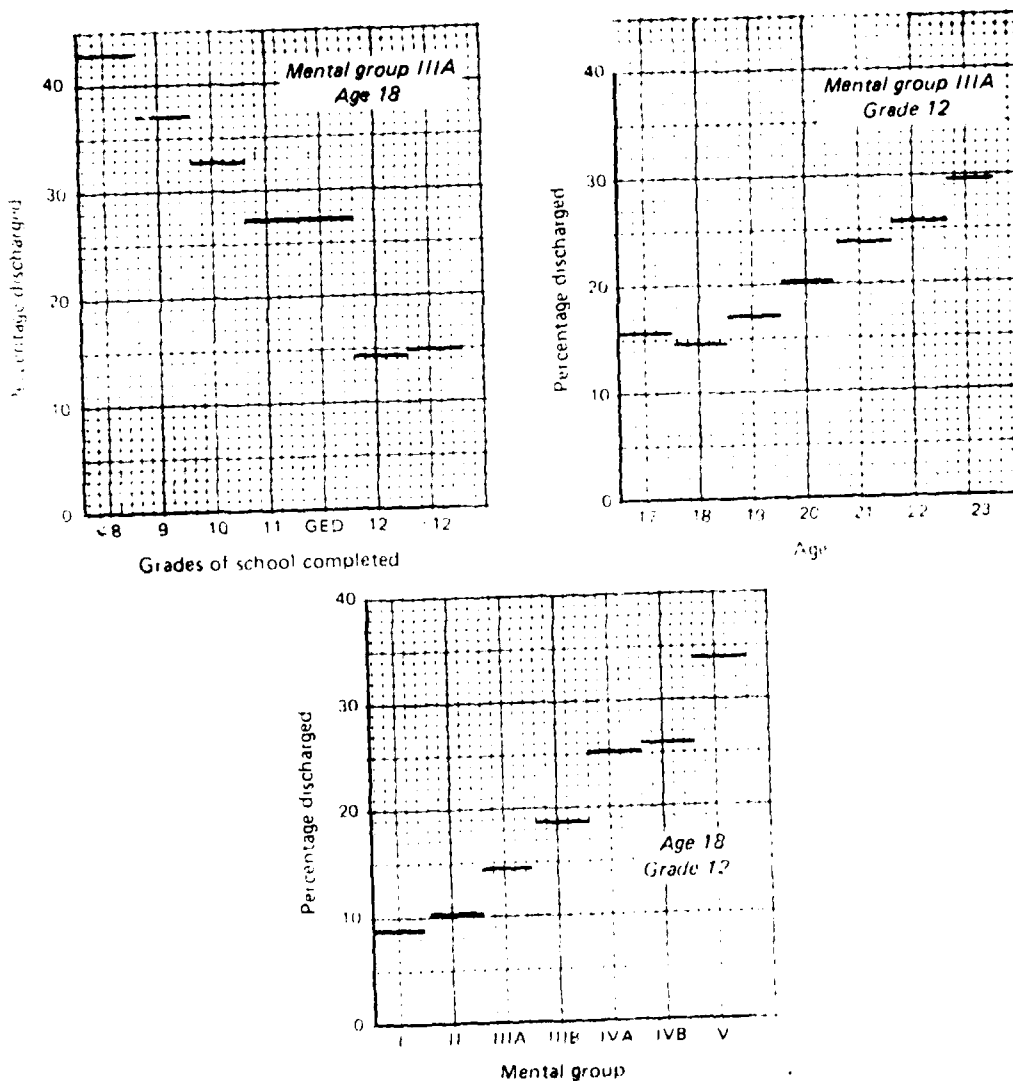
● The distribution in chances of success by educational group (HSG vs. NHSG) is shown in Figure 5.[10]

FIGURE 5

DISTRIBUTION IN CHANCES OF SUCCESS BY

EDUCATIONAL GROUP FOR PROFILE 3
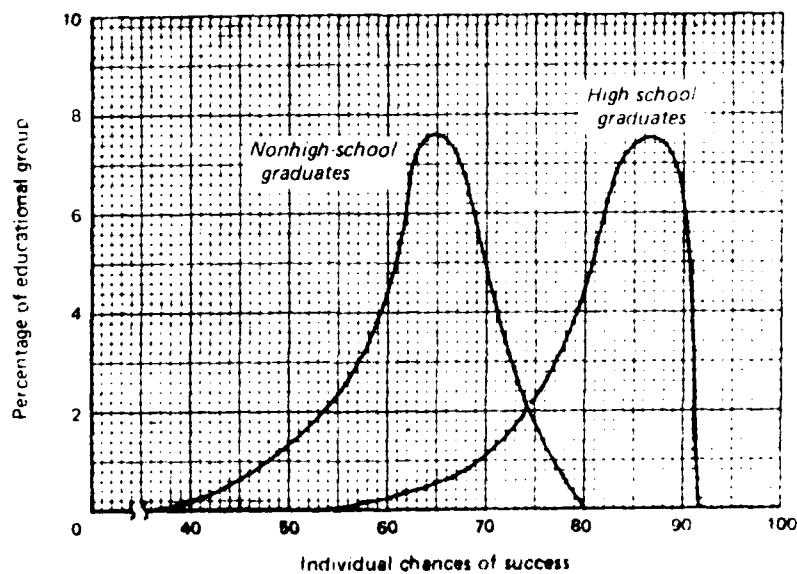
This profile of success is consistent with a previous analysis of USMC school assignment and performance also performed by the Center for Naval Analyses. This study (N = 24,380 students in 84 courses) determined, among other things, that students in electronics courses (EC), who

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were ineligible by virtue of low AFQT and/or ASVAB aptitude
composite scores but were sent to the school in spite of
ineligibility,failed almost four times more frequently
than eligible students.[11] Further, the failure rates of
the ineligible non-high school graduates were more than
three times the failure rates of the eligible high school
graduates. Thus, if the educational and aptitude requirements
for these courses had been met, fewer students would have
been needed to produce the same number of graduates.
Once again, measures of general intelligence and educational
levels were found to be excellent predictors of successful
learning behavior.[12]

The impact of educationally unqualified soldiers ex-
tends beyond the school system into operational units.
The Army's operational testing of the complex AN/GSG-10(V)
Tactical Fire Direction System, TACFIRE, was severely
hampered by the non-availability of qualified soldiers.
The test agency concluded:[13]

     The complexity of TACFIRE will place a
significantly greater unit and formal training
burden on the artillery than presently exists...
one third of the available manpower pool of fire
direction enlisted personnel do not have the
aptitudes which will allow them to pass the TACFIRE
training courses...training deficiencies are a
significant factor in the TACFIRE failure rate.

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Discussion

The reader is now asked to recall the background synopsis introducing this paper, wherein it was noted that a large percentage of entry level soldiers were not high school graduates, most of whom scored in the lower percentile of the AFQT as did a large percentage of the high school graduates.

The results of the above two studies would indicate that a large percentage of these soldiers will fail to successfully complete either their training or their enlistment or both. One must ask two additional questions: (1) How many of these men would have been successful if they had acquired additional skills through individualized training that compensated for their lack of education and reading/arithmetic deficiencies? and (2) How much better would the successful students have performed if they had not been burdened with training structured for the norm, which was probably tailored to accommodate low skill people who comprise the majority of entry level personnel? Obviously, it will require further research to answer these questions, but the lack of an answer does serve to emphasize the importance of TEA and the need to proceed with ATI research. This said, a research experiment that attempted to develop the potential of low ability personnel has been completed with some success. While this experiment did not in fact deal consciously with ATI, it does provide an insight into

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the problems of individualizing instruction for low
achievers. As such it is an appropriate lead-in to an in-
depth discussion of ATI research.[14]

Developing the Potential of Low Ability Personnel

This project was a one year effort by the Human Re-
sources Research Organization (HUMRRO) to develop the learn-
ing capacity of marginal Army personnel.[15] The approach
to this effort was to design an "individualized" instruc-
tional program based on each man's entry level capabilities
and interests.[16] The goals were to provide participants
with the skills and knowledge to manage their own training
and future development, while simultaneously acquiring
basic reading and arithmetic skills. Participants (N = 24)
were all mental category IV personnel who had completed
AIT successfully. Twelve of the 24 were high school gradu-
ates; their mean reading level was at a grade equivalent of
6.86. The mean full scale IQ, measured on the Weschler
Adult Intelligence Scale (WAIS), was 91. Thus they were a
distinctly below average group.[17]

The HUMRRO staff constructed an operational teaching
strategy that provided for the following:[18]

● Feedback

● Individualized instruction to include self-
selected goals.

● Private and small (5 to 6) group work spaces.

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● A "protective" interface between training and larger organization needs.

● Staff selection emphasizing training in inter-personal relations and flexibility and the ability to accept criticism.

The strategy was based on the hypothesis that, although conventional wisdom held that marginal students are of fixed and limited capacity, the creation of a favorable environment for learning would result in noticeable gains in measured intelligence and in basic skills. "...the staff made the unstated assumption...that each participant, given opportunity, would orient himself and organize his efforts towards achieving some goal."[19] The event was dramatically different. The lack of structure led to "chaos and a series of disciplinary problems...."[20] This is largely consistent with the literature on ATI research. Low ability people commonly differ from high ability people in their lack of organization to achieve goals. In this case the researchers found that training requirements were...often secondary to distractors; "spending money to buy clothes, stereos and cars, drinking, smoking marijuana and peer confirmation for their masculinity were often the main focuses of their attention."[21] The first lesson learned then was that a lack of structure impedes learning by creating chaos and disciplinary problems. Low ability personnel need to:[22]

- Improve their basic skills

- Learn to respond positively to authority figures

- Experience success

- Learn to use the community to develop personal
resources.

Trainers of low ability personnel need to understand
that:

- The training environment is as important as the
curriculum.[23]

- Instructor must focus on how their behavior
contributes to the disciplinary problem.[24]

- Each trainer must be capable of providing basic
skills,tutoring and evaluation to help design independent
study programs and counseling.[25]

Results

After a period of from six to ten months this experi-
ment demonstrated that intense, individualized instruction
of low ability personnel (grouped on the basis of their
lack of basic skills and low IQ scores) could improve their
performance (the IQ mean rose to 96.48) and more importantly,
could develop abilities to formulate their own goals and
means of achieving them.[26] While the participants had a
history of few sustained, goal directed, self-development
activities, after training the average participant was
involved with eight self-development activities.   Their

abilities to interact with authority figures had also improved.[27] In other words there are strong indications that CAT IV soldiers are not functioning at their full capacity prior to entering the service and that they will present disciplinary problems for their units until they are trained. On the other hand, these CAT IV soldiers were still functioning at below the GT score 50th percentile even after six months and more of intense individualized instruction.

At this point the reader must seriously question the Army's capability to devote this amount of resources to achieve so small a gain. Further, an emphasis on individual well being and achievement of civilian related job skills (no matter how satisfying), rather than on individual and unit training, may be counter productive to the development of a cohesive and responsive Army. The authors of the HUMRRO study, however, believe that individualized instruction, to improve basic skills, to instill discipline by improving interactions with authority figures, and to provide an experience of success through development of personal resources, is well worth the cost. Given the numbers of low ability personnel entering the Army and the growing performance gap, they contend that it is worthwhile in "terms of greater technical skill acquisition and a greater sense of responsibility and accountability."[28]

Whether or not this program with this type soldier is cost effective, if one assumes that prior civilian educational experiences resulted in low learning levels, the experiment did demonstrate an interaction of aptitude (low) with an instructional treatment. This treatment was characterized by quality control of instruction/learning, based on performance criteria, small group and peer instruction, feedback within a functional context wherein students had to use previous learning to achieve new learning within a framework of self-generated goals and organization and discipline.

As will be seen in the next chapter, this is consistent with the literature on ATI and tends to support a conclusion that individualized instruction based on aptitudes and traits is a workable concept. It also demonstrates that the broad diversity of ability "makes collective descriptions of limited value...many (students) spent most of their time resolving emotional problems which made concentration on other skill development nearly impossible."[29] In other words if the Army is going to train them at all it will have to be individually--at least until basic skills, discipline and self-development skills are acquired. All of this leads to the next step into the world of ATI, a review of the literature to encapsulate what is known about ATI and what should be learned before making changes to existing training programs and procedures.

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CHAPTER IV

A SUMMARY OF THE LITERATURE

A review of the literature of ATI reveals a dismaying
diversity of theory, experimental design and contradictory,
non-replicable results. It is important to note straight
away that "no interactions are so well confirmed that they
can be used as guides to instruction."[1] No general princi-
ples have been developed and no generally agreed language
to describe aptitudes, treatments, nor type interactions
has emerged to guide the researcher or instructional developer
in his endeavors. The literature is as rich in criticism of
past studies as it is in conclusions. General principles
have not emerged because study findings have rarely, if ever,
been confirmed when different tasks or curricula were used
or when similar studies on the same tasks with different
learners, or the same learners at different times, were
undertaken.

As Bond and Glaser have noted in their review of
Cronbach and Snow (1977):[2]

> Even when allowance is made for the
> methodological flaws of many studies, one is
> still struck by the lack of a coherent picture
> and the absence of any prescriptive assistance
> to instruction.

However, this same review noted a trend that cannot help but cheer those engaged in this research.

> A pattern seemed to emerge suggesting that the more promising results appeared in precisely those situations when investigators were forced, in a word, to think quite explicitly about what they were doing because no ready-made and labeled aptitude tests were available.[3]

Precisely so. What is available are lessons learned that can be used to analyze specific instructional situations. As quickly becomes evident, the use of existing psychometric measures in ATI research must be reinforced by scientific analysis of the processes "that relate aptitude, treatment, and the knowledge or skills being learned."[4] Because neither the traditional psychometric tests nor past ATI studies provide adequate prescriptive data, they do not establish a basis adequate for design of instructional treatments that correlate with individual aptitudes. However, recent research has identified the methodological errors of past studies and formulated methods for future research on aptitude-treatment interactions and statistical analysis techniques.[5] The Defense Advanced Research Projects Agency (DARPA) has also compiled an extensive, selective review of the literature on instructional strategies and individual differences.[6] The reader interested in tracing data to primary sources or desiring an overview of the central contributions being made in this field can simply turn to these volumes to gain admission to the discipline.

The purpose of this chapter is to encapsulate the scope
and range of the research in order to focus what is known
and what is known to be unknown within a context of the
TRASANA TEA program. What follows is a summary of the
major lessons learned in ATI research to date. In short,
this and following chapters set forth how what we know
about ATI can be used in TEA and what remains to be explored.

Lessons Learned About ATI

Aptitude-Treatment Interactions exist. "The substan-
ive problem...is to learn which characteristics of the per-
son interact dependably with which features of instruction-
al methods."[7] Careful analysis and synthesis of the liter-
ature reveal quite a bit about what is known as well as
what remains to be discovered about ATI.

Aptitudes

● While controversy exists over whether researchers
should concentrate on a few key dimensions of aptitude or
try to consider the many dimensions required to fully char-
acterize the individual, it appears best to focus initially
at least, on a short list of significant traits.

● Measures of general abilities such as those
measured by the ASVAB AFQT/GT subtests, (word knowledge,
(WK); arithmetic reasoning, AR); etc.) predict the amount
learned or the rate of learning or both. Special abilities
such as psychomotor skills, auditory abilities, biologic

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reactions, etc. interact less frequently with instructional

events and do not relate to subsequent performance as

strongly as do general abilities.[8]

● Measures of scholastic ability or academic

achievement do often predict learning of new material--the

correlation is often in the range of 0.40 to 0.60.[9] However,

individuals learn at different rates and also adapt to

different instructional conditions at different rates.

Insofar as learning rates are evidenced by performance, the

effect probably cannot be attributed to any single apti-

tude but has to be attributed to information processing

skills and motivation.*

● "intellectual development is cumulative: the

person who succeeds in early intellectual adaptations lays

down skills and attitudes that help him...later.... For

this reason measures of past achievement are thought to be

good indicators of learning aptitude."[10]

Interaction

● Significant interactions are more likely to be

realized in treatments extending over several weeks than in

short experiments.[11] Training courses selected for

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  * Information processing and associated research
models will be described later in Chapter V, *Research
Methodologies*. Suffice it to note here, that this is
a complex area of aptitude differences dealing with the
learner's ability to detect, analyze and evaluate incoming
information. Motivation, thought by many to be a key
factor in learning, will be discussed separately later
·· this chapter.

evaluation of learning style interactions should be of at least two weeks duration.

● One can mask individual differences only by restricting the faster learner. Students high in an aptitude central to the training at hand or high in general ability will profit from the opportunity to process the information at their own pace in their own way. Lows however tend to be handicapped by this type instruction. This is not a universal rule, but it encompasses a wide range of results.[12]

● For some instructional content, using audio-visual/symbolic techniques to replace or supplement verbal instruction helps persons of low general ability to learn.[13] This has not proven to be as beneficial to high ability people and may even be detrimental to them by lowering their motivation.

● No evidence has been found to support a thesis that programmed instruction, using small steps with continual overt response and correction techniques, is helpful to lows. Nor has branching to enrich programmed instruction been found to be helpful to highs. The conclusion is not that such treatments do not interact with student aptitudes; it is that the interactions are not predictable. Sometimes they (the programmed texts) do help as predicted. Sometimes not, and sometimes they interact in the direction opposite to that predicted.[14]

●   Instruction that is heavily verbal frequently
is more fruitful for those of high general abilities, but
is detrimental for lows.[15]

Prior Learning

●   Findings that most clearly match special aptitudes
to special instructional techniques are the interactions that
use prior experience. A treatment works most efficiently
for those who have already developed skills in using the
treatment. Thus, inferior performance need not be a fixed
inaptitude as the ability to perform evidently is rooted in
experience with a specific type of instruction. Rather,
the poor performer is simply not yet ready for the instruc-
tion.[16] This was clearly and consistently demonstrated during
ARTS sponsored TEA in 1978.*

Personality Factors

Interactions traceable to personality factors have been
found in the ATI literature with "considerable frequency,
and some combinations of variables and treatments appear
more promising than others."[17] Personality variables are
many, complex and evidently not always completely understood
by ATI researchers.

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*   See the Army training study, Final Report, data
book, Aug. 1978, pages SQ 2-3 which discusses the influence
of prior experience on training time and costs to attain
criterion terminal performance.

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However, one of the basic principles of psychology is
that all behavior has a purpose. In the simplest terms,
a person is motivated to act or to refrain from acting in
order to satisfy a perceived need (aside from the need to
satisfy basic physiological needs) such as to reduce anxiety
or to satisfy a need for achievement. Thus personality
variables may be viewed for purposes of ATI research as
motivational constructs. A major problem for the Army,
however, is the fact that the Department of Defense (DoD)
does not now routinely administer personality inventories.
As noted by the Office of Naval Research study on the pro-
file of success in the Marine Corps, there is need for the
"development of non-transparent psychological tests designed
specifically to predict success in military service."[18]
Such development is indeed required. At this time a great
many personality variables are surfaced in the literature,
often without a common, cohesive behavioral definition
of the trait. This said, it is evident that some personality
variables do seem to hold promise for ATI research. These
are: traits of anxiety, and need for achievement, or their
opposite extremes, low anxiety, low need for achievement.
Anxiety, sociability, and need for affiliation may also
have strong effects on motivation.

Before going on it is important to differentiate between
a personality trait and a state. One who is generally

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fearful, nervous, and concerned to the point of distraction from the task at hand, could be labeled as an anxious person--this being his predominant condition. Anxious learners under even mild stress may become paralyzed by confusion and turn in an inappropriate performance or even give up entirely. Conversely, one who is normally calm, sedate, and secure could be moved to a state of anxiety by circumstances. This anxiety state is similar to an anxiety trait but is temporary and need not necessarily be treated by individualized instruction. Some studies do indicate that a mild degree of anxiety is necessary to motivate a student to learn.

• Single personality trait studies have identified the important variables discussed above but no single trait has been found that, by itself, contributes as significantly to the students response to instruction, as they do in combination. As an example, a study by Domino produced consistent evidence of interactions of instruction with learner need for achievement. Performance was better when the instructor encouraged the student's natural style. Domino's aptitude variable was the difference between achievement through independent action (Ach i) and achievement through conformity (Ach c) to rules and the desires of others. Domino administered the California Personality Inventory (CPI) and scored only the Ach i and Ach c scales. Those high on independence describe themselves as self-reliant,

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demanding, and mature. Those high on conformity describe
themselves as responsible, sincere, organized, and efficient.
These are both favorable self images that differ in kind.
Those whose self-image is not favorable will not score high
on either scale. High independents did best when the instruc-
tional media favored conformity.[20] Further, there is
evidence that anxiety traits combine with the need for
achievement, with students high on anxiety being helped
more from a teacher-dominated class structure and students
low on anxiety doing better with student-centered instruc-
tion. From these experiments a considerable theory has
emerged emphasizing the combination of need for achieve-
ment with anxiety as the predictor.[21]

• Motivation which, of course, often results from
recent motivational experiences such as expectation of
reward and understanding of relevance, can also be condi-
tioned by long term success or failure in like circumstances.
Many research scientists aggreate measures of anxiety,
sociability, need for power and/or achievement within con-
cepts of motivation. Cronbach and Snow employ the concept
of "defense motivation" and "constructive motivation" to
categorize individual motivation traits. Defensive motiva-
tion refers to those who are alert to threats and who
organize their responses to the environment so as to handle
a particular threat effectively. Constructive motivation

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encompasses need for achievement or other ..... that tend
to motivate towards seeking success.[22] Motivation appears
to occur in a three phase cycle:[23]

1.   The motivated state

2.   A stress situation leading to action

3.   Relief as a result of action.

An impressive amount of evidence confirms the importance
of constructive motivation to learning. The Domino study
indicated that motivated students respond better to instruc-
tion that places responsibility for learning onto the student.
It is not equally clear that the unmotivated student responds
less well to less directive treatment, but the literature
does indicate that students who are not motivated to learn
need more direction.[24]

Motivation as it relates to recent experiences may be
such a transient trait that it is difficult to envision a
way for it to be of much use to the ATI researcher except
in terms of motivated or not motivated. One approach would
logically seem to be to determine what motivated the soldier
to enlist and to separate his expectations regarding training
and education and seek to capitalize on these to maintain
his motivated state throughout his service. One problem
with this approach is the fact that ATI research indicates
strongly that individuals do not always learn best that which
they enunciate as being most desirable to them. With that
caveat, recent surveys by various Army agencies appear to

point towards a need for skill development and educational
benefits to be the main reasons why a majority of young
people are joining today's Army.

One such study was recently completed by the community
Mental Health activity at Ft. Knox, Kentucky, which surveyed
1,068 armor trainees who underwent training during May through
August 1978.[25] All individuals included in the sample were
surveyed prior to undergoing basic and advanced training.
Thus, their original motivations, and her positive attitudes
towards the military, were presumed to be intact. The
sample was analyzed by educational level, high school vs.
non-high school graduate), age, and reason for joining.
Of the 860 high school graduates in the sample, 58% reported
the desire for educational benefits as their prime reason for
joining, while 51% joined primarily secondarily to
"develop a special skill." The non-high school graduate
joined for similar reasons; 62% stating the desire to develop
skills as their primary reason for enlisting, while 61%
joined for the educational benefits. Both groups revealed
a strong desire to help the country. Four statements were
selected as reasons for joining the Army by more than 50%
of the sample studied:[26]

- I wanted to develop a special skill
- I wanted the educational benefits
- I wanted to travel
- I wanted to help the country

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These data are consistent with the majority of attitudinal
surveys conducted for and within the military. It doesn't
take much imagination to put these data together with the
results of ASVAB testing and the USAIS Reading Study to
produce a picture of young people who have not previously
been successful at learning who have joined the Army in order
to correct their deficiencies and to acquire skills. It
appears that if the Army can catch them at the beginning
of their training, instructional developers can capitalize
on positive motivation/attitudes to individualize instruction.
Hopefully, early success in learning will have positive
effects on subsequent training, discipline and retention.

   • Other personality traits, singly and in com-
bination present an essentially unfocused picture.[27]

Cognitive Styles

   The term "cognitive Style" refers to patterns of informa-
tion processing. Cognitive styles seem to mediate between
personality variables and aptitudes as they apply to instruc-
tional strategies. Use of the term is often made to dis-
tinguish styles from abilities, although this distinction
is blurred and it is difficult to determine a practical use
for this concept. Two stylistic variables that appear
to have promise in ATI research, however, do appear often
and positively in the literature on interactions. These are
"conceptual level" (CL) and field independence (FI). These
"styles" seem to reflect both ability and personality. Hunt

and Sullivan [28] did early research on the CL con-

cept.

Conceptual Level

CL is assessed by essay and sentence completion tests
to determine individual levels of conceptual complexity.
The complex person is believed to view his world as both
differentiated and integrated. The person who perceives
his world in stereotypes does not. Persons high in CL show
a greater tendency to think abstractly than do lows and are
generally more mature in their personal relations. They
are more tolerant of stress, and thus perform under pressure.
Hunt, et.al. have hypothesized that CL will interact with
the structure of a task. High-CL persons are thought to
do better with less structure; lows do better with more
structure. Instructional variations of structure might
include highly teacher centered courses versus self-pacing,
teaching problem solving rules versus teaching by examples,
etc. Cronbach and Snow (1977) reviewed the significant
ATI research on CL and found the need to combine an analysis
of academic aptitude along with CL to better explain signif-
icant ATI results.[29] This said, the research does tend to
support Hunt's hypotheses that low structure instruction
serves high-CL groups better and structured instruction serves
low-CL groups better.[30] However, it is also noted that
"...persons high in ability and low in CL did considerably

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better under external direction..." than did persons high

in CL and low in ability. In other words high CL cannot

offset poor overall ability.[31] Once again, it is evident

that general ability is a powerful predictor of learning

performance and should probably be used in all aptitude

constructs.

Field-Independence

The principal work on field-independence (FI) had been

done by Witkin[32] and his associates. FI is usually deter-

mined by results of Embedded Figures in which the individual

must detect simple geometrical figures contained within

more complex figures, or performance tests such as the Rod

and Frame test, in which the subject is required to directly

or indirectly adjust a moveable rod to the true vertical

position while the rod itself is located in a separately

tilted frame. Persons able to identify a simple figure or

a vertical position in a complex context are said to be

field-independent or able to analyze complex situations

rapidly and accurately. One who has difficulty in doing so

is said to be field dependent.[33] A relatively few studies

have examined the interactions of FI with instruction. These

studies have found that it helps to make instruction similar

in style to that of the learner. That is, if the learner

is high-FI then instruction should center around discovery

and application of concepts; if the learner is low-FI

then instruction should avoid dealing with concepts and should substitute the teaching of rules and procedures. However, as noted by Cronbach and Snow after a complete review of past research, there are "...enough inconsistencies to make generalization (as to the ATI of FI) impossible for the present."[34] As with conceptual level (CL), it will be essential to quantify the effects of FI in a multi-trait experiment.

ATI Testing

Instructional comparisons in the literature invariably involve measures of central tendency. This tends to weaken the effects of individual differences in learning and performance. Thus, while some students may do better with one mode of instruction while others profit more from a different mode, the use of the statistical mean tends to disguise this fact and on the average no differences between groups would be observed.

Cronbach and Snow recommend that "...ATI research use confidence limits instead of testing the null hypothesis... every report on an ATI study should carry basic descriptive statistics within each treatment. The needed statistics are the mean and Standard Deviation of each aptitude and each outcome, plus the regression slope or correlation for each aptitude-outcome pair...interactions that do not reach significance should be described along with those that do, especially in analyses with low power. Consistent non-

significant results."[35] As a minimum, a careful regression

analysis of the relationship between individual differences

and mode of instruction is required. The truth and impor-

tance of this lesson to researchers and instructional developers

alike cannot be overstated. Time after time study results

have been discounted because correlations were not signifi-

cant at the p.05 level. As a result, individual aptitude

treatment interactions become lost in the group statistics

as researchers strive to separate the chance perturbation

from solid, predictive, results. In reality, finding out

what happened to an individual during instruction and report-

ing it is what is important. Significance testing is then

of secondary importance; a useful guide, but not the final

authority for separating form from substance. Also, Cron-

bach and Snow[36] "...take ordinal interactions (a situation

where two regression slopes do not cross) seriously." And

take them seriously we must, if we are to avoid losing the

forest for the trees; the important thing being the amount

a student or group of students improve under one or more

treatments. (See Chapters II and III of Cronbach and Snow,

1977, for a complete discussion).[37]

   ● Most ATI research has been accomplished with too

few subjects. It has been shown that researchers should

employ samples of 100 subjects per treatment.[38] The numerous

"no difference" and contradictory results emerging from the

ATI literature are most probably the result of the lack of

power resulting from small samples in regression analysis.

"As correlationists are well aware, the sampling variability of a correlation coefficient is surprisingly large relative to its range of permissible values."[39]

The reader should turn to Chapter 3 of Cronbach and Snow (1977) for a complete discussion of the inadequacies of the ANOVA for interaction research and Chapter 4 for advanced statistical analysis topics.[40] These two chapters are highly technical in nature but provide detailed guidance as to use of statistical analysis in testing. As such, they are a must for ATI researchers for use in both the test design and data analysis phases of research.

● As indicated previously, most reported ATI studies have employed treatments of short duration. This has added to other deficiencies of design, analysis and reporting to frustrate researchers and instructional developers alike.[41] Since it has been demonstrated that subjects exposed to treatments for the first time will probably differ in performance from those who are experienced with the treatment, short treatment results are often very misleading. This difference is parallel to aptitudes developed through previous learning. Under such circumstances, an interaction demonstrated early on may well be changed or even reversed in later stages. Therefore test plans must provide for a period of habituation. At the same time, because of the difficulties of transferring results from laboratory settings to natural learning situations, it is advisable to integrate ATI experiments with ongoing training.[42]

• Learning research can be designed to either hold
training time constant or to allow time to vary so as to
allow all students to be trained to "criterion." Research
into programmed instruction is a good example of allowing
time to vary by student as the measure of effectiveness is
obviously time to criterion. Sounds logical. However, for
ATI research there are strong reasons to recommend that
ATI researchers hold time constant. This recommendation
centers around the fact that how much a student learns
within a specified treatment is a meaningful measure of the
effectiveness of that treatment. If time is allowed to
vary then it is possible that treatment A could produce
better post-test scores while treatment B produces lower
scores in a shorter period of time. If times and scores
point in opposite directions interpretation is impossible.[42]
Similar problems arise when soldiers are trained to "mastery"
by being given remedial training until they are able to
satisfactorily perform specified critical tasks. It is
possible however, that terminal performance was not really
uniform. There have been circumstances when this has been
shown to be the case. This was discovered in retention
testing which measured performance differences of ATI
graduates subsequent to unit assignment. Loss of performance
had been attributed to skill decay when in fact the skill
had never been mastered.[43] Thus, an experimental design that
allows time to vary cannot be said to have the compensating
tage of holding learning constant.[44]

In summary the literature reveals general ability to be the most powerful predictor of learning performance and lays out some universally applicable instructional strategies which, together with the lessons learned from pas ATI efforts, can be used as initial ATI principles to support development of the TEA process. An excellent summary of the range of instructional strategies which can be related to individual aptitudes was prepared by the Canyon Research Group, Inc., for the U.S. Army Research Institute (ARI). This quote from their work on developing instructional alternatives for the training of Air Defense (REDEYE) gunners, is included as one of the best available.[45] (A complete discussion of this interesting study is contained in Chapter VI

> The most efficient strategy containing the greatest motivation for high aptitude learners is a non-structured individualized program. The learners in this category should be given the instructional objectives, the freedom to choose their own study method, and to pace themselves... to decide whether to work in groups or alone.... Extensive feedback and motivation are not needed, since this group provides its own intrinsic feedback and motivation.
> In contrast to this, low aptitude learners require complete structure with instructional sequences broken into small steps, a slow rate of presentation, high degree of repetition, elementary language level, with content presented in a functional context, and extensive practice. The presence of a live instructor to provide constant external feedback and motivation appears to be essential.
> Research to date has also indicated cognitive style to be an important learning variable. The extent to which an individual is analytic

or non-analytic (field independent or dependent)
may affect how efficiently and effectively he/
she attains certain skills and knowledge and may
suggest appropriate instructional strategies,
media, and methods of instruction.

The ability to provide structure and re-
organize perceptual information presented as
variations of a structured field can determine
the effectiveness of given instructional method-
ology and a learner's success in mastery and
retention on specific tasks. It has been hypo-
thesized that the greater structuring capacity
will enable field independents/analytics to pro-
vide their own strategies for encoding and util-
izing instructional materials. Field dependents/
...will be more dependent upon the instructional
materials to provide structure and organization
(Goodenough, 1976).

In determining appropriate strategies for
either group, existing research has suggested
that field dependent persons tend to: (1) learn
socially relevant material more effectively;
(2) prefer to assume a passive or spectator
learning role: (3) are more affected by nega-
tive reinforcement; and (4) favor interactive
teaching methods. The field independent person
tends to: (1) assume a more active or partici-
pant learning role; (2) learn more efficiently
with intrinsic motivation; (3) perform better
without feedback; (4) need less external struc-
ture; and (5) favor expository teaching methods
(Rosenberg, Mintz, and Clark, 1977)

In any perceptual/psychomotor task, such
as the one of interest in this study, the learn-
er's perceptual abilities have proven to be
important variables in determining the level of
proficiency that will be attained (Michael, Guil-
ford, Fruchter, and Zimmerman, 1957). ..

In effect, the instructional developer is led to a

dichotomy. A learning strategy would appear appropriate

for high-aptitude learners who are field-independent, low

on anxiety and have a need for achievement thru independent

action. A teaching strategy seems to be the more useful

approach for low-aptitude learners who are field-dependent

and high on measures of defensiveness such as anxiety.

The teaching strategy implicitly encourages rote memoriza-
tion leading to information storage which may not get mean-
ingfully related to other stored material. Such a strategy,
although obviously useful in the Army's present training
situation, is likely to prove maladaptive in many combat
situations where understanding may be far more important
than mere performance of a limited number of critical tasks.
By training low ability soldiers by means of teacher oriented
strategies the Army, in essence, may discourage a soldier
from developing an awareness of his cognitive capabilities:
capabilities that must be developed if the soldier is ever
to grow into the higher skill level tasks required of non-
commissioned officers. This is not to suggest that ATI
results demonstrating the need for teacher centered instruc-
tional strategies are inappropriate. Rather, it suggests
a more complex learning strategy is also needed to develop
the individual's cognitive abilities to facilitate the
transfer of acquired skills later in his service. This is
one reason why TEA is so important. TEA provides the
Army with a methodology for developing instructional strate-
gies of the requisite complexity needed to develop the
young civilian into the trained, mature, skilled soldier.

Chapter Summary

To briefly sum up. The view emerging from the litera-
ture as regards aptitude interaction with instructional
strategy is that the individual must be viewed as a being

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shaped by the interplay of his genetic structure and exper-
iences. For this reason research strategies must provide
for the analysis of information processing and cultural/
personality differences, as well as general and special
abilities. The importance of this perspective cannot be
overstated as this allows researchers to carry measures of
these aptitudes through their studies. Since the literature
is much less clear as to the power of such variables as
creative thinking, impulsiveness, cognitive complexity and
other constructs to interact with treatments,and because
reliable tests are less available to measure these constructs,
research into their effects should be carried on separately,
apace with ATI research so as not to impede progress while
seeking additional information.

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CHAPTER V

RESEARCH METHODOLOGY

Identification of the general results of diverse
studies on aptitude-treatment interactions is useful as
background information but does not provide guidance adequate
for the analyst attempting to continue ATI research within
the context of TEA. What is needed is a theory or model of
the learning process that provides a framework for the col-
lection of data on aptitudes and treatment interactions
and can be used by the instructional developer in the design
and revision of training. The theories and methodological
concepts needed by the researcher are now available. Many
leading psychologists are now working on these problems.
Glaser (1976), Cronbach and Snow (1977), Hunt (1977),
Greeno (1977), Sternberg (1977), Resnich (1976), Gagne (1968,
1970), and many more, have made significant contributions.
A complete discussion of all these important efforts is
impossible in a short research paper. Although only an out-
line and summary of the most applicable concepts about
individual differences can be presented here, it is necessary
at least to generate hypotheses about the cognitive pro-
cesses that distinguish aptitude constructs. Further, it
should be recognized that all relevant concepts and methods
will need to be combined if ATI theory is to be useful in
improving soldier training.

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Because general abilities are known to interact most often and strongly with instructional treatments, this aspect of individual differences would seem to be the most logical starting point from which to construct a research theory.

General Mental Abilities

Berliner and Cohen have discussed the problem of general intelligence (G), and suggest that many instructional situations require such a high level of general intelligence that little variance remains after the effect of general intelligence is removed. For this reason they believe interactions of G with instruction are difficult to detect. They urge discovery of treatments that do not rely on general intelligence.[1] McKeachie[2] and Glaser[3] would apparently agree; both seeking "new aptitudes" conceptualized in terms of the processes needed to perform given tasks. Researchers such as Hunt (1973) have conceptualized learner characteristics in terms of "accessibility" translatable into specific forms of educational environments. Hunt envisions learner profile in terms that describe a specific orientation as: (1) cognitive orientation; (2) motivation orientation; (3) value orientation; (4) sensory orientation.[4] His idea being that these "accessibility characteristics" provide a means of tailoring instruction to an individual's orientations.

These approaches present several problems, however. First of all, very little work has been done on other than the cognitive processes. Secondly, general mental ability

measures are available for use and have been shown to inter-
act with identifiable instructional treatments and, to a
lesser extent, with personality variables more reliably
and often than have special abilities and aptitudes. Lastly,
such characteristics as motivation and values, or even
sensory orientation, are more likely to be transitory in
nature and to be overwhelmed by general ability given a posi-
tive motivation. This suggests that what is needed is a
way to define and model general intelligence in such a
manner that it is compatible with information processing
models. In other words, we need valid terms of reference
to describe what happens during an instructional event.
Snow has provided an excellent theory of general intelli-
gence and linked it to a research framework which serves
to combine other relevant information processing concepts.[5]
Snow's work is useful precisely because he has brought the
research results of others into a cohesive framework.
His paper, entitled "Theory and Method for Research on
Aptitude Processes: A Prospectus," is particularly suitable
for use as a TEA research construct for the development
of soldier profiles as they relate to training. Figure 6
shows a structure designed by Snow to "approximate those
fashioned by Vernon (1965), Cattel (1971), and Cronbach
(1970), and to be consistent with Guttman's (1965) multi-
dimensional scaling of Thurstones data...."[6]

FIGURE 6

HIERARCHIAL ORGANIZATION OF ABILITIES
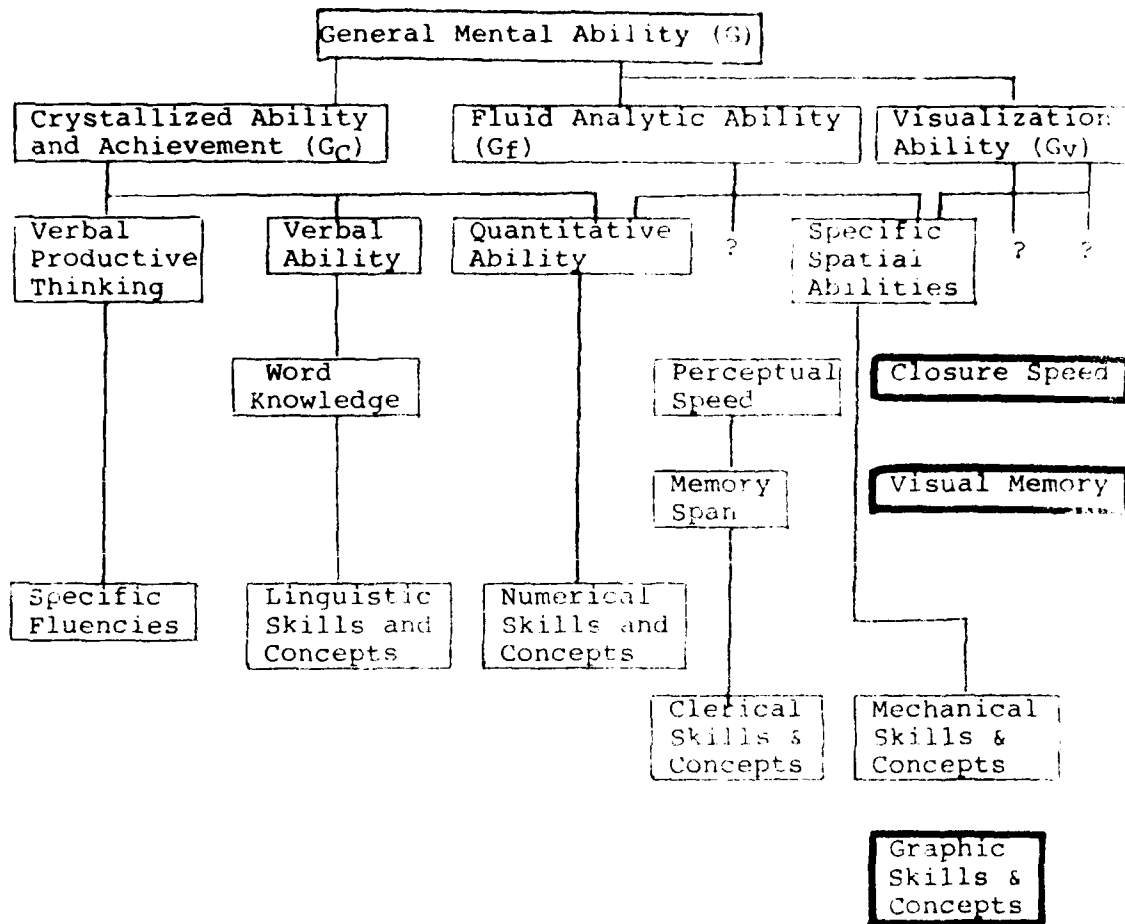
This hierarchical construct provides a framework on which can be placed many of the separate aptitudes and differences discussed in Chapter IV. For a full discussion of Snow's approach the reader should consult the primary source.

General mental ability is divided into three major subdivisions: Fluid analytic ability (G_f), crystallized verbal ability and educational achievements (G_c), and visualization ability (G_v).[7] As can be seen by a review of the ASVAB/AFQT subtests at Appendix I, spatial abilities are also categorized as a component of general mental ability by the military. This is consistent with the literature (Horn, 1976), and is one element represented by visualization (G_v). Other subdivisions of G_v are, however, unknown at this time. Below these, Snow has placed more specific abilities and skills as subordinate, but inclusive of, general abilities. By comparing the elements included on the ASVAB with Figure 6 it can be readily seen that many reliable measures of general ability are already to the TEA analyst. There are, however, more data supporting the crystallized ability and achievement side of the hierarchy than are available for either fluid or visualization abilities (G_f and G_v). This is reflected by the question marks, dashed lines, and the unconnected perceptual speed and memory span boxes in Figure 6. This suggests, of course, that future research should focus on the G_f and G_v aspects of G;

a task more appropriate for ARI than for TRASANA, but

necessary for the mature TEA.   As concluded in the

Chapter IV summary of the Literature, ATI researchers

should deal with as few aptitude variables as possible

and should allow additional ones only as demanded by the

data.   The hierarchical organization of aptitudes in

Figure 6 assists the researcher in this regard as one need

not interpret an interaction in terms of a special ability

unless it can be shown that a more general mental ability

does not account for the result.   Snow's hypothesis con-

cerning this hierarchy is that:

> ...the vertical dimension...represents differences
> in reference generality among ability constructs.
> Constructs at higher levels typically refer to
> higher classifications of tasks...that are likely
> to transfer to...a broader range of intelligence
> measures.

A compilation of the varied definitions of major human

abilities portrayed in Figure 6 is to be found in

Appendix II.

By starting with the hierarchy in Figure 6 it appears

that the researcher has a foundation upon which to build his

initial framework that has not been provided elsewhere.

The next step would logically appear to be to build on

this general abilities model in two ways:

a.   Additional laboratory research is needed to

develop fully the range and scope of the G_f and G_v subelements,

and their relation to other G constructs.

b.   A theory is needed to connect the hierarchical model of G with a concept of information processing to answer the question as to how an individual uses his general abilities to translate instruction (stimulus) into performance (response).   The first requirement is beyond the scope of this paper as it will require extensive long range research. The second requirement has in fact been largely accomplished. Snow has synthesized the works of numerous researchers to link the gross concept of stimulus-response into a transformational schema, which not only builds on the concept of "G" shown in Figure 6, but also provides a framework for testing and evaluation which should be useful in TEA.   While lacking precision and oversimplified, this schema maps the transformation into three hypothetical phases: (1) Cognition, i.e., discovery of new information through the stimulus of learning; (2) Production, i.e., thinking in terms of patterns, systems, and transformations; and (3) Evaluation of the implications and adequacy of possible responses. By synthesizing this concept of the stimulus-response theory with the hierarchy of general ability, the researcher can construct a hierarchical learning taxonomy useful for designing ATI experiments and data evaluation.   Figure 7, Snow's schematic coordination of learning and ability hierarchies provides such a taxonomy.   In Snow's words:

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FIGURE 7

SCHEMATIC COORDINATION OF LEARNING AND ABILITY HIERARCHIES
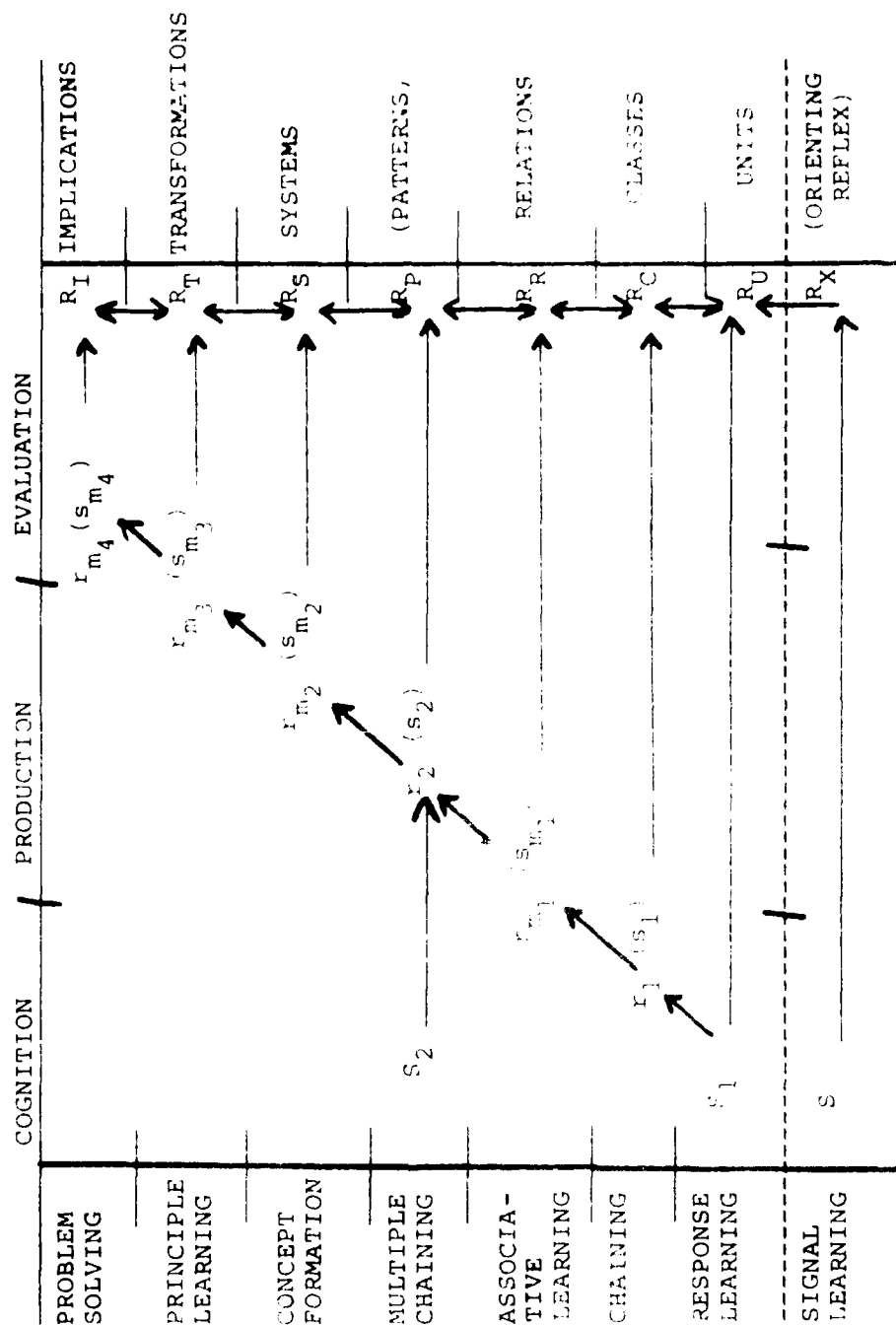
> The ordering of steps implies further
> that abilities representing these operations
> product cells...both reflect prior learning up
> to the associated...level and predict individual
> differences in new learning at those levels.
> One could imagine the design of learning tasks
> to represent several adjacent levels or stages
> of learning and their use in research aimed at
> correlating individual differences in learning
> at each level with ability tests chosen from
> the corresponding response product hierarchy.
> The hypotheses would be that measures of gen-
> eral ability would correlate with learning in
> all stages, if the task began at the simple
> response learning level. Specific tests chosen
> to represent particular products would correlate
> primarily with performance at the associated
> learning level.[10]

Chapter 5 of Cronbach and Snow's "Aptitudes and Instruc-
tional Methods" had a discussion of the few studies which
have tested this type hypothesis.[11]

While research is necessary to validate and refine
these levels of learning, they do provide a framework for
continuing ATI research that is superior to that found else-
where in the literature. The hierarchy in Figure 7 provides
a continuum of increasing complexity in learning and ability
which facilitates conceptions of the learning process and
allows the ATI researcher to continue to build a test methodol-
ogy. The simplest ability tests and learning tasks involve
understanding of units, classes, and relations. The more
complex tasks involve the skills associated with the under-
standing of systems, transformations into new tasks/skills
and the evaluation of implications being the most complex.[12]

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This is consistent with what has been established in the literature concerning high versus low general abilities and provides a needed link between "G" and performance as a result of learning.

While Snow (1977) admits this is now all "mere speculation" the construct is compelling precisely because it is consistent with trends established in ATI research and, dare it be said, it is intuitively satisfying in that it corresponds with the common knowledge of the existence of a hierarchy of difficulty in learning and real life tasks.[13]

A Stimulus-Response-Response (S-R-R) Pattern

Mention has been made of the well established stimulus-Response theory. If the concept of learning in Figure 7 has validity however, an intervening response, conditioned by individual differences, is to be expected. That is to say that a psychological theory linking a stimulus to a behavioral response should encompass the process believed to occur within the individual. As an example, if a student must translate numbers or figures into concepts before he can react appropriately to a stimulus, then complex or poorly organized numbers or figures will take longer to translate and will likely be incompletely conceptualized under conditions of short exposure or reaction time. The degreee of concept completion--the middle R--can then be thought of as a cognitive aptitude which differs among individuals. Snow makes this

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point in proposing a Stimulus-Response-Response model for research on individual differences in psychological processes. This S-R-R model is necessary if efficient use is to be made of what is known about information processing because it provides the link between the hierarchy of learning and ability in Figure 7 and useable information processing concepts necessary to develop instructional strategies for specific groups of individuals.[14]

Snow points out that for research on individual differences in psychological processes the two response variables must be measures applied to the same subjects which yield individual scores for each subject. He states the S-R-R paradigm succinctly as:[15]

> ...effects of experimental manipulation...
> are reflected in changes in the R-R inter-
> relations as well as the mean of each R.
> The middle R might be truely an intermediate
> response measure in an experiment, or it might
> be a measure of an individual attribute taken
> before the occurence of S. (before the train-
> ing). All experiments on ATI are instances of
> the latter type. The aptitude, while measured
> before treatment, is presumed to represent
> individual differences on an intervening varia-
> ble essential for learning.

The utility of this construct for ATI research and the TEA analyst is obvious. If the manner in which an individual processes stimulus information is a predictable variable reflecting aptitude and if the ultimate performance (the

second "R") is dependent on these differences, the concept of ATI is not only reinforced but an experimental methodology applicable to TEA goals and objectives is also indicated.

Information Processing

Information processing models are increasingly important to the psychology of human learning. These models, largely supported by computers, provide a basis for increased knowledge as to the complex cognitive processes connecting stimulus and response. The literature on information processing is both complex and lengthy and a detailed discussion is beyond the scope of this paper. However, an adequate information processing model is essential to a well designed ATI experiment if an interaction between aptitudes and instructional treatments is to be made. Bower (1975) provides an outline of the major elements of most information processing models.[16] Snow (1976) uses this as a framework within which to consider individual differences in information processing. Bower begins by making a distinction between the initial perception system, short term memory (STM), intermediate memory (working memory) (ITM) and long term memory (LTM). Within these are assumed to be subroutines to detect, analyze and evaluate incoming information in order to recognize patterns and to add previous knowledge to new information. The theory is that STM maintains the spatial and temporal order of the information

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and categorizes and relates groupings of data. Thus, the STM allows the individual to react rapidly to information conveyed by the eyes, ears, nose, etc. However, since STM does not store information, people use the ITM to maintain data concerning the task setting and local environment within which the overall activity is taking place. ITM maintains the ongoing situation in a coherent manner while STM is actively engaged in learning/performing. LTM is the site of storage for permanent knowledge, concepts, attitudes and skills. Data are withdrawn from LTM to update/improve more limited data available in ITM and to improve the quality of the overall problem solving performance.

As portrayed in Figure 7, tasks are believed to differ in their complexity. Snow (1977) has translated the implications of Figure 7 into information processing terms and added Bower's concepts of STM, ITM and LTM to analyze learning, ability and problem solving. The hypothesis is that individual differences in information processing are at the heart of observable differences in learning. Because no simple list of standard differences or measures of differences are likely to be generalized across the population or to remain static over time, it appears necessary to establish difference sources and kinds of individual differences in information processing and to show how they can be combined and/or further differentiated so as to determine how they work in combination to produce differences in performance resulting from distinct instructional treatments.[17]

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As discussed in Chapter IV there is evidence that familiarization alters individual differences in learning and that various personality and motivational factors tend to modify the role of ability in learning. Further, as Snow points out, measures of individual differences may be relatively unimportant in simple learning and become highly important and intercorrelated in more complex learning. People may also differ in the sequence each uses to accomplish a common set of information processing steps, or may differ in the routes or alternatives they choose to employ to process the data.[18]

To keep these logical possibilities distinct, the use of four different sources of differences in information processing appears to be necessary. These are:[19]

- Parameter differences (P-variables) which refer to differences on particular steps of components such as capacities of STM, times needed to process information, amount and quality of information in the LTM, etc.

- Sequence differences (Q-variables) which refer to individuals taking the same steps but in different sequence.

- Route differences (R-variables) which are indicated by qualitatively different steps taken such as double checking the data, use of audio derived data in preference to visual, etc.

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● Strategic differences (S-variables) represent individual differences in complex learning and problem solving. This category would include large differences in assembly and structure of memory and programs. The S-category is necessary to account for themyriad complex differences known to be present in learning and which cannot be accounted for by the simpler variables of P, Q, and R.

In their work, Newell and Simon have developed some definitive statements about the kinds of individual differences found in the processing of complex information. Snow has paraphrased their observations as follows:[20]

> 1. Subjects differ in the detailed contents of LTM when beginning a problem. This places constraints on the problem spaces and programs available for use.
>
> 2. Subjects differ in the way they characterize the initial problem. They learn gradually which aspects of the problem should be given first priority and which can be ignored.
>
> 3. Subjects differ in persistence in pursuing a subgoal and, conversely, in their readiness to return to the overall problem in pursuing a complete solution.
>
> 4. Subjects differ in the priority given to restructuring the problem as information is acquired as opposed to working in the framework of a definite plan.
>
> 5. Subjects differ in the cues used to detect lack of progress toward a goal.
>
> 6. Subjects differ in trying to explore paths mentally, as opposed to writing out expressions for examination.

7. Subjects differ in the degree to which operational rules are associated directly with problem features, reducing the need for searches to find appropriate rules.

8. Subjects differ in acquiring knowledge that certain features are not remediable, indicating termination of search, while other goals are automatically achieved by fixed sequences.

These kinds of differences suggest the possibility of adapting instruction to suit specific situations resulting from the interaction between individual information processing differences, task complexity and type, personality variables and instructional environment differences. Snow goes on to observe:[21]

> Thus the problem for further research will be to distinguish P, Q, R, and S sources of individual differences, and to show how they can be combined and/or further differentiated. Information processing models of particular tasks or tests will need to show how these kinds of differences work in consort to produce observable differences in performance. Aptitude variables (A), and instructional treatment variables (T), and their interactions will need to be analyzed and understood in these common terms. This will best be accomplished by a combination of Q, R, and S variables, and experimental research that manipulates T in ways that influence these relationships. This suggests...the value of an elaborated S-R-R paradigm.

Some ways in which treatment may be related to strengths and weaknesses in information processing are suggested in the literature. Salomon (1972) and Cronbach and Snow (1977) have discussed alternate models that are defined by the manner in which treatments are used. These models are:[22]

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- The preferential model, which capitalizes on the learners assets.

- The compensatory model which provides compensation for learner weaknesses.

- The remedial model, which attempts to overcome some deficiency in the learner. Since proficiency in a specific task may depend on how well the basic information process and relevant knowledge have been organized into an effective program,it is useful to think of the above differences in terms of these corrective treatment models.

A review of the literature reveals concepts that are supportive of the S-R-R and information processing models and which reinforce the conclusion that these combined theories are likely to be productive in ATI research. DiVesta[23] stresses that ATI studies would be more productive if cognitive processes were considered which correlate with traits induced by instructional treatments, and Shapiro identifies three distinct concepts of mental ability differences which could be used in testing aptitudes.[24]

- General mental ability.

- Finer distinctions such as those considered in models such as Guilfords' Structure of the Intellect and hierarchical models in which general ability underlies more restricted abilities.

- Problem solving approaches (mental processing, perceiving, coding, storing and retrieving information.

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Gagne (1974) presents a classification scheme consisting of five categories: (1) verbal information, (2) motor skills, (3) intellectual skills, (4) attitudes, and (5) cognitive strategies.[25] These concepts are compatible with Snow's theories and add to the credibility of his constructs which have been paraphrased above.

Before formulating a more detailed research strategy for use in the TEA process, it may be useful to outline how some useable personality variables may be combined to predict learning performance and to summarize what has been suggested so far.

Personality Variables

As discussed in the summary review of the literature in Chapter IV, variables such as anxiety (A_x), and need for achievement (Ach), have been shown to interact with instructional treatments and appear also to combine with one another and/or with General Mental Ability in higher order ATI. While much is to be learned as to useful categorizations of personality variables, the above factors appear to interact with instructional treatments more strongly and often than others and should logically be included in ATI research aptitude constructs. The combination of these variables is dependent on the trainee population. That is to say while need for achievement has been shown to combine with trait anxiety to form a more powerful predictor, both the strength

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of the combination and its direction are individually determined. For a complete discussion as to the effects of these variables, separately or in combination, the reader should turn to Chapters 12 and 13 of Cronbach and Snow's "Aptitudes and Instructional Methods."[26] Although the final conclusion must remain that the nature of the interaction of these variables is complex and yet to be defined fully, their inclusion in ATI research through the medium of TEA will provide a greater measure of the percentage of the differences in individual aptitude and performance than would otherwise be attainable.

Ability Constructs

Certain ability differences have also been identified with concepts of information processing and should be included in the aptitude construct. Some of these abilities unfortunately, are also those for which measurement instruments are not yet developed fully. As shown on Figure 6, however, ability constructs relating to perceptual speed, closure speed, visual memory, and memory span, as well as the various cognitive style constructs comprising crystalized ability and achievement (verbal, numerical, and mechanical skills, etc.), should eventually be included as they relate to the task characteristics being taught. The reader should recognize however that this will require additional

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research before operational use can reasonably be expected in the TEA process.

Task Analysis

Having developed an aptitude construct or constructs, it becomes extremely important to complete an accurate analysis of the task to be trained. It is crucial to develop a listing of component student behaviors expected as the end result of training. Phase I of the ISD · :ocess used by all military services, provides for the compilation of an inventory of job tasks to be trained and for a determination of job performance measures. As a final step the list of tasks selected for instruction is to be analyzed to determine the most suitable instructional setting for _each_ _task_.[27]

However, there does not now seem to be any one best way to gain detailed knowledge about the processes to be expected in task performance. In fact one of the most important tasks of the TEA program should be to validate, refine and standardize task analysis procedures.

A Synthesis

The next logical step is to develop a means of correlating the relationship between the aptitude constructs that have been suggested and the various treatments that can be designed by making full use of procedures that have been established by trial and error in prior ATI studies. It

is suggested that this be done within an analytical framework of the information processing model. Snow (1977) has proposed a theoretical framework for doing this. Figure 8 shows the categories of variables that have been identified and indicates by arrows the direction analysis should take.

FIGURE 8

SCHEMATIC REPRESENTATION OF STANDING CORRELATIONS BETWEEN APTITUDE (A) AND OUTCOME (O) VARIABLES, A x TREATMENT (T) INTERACTIONS, AND THE ANALYSIS OF A AND T VARIABLES INTO INFORMATION PROCESSING VARIABLES, BRACKETS INDICATE COMPLEX INTERACTION.
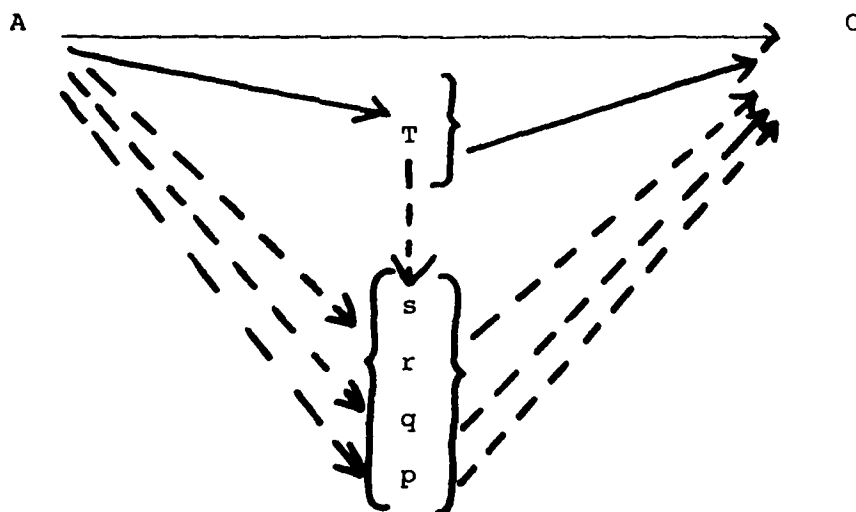
s = strategy
r = route
p = parameter
q = sequences

Snow explains his theoretical framework in these
terms:[28]

> Standing predictive relationships between
> aptitude variables (A) and learning outcomes (O)
> from instruction have been shown to be moderated
> by instructional treatment variables (T), with the
> recognition that ATI often occurs. It is clear
> that AT combinations can be studied in real in-
> structional settings, and should continue to be,
> but that this research must be supplemented by
> analyses conducted in laboratory settings where
> there is more chance of building theoretical models
> of psychological processes operating in ATI. The
> cognitive information processing approach of modern
> experimental psychology seems best equipped to
> guide and inform such analyses. But computer
> simulations and related work already completed
> show that individual differences in these apti-
> tude processes probably take a variety of complex
> forms. A distinction among four major forms or
> sources of apparent individual differences in
> processing should help to unravel these aptitude
> complexes. It appears that individuals can differ
> in parameters(p) reflecting efficiency and capa-
> city in particular processing steps or components,
> in how a sequence (q) of processing components is
> organized, in the inclusion of different components
> or processing routes (r), and in the overall
> summation (s) of assembly and adaptation of pro-
> cessing to particular tasks.

Researchers making use of this framework should conduct
their investigations within the stimulus-response-response
model (S-R-R) wherein "stimulus conditions are manipulated
to test R-R relations by controlling or modifying them."[29]
Snow (1977) cautions that adequate theory will have to be
built on this combined S-R-R/information processing theory.
The literature bears witness that this is true. Requirements
to establish the validity of these constructs make inclusion

of a representative set of these factors in the analysis
process a necessity to ensure the attainment of the requi-
site scientific rigor.

Summary

The aptitude process analyses discussed in this Chap-
ter are most likely to be predictive if linked to instruc-
tional alternatives on the basis of the predictive power
of aptitude-instructional interaction (ATI) theory. This
process is portrayed in Figure 9,a general methodology con-
struct.

Figure 9 depicts graphically that the ATI researcher
should start with the   evelopment of aptitude constructs
to cluster his student population into groups of hypothetic-
ally similar aptitudes. Beginning with general mental
abilities, he should add appropriate elements of personality
variables and physical ability measures (persons without
death perception should not be trained as tank drivers,
etc.). To these factors should be added measures of prior
achievement such as SQT scores and educational levels
and cognitive style such as measures of field dependence
and concept level to construct a profile of the soldier
to be trained. Turning to the ATI literature, a tentative
hypothesis should be formulated as to how the individual
profile is expected to interact with instructional treatments

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FIGURE 9

GENERAL METHODOLOGY CONSTRUCT

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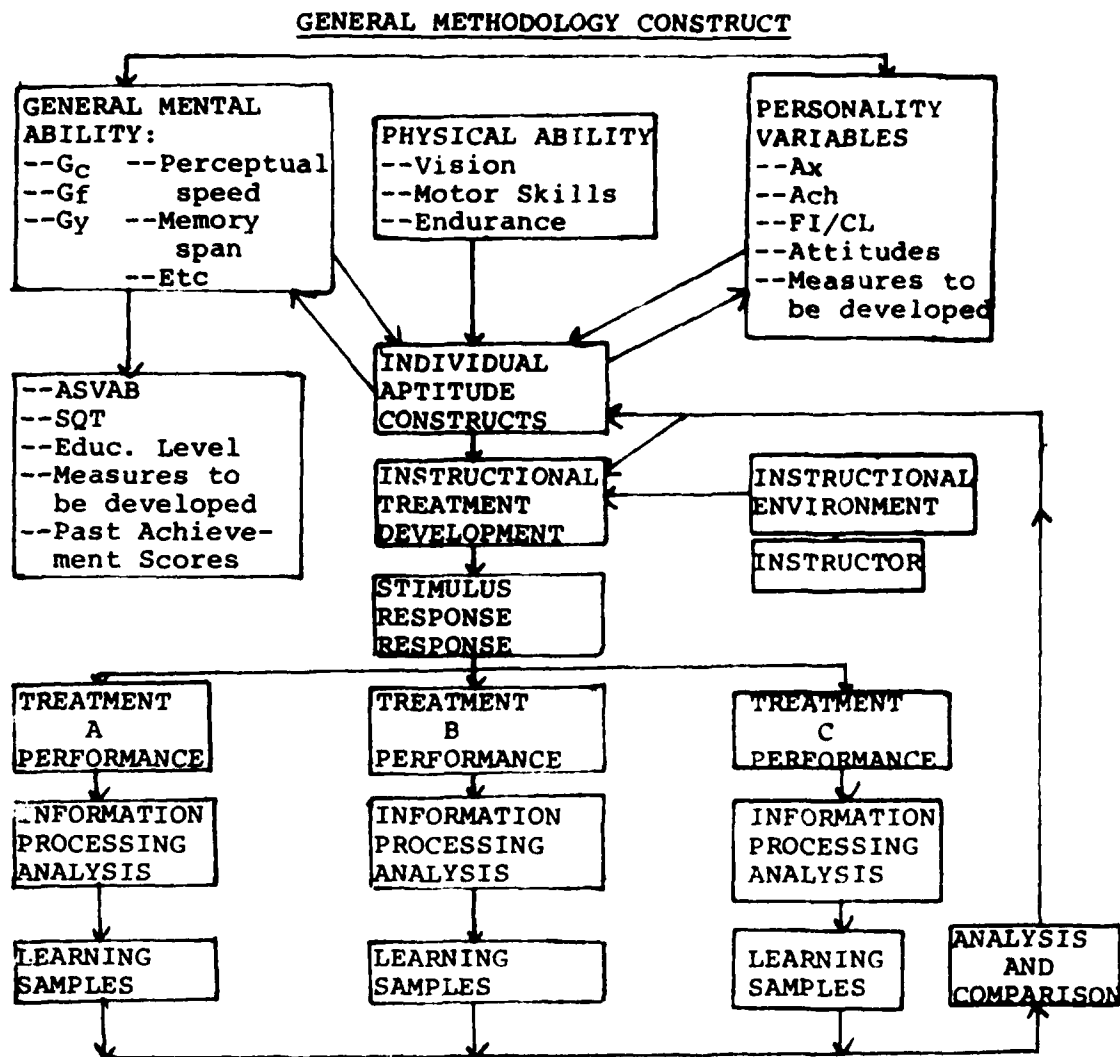
(high-ability, Ach i, low-A_x students do best with self-
paced instruction, low-ability, low Ach, high-A_x students do
best in a teacher dominated, structured, training environ-
ment, etc). After clustering his population by aptitude,
and previous learning (i.e. trained mechanics should score
high on the MM subtest of the ASVAB and should acquire new
skills at a greater rate than others also scoring high on the
MM subtest) a task analysis is made of the tasks to be
trained in accordance with the ISD model. Instructional
treatments snculd then be developed in accordance with the
ISD model, Phases II-IV (Design, Develop, Implement).
It should be noted in passing that Phases II-IV of the ISD
model already require an analysis of basic aptitudes and
abilities and direct that course designs be based on these
aptitudes.

However, it is at the beginning of Phase III, develop-
ment, that the analyst should make maximum use of the know-
ledge to be gained through the ATI research process to
better implement the requirements of ISD. In determining
how the instruction is to be packaged and presented to
the student, full use should be made of the concepts of match-
ing such factors as the media, training setting and instructor
to the students, who have been grouped by aptitudes. It is
entirely possible, by the way, that given how little is
known about ATI interactions , a large percentage of the

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student population will not be amenable to groups on the
basis of a homogenous aptitude. It is suggested that
these students, for want of a better solution, be trained
by an entirely conventional program developed without the
aid of ATI research derived insights, and that this treatment
be used by the researchers for control purposes.

Once the treatments have been developed, the ATI eval-
uation plan should be structured around the S-R-R model
and student learning analysed in terms of the information
processing model. It is at this point that the process
analysis of aptitudes should be brought together with the
comparable analysis of instructional treatments. Combined
assumptions and hypotheses should be scrutinized for valid-
ity by tracing components of the aptitude profiles through
to individual differences in learning resulting from the
alternative treatments. Extensive use should be made at
this time of the statistical techniques outlined in Chap-
ters 3 and 4 by Cronbach and Snow (1977), emphasizing the
language of the multiple regression analysis to document apti-
tude and treatment interactions. Because many of the neces-
sary aptitude measures will have to be developed apace with
the test program,it is likely that feedback to the individual
aptitude construct procedures and to the instructional
development process will result from an analysis and compari-
son of the relative treatments.

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Two notes of caution appear to be warranted here.
First, researchers should take extensive precautions against
the possibility that the "Hawthorne effect" will skew their
data. As noted previously, students do adjust to different
treatments--they are likely also to adjust in novel ways
if they are aware that they are part of an experimental
(special?) group. For this reason all aptitude groups must
not only be given a chance to habituate to the instructional
strategy; they must also be led to believe that they are
undergoing routine instruction. Second, the control group
may no longer represent a normal population once those
grouped by aptitude categories have been removed. This
suggests that it may be wise to carefully screen control
group members, adding select personnel as necessary, to
ensure a normal representation of the target population.

CHAPTER VI

AN IMPLEMENTING STRATEGY

To this point the research has highlighted the need
and feasibility of establishing alternative instructional
strategies for training entry level soldiers to improve
job performance. It is evident that to be acceptable an
implementing strategy must be as simple as possible, make
maximum use of existing training and personnel testing pro-
cedures and be achievable within existing resource con-
straints.

An Approach to Testing

A four-phase approach to field testing during TEA
appears appropriate.

● **Phase I**. Efforts during this phase should be
devoted to: (1) the identification and analysis of the
tasks to be trained in accordance with the ISD model, in
coordination with the appropriate TRADOC school for fielded
systems and the TRADOC Systems Manager (TSM), DARCOM Project
Manager (PM), and the Operational and Test Evaluation Agency
(OTEA) for developing systems; (2) definition of probable
target audience aptitudes, and identification of aptitude
measures; (3) the development of initial instructional
treatments keyed to the aptitude profiles; and (4) refine-
ment of the combined S-R-R/information processing models

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to ensure the appropriateness of aptitude measures and data collection instruments.

- **Phase II.** Phase II should be devoted to the refinement of instructional strategies; development of instruction treatment materials; the grouping of personnel to be trained by aptitude constructs and an initial determination of the terminal performance of different aptitude-treatments on tasks developed in Phase I. It is expected that instructional strategies will be driven by both the aptitude profiles and the task analysis, and thus cannot be predicted in the abstract. However, three broad types of treatment strategies are available for implementation. Which strategy or strategies are actually developed depends on the actual aptitude grouping and the characteristics of the tasks retained for teaching. A control group strategy is probably necessary during research or validation phases. The treatment strategies should be modeled after the Solomon (1972) and Cronbach and Snow (1977) models outlined in Chapter V. Of course, to more precisely focus on aptitude groupings within the student population, several variations of specific instructional strategies may be necessary within each broad strategy. Although these models were introduced in Chapter V, it appears appropriate to discuss them in more detail now so as to set the stage for the discussion to follow.

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● The preferential model contains treatments
that capitalize on student strengths by matching require-
ments of the treatment to the learner's higher aptitudes.
As an example, learners with high AFQT scores would nor-
mally be high in G_c, G_f, and G_v abilities. A learning
strategy for them would logically stress word knowledge,
spatial relations and dealing with concepts in a relatively
self-paced course. Such a strategy would be particularly
appropriate if they were also high on a motivation construct
featuring achievement thru independence, were field-inde-
pendent, and were low on anxiety measures, that is to say
they were constructively motivated and non-defensive.

● The compensatory model should contain treatments
designed to overcome learning deficiencies to circumvent
the disabling effects of specific deficiencies. For
example, learners with low AFQT scores would probably lack
reading, word knowledge and arithmetic skills. A learning
strategy for these soldiers might center around media
treatments featuring extensive use of audio-visual aids
and be teacher centered/dominated, stressing oral presen-
tation of lessons, in small steps with frequent review of
the same type information given to the soldier trained by
the preferential strategy. This would be particularly
applicable when teaching low-ability soldiers who lack a
positive self-image who are also found to be field-
dependent.

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• The remedial strategy contains treatments designed to overcome deficiencies in prerequisite knowledge. Learners with language, arithmetic or general education deficiencies will probably respond best to a learning strategy that addresses the deficiency within a context of the specific tasks being taught. In this sense this learning strategy would require not only different media and materials but may actually require the teaching of distinctly different tasks which must be mastered as a prerequisite to successful learning of the primary tasks.

• Phase III is the actual conduct of the research as a part of the TEA process. This phase entails the conduct of the training, to include necessary pre-tests and post-tests and the collection of necessary data. Care must be taken to control the instruction by ensuring lesson plan fidelity, student attendance and participation, interrater reliability and maintenance of an instructional environment conducive to learning. While these conditions may not prevail at all times in "the real world" they are necessary for ATI research. To allow uncontrolled variables to be present in the instructional setting is to make accurate analysis impossible. In this regard the reader is asked to recall the HUMRRO experiment in developing the potential of low ability personnel. A structured learning strategy must be just that. It must be structured wherein

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students complete all learning requirements and it must be teacher-centered in that learners devote their efforts to that which the teacher directs.

- The control strategy should be used to train those students who, by virtue of the lack of precise aptitude constructs, cannot be grouped by learning style. This strategy should be the one that would have been used had there been no TEA/ATI program. This strategy serves three important purposes: (1) it provides training for soldiers not otherwise in a definable aptitude grouping; (2) it provides a baseline against which to contrast skill acquisition gains of the other three strategies; and (3) it helps the researcher hold time constant, a necessary precaution if reliable interaction results are to be obtained.

- Phase IV is simply the data analysis and feedback phase. Data analysis requires advanced statistical techniques which are beyond the scope of this paper. A detailed presentation as to generalized regression analysis and advanced statistical techniques appropriate for use in ATI research can be found in Cronbach and Snow, (1977) Chapters 3 and 4. Their discussion on use of gain scores as the dependent variable, improving the interpretation of ANOVA, and appropriate confidence levels for regression effects would appear to be of special benefit to analysts seeking to verify the validity of aptitude-treatment

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interactions.[1] Here, only a general statistical analysis
process can be suggested. A progression of analyses would
seem to be necessary in most cases. This progression would
likely be: (1) analysis of the data gathered in Phase I
to develop a correlation matrix of all the variables of
aptitude measures and critical task performance requirements;
(2) a multiple regression analysis of all the independent
and dependent variables is the next logical step. Inde-
pendent variables would include the group aptitude measures
and the dependent variables would be the terminal performance
data gathered during training. These data would, of course,
be grouped by aptitude composite and instructional treat-
ment. Multiple regression analysis should be used to deter-
mine how much of the variance in the terminal performance
(dependent variables) was explained by the various aptitude
composites (independent variables) in different combinations.
Variables (aptitude constructs) that do not account for
significant amounts of variance in terminal performance
should be eliminated from further consideration. Verifica-
tion of the results of the multiple regression analyses by
use of a discriminant analysis is necessary to focus on
those aptitude constructs that will reliably discriminate
within treatments between those soldiers obtaining high
scores and those obtaining low scores on the terminal per-
formance measures. Care must be taken to select an appro-
priate statistical method when performing the discriminant

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analysis. The basic question is to what degree do differences between the treatments and/or aptitude groups contribute to terminal performance? Analysis of variance methods (ANOVA), while less powerful than regression analysis, are designed to handle this type of analysis and thus the researcher would normally turn to ANOVA techniques to answer the question. However, Cronbach and Snow have shown that associating confidence limits with regression lines provides the most satisfactory form of statistical rigor in ATI research.[2] The lack of success reported in ATI studies making use of ANOVA techniques is frequent and the knowledge gained by Cronbach and Snow in reevaluating the same studies by use of the regression analysis tends to give validity to this belief. Therefore, it is suggested that regression analysis is the appropriate language to use in describing patterns of significant and non-significant effects of the treatments and aptitudes as they relate to the terminal performance measure.

The analysis of trainee performance must be used to both refine aptitude measures and treatments. Hopefully this will lead to a definition of aptitude with two or more aptitude measures that reliably relate to job or task performance and interact positively with specific instructional strategies. By successive refinement, it should be possible to establish whether the aptitude groups defined in a task specific study exist in other parts or all of the Army trainee population. If so, then ATI research techniques

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can be generalized within the Army training system through the use of TEA process.

To summarize briefly, to determine the soldier's individual learning style the TEA analyst must first develop measures of an aptitude construct that have validity in relation to the task being taught. Variables composing the aptitude construct should be as few as necessary to differentiate within treatments between students as to attainment of terminal performance objectives. Experience to date has demonstrated the variables in Figure 9, A General Methodology Construct to be the most promising, (general mental abilities; cognitive style personality variables, and physical abilities). Instructional treatment development should be guided by the knowledge gained in prior studies with regard to how students learn best in terms of learning processes-independent study, lecture, visual presentation, etc., in consonance with the three instructional strategy models; preferential, compensatory, and remedial.

Data gathered should be analyzed in terms of the combined S-R-R/information processing model using the language of the regression analysis. The results of the experiment should be used in the feedback process to identify clusters of relationships within the intended student population to designate alternative training subsystems.

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An Example

It is realized that ATI techniques may be considered too exotic for use in a military training system. However, that such may not be the case has been demonstrated by the successful application of an ATI research project by the Canyon Research Group, Inc., working under contract to ARI to improve REDEYE gunner performance at the U.S. Army Air Defense Center, at Ft. Bliss, Texas.[3] Canyon Research conducted a program to investigate the effects of various instructional strategies on REDEYE gunner skills across individuals varying in measures of academic aptitude. The original hypotheses for this investigation was that an analysis of the cognitive processes and/or perceptual pre-cesses in operation during terminal performance actions would provide a sound basis upon which to develop instruct-ional strategies. While this study used specific perceptual/ psychomotor tasks with relatively low cognitive demand as the criterion skill to be learned, and was limited in the design factors used to develop the alternate instructional strategies, it did demonstrate the usefulness of ATI re-search techniques in improving soldier training and per-formance.

This study is important because the researchers made extensive use of the ATI work of Cronbach and Snow (1977), DiVesta (1975), Gagne (1977), Sal_____ (1972), Shapiro (1975),

Snow (1977), and others within a framework of early TRASANA
TEA efforts on REDEYE training effectiveness. In other
words, Canyon Research has attempted much of what this
research paper suggests as being necessary to improve train-
ing. The study concluded that:

● The use of Aptitude Group profiles in develop-
ing instructional strategies with design characteristics
specific to the defined group...appears to be feasible....

● ...results were such that strong inferrences can
be made regarding Aptitude Group profiles as a basis for
strategy selection/development.[4]

Because Canyon Research Group analysts generally
followed (though limited in resources and scope) sound
ATI research principles, it is useful to quote the manner
in which they constructed four alternative instructional
strategies based on aptitude grouping of the student popu-
lation. These strategies were subsequently found to interact
positively with aptitudes in improving student terminal
performance.[5]

> In the present study, a finite number
> of learning strengths were identified within
> learners and seen as representative of our
> target population. Strategies can be created
> to exploit each one of them to some degree.

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The various facets of any instructional strategy are often independent characteristics which the designer must make some judgement about. One facet is that of presentation logic. Should everything be stated or should the learner be required to find things for himself or does it make any difference? Should the individual learn in a group or by himself? Should most of the materials be pictorial and in motion or with a tutor and the real world tools? Should he watch other people before he tries it? Should he be told he will be sent to Antarctica if he fails? These questions illustrate the facets of (a) Instructional sequence, (b) Peer environment, (c) Materials mode, (d) Reinforcement type. This can better be displayed in a complete mapping sentence. (See the following page.)

Some elementary arithmetic will indicate that this could require 945 discrete products which would be of little practical use.

A finite number of paths need to be selected in terms of the potential for results with the cognitive style profiles present in the population of interest.

Based on the available research in the area of design and prescription of instruction for aptitude (Allen, 1975; Cronbach and Snow, 1977) strategies were developed for the aptitude profiles identified in the screening study. Table 1 displays the components of each strategy.

Strategy 1 was designed for individuals with relatively high mental ability who are field independent. These individuals benefit from self-directed instruction in which they choose their own method and pace themselves (Taylor, Montague and Hauke 1970). The learner of higher ability could be allowed to organize and manipulate symbolic meaning with a rapid rate of development in the materials (Allen, 1975). Field independent learners assume a more active role in learning, perform better under conditions of intrinsic motivation without performance feedback, and need little externally provided structure (Witkin, Moore, Goodenough and Cox, 1977; Cronbach and Snow, 1977).

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Will individuals with a specific cognitive style learn more

rapidly when information is presented in an

- Inductive
- Deductive
- Learner Controlled
- Random
- Instructor Preferred

sequence in a

- Group
- Individualized
- Mixed

setting with materials presented in

- Visual
  - Still
  - Motion
  - Line
- Print
- Aural
  - Lecture
  - Tape

mode with

- Model
- Simulation
- Actual
- Mental

- Intrinsic
  - Immediate
  - Spaces
- Extrinsic
  - Negative
  - Reward
  - Praise
  - Prestige
  - Competition

Reinforcement

in a task when results are measured by a written and a performance test

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TABLE 1.   TABLE OF STRATEGY CHARACTERISTICS

	STRATEGY 1	STRATEGY 2	STRATEGY 3	STRATEGY 4
GROUP VS. INDIVIDUAL INSTRUCTION	INDIVIDUAL	GROUP	GROUP	GROUP
PRESENTATION MODES	PRINT SIMULATOR	DIAGRAMS VISUALS	SIMULATOR SOME PRINT	LECTURE PRINT SIMULATOR
PRACTICE	MENTAL SELF ACTUAL PACED	AT END OF TRAINING	MAIN METHOD OF INSTRUCTION	LIMITED ACTUAL
MOTIVATION	INTRINSIC	EXTRINSIC PEER GROUP	EXTRINSIC COMPETITION	EXTRINSIC NEGATIVE INCENTIVES
FEEDBACK	INDIVIDUAL PROVIDES OWN FEEDBACK	IMMEDIATE AND CONTINUAL IN BOTH WRITTEN AND PRACTICE	IMMEDIATE THROUGH PRACTICE	DELAYED FEEDBACK ON TESTS IMMEDIATE ON PRACTICE
PACING	INDIVIDUAL	GROUP	GROUP	GROUP
MEDIUM	PRINT SIMULATOR	VISUAL SIMULATOR	SIMULATOR	LECTURE PRINT SIMULATOR

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On the basis of the above research, the
first learning strategy was designed as inde-
pendent study. It included printed and visual
information followed by practice (both mental
and physical) when the individual decided he
was ready, he was allowed to attempt the task.
This strategy relied on intrinsic motivation
with limited feedback.

Strategy 2 was developed for those subjects
high in two-dimensional perceptual ability, and
who scored high on ratings of anxiety. Gagne
(1960) hypothesized that high spatial ability
subjects learn from spatial presentations.
Matching of figural treatments and high figural
aptitude also increased retention of material
(Hancock, 1975). High spatial ability subjects
when given information in visual form were found
to require fewer written and verbal instructions
in order to process the information (Frandsen and
Holder, 1969). Based on these findings, Strategy
2 relied on visually dense presentations with
printed information used for attention direction.

The visuals were sequenced and progressed
from single diagrams to more complex visuals.
Actual practice of the task followed the visual
presentations.

In dealing with learners exhibiting anxiety,
Grimes and Allinsmith (1961) reported that a more
structured presentation that does not rely on the
individual's own resources will reduce anxiety
and enhance learning. High anxiety learners have
also been found to benefit from greater amounts
of feedback on performance (Campeau, 1968).
Strategy 2 represented structured learning materials
that rely on frequent positive reinforcement and
feedback concerning level of performance.

Strategy 3 was designed for low mental
ability, field dependent subjects. Low aptitude
learners perform best under conditions in which
the instructional sequence is broken into small
steps, is highly structured, and where extensive
practice is provided. The instructor provided
feedback and prompting (Taylor, Montague, and
Hauke, 1970). The field dependent learner is

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influenced by authority and peer opinion, favors
interactive teaching methods, and requires exten-
sive structuring of the learning situation (Witkin,
Moore, Goodenough and Cox, 1977). Strategy 3 began
with a very structured step-by-step demonstration
of the task followed by practice. Necessary infor-
mation was presented in small doses at a simple
level.

Strategy 4 is the present mode of instruction
used by the Army, and was used with the subjects
that did not fit the criteria for the other 3
aptitude groups. This group represented varying
combinations of the aptitudes measured, and
would be comparable to a general student group.
If no specific aptitudes were isolated, the pre-
sent mode of instruction was deemed acceptable
as a strategy considering the wide range of in-
dividual differences within the group (Parkhurst,
1975; Cronbach and Snow, 1977). This instruction-
al strategy relied on lecture as the main method
of instruction with print support materials.
Limited practice in the simulator was provided
as the final phase of instruction. This approach
was used with the fourth aptitude group."

The results of this attempt to match aptitude groupings

with instructional strategies are paraphrased on the follow-

ign page. The reader will note that all three experimental

instructional strategies were developed within either the

preferential model, taking advantage of high student mental

abilities, or the compensatory model, which substituted

structure, feedback, demonstration, and structure for high

mental ability. The remedial model was not employed.

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Results

- Training time for trainees to reach proficiency under alternative strategies was reduced by a factor of two measured from the base course, strategy 4.

- Response time to engage targets was decreased.

- Attitudes towards training under alternate strategies were favorable.

- Significant ATI were not demonstrated for either the written or performance tests. However, a standard, rather than a random increase, of terminal performance was evident. (Note: This lack of significant ATI may have been the result of use of a two-way ANOVA for the discriminant analysis phase of data reduction. Cronbach and Snow caution against use of the ANOVA for this reason.)

- Strategy 2 training resulted in significantly ($p > .05$) better performance on written tests than did strategies 3 or 4.

- Written test retention results indicate that strategy 3 enabled soldiers to retain their post test level of performance. Strategy 3 retention improved from original testing by a 10 percent mean gain.

- As with the written test no significant ATI were present for the performance test result, (use of ANOVA?). However, the following relationships were significant:

  -- Soldiers trained by strategy 3 scored significantly better on the performance test than those trained

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by either strategy 2 or 4 regardless of aptitude grouping.

       --   Soldiers in aptitude group 2 scored significantly better on the performance test, regardless of training strategy grouping than those who were classified as being in aptitude group 3 or 4.

Discussion

The reader will of course draw his or her own conclusions as to these results and utility of ATI to improve soldier training. Two points concerning this study, are worth raising however. First, the fact that soldiers trained by strategy 3 scored significantly better on the performance test than those trained by either strategy 2 or 4, regardless of aptitude grouping, is very interesting. Strategy 3 was developed for low aptitude learners. Hence the strategy was heavy in extensive practice, structure, feedback, etc. It may well be that psychomotor task mastery requires just this type of training to develop proficiency, much like golf or baseball. This importance of task characteristics, at least for this type of noncognitive task, on ATI is reinforced by the finding that soldiers in aptitude group 2 scored significantly better on the performance test regardless of training strategy. This strategy "was developed for those subjects high in two-dimensional perceptual ability, and who scored high on ratings of anxiety...strategy 2

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relied on visually dense presentations with printed information used for attention direction."[7] And yet students in aptitude group 2 who were trained by strategy 3 (as opposed to strategy 2 developed specifically for them) scored significantly better on the performance test, regardless of ability grouping. Why? One can only speculate. However, since the REDEYE gunners tasks are perceptual and psychomotor with relatively little cognitive demand, it may well be that task characteristics were the most important variable and that instruction emphasizing these aspects was sufficient to overpower advantages inherent in other strategies more nearly matching the cognitive styles of the other aptitude groups. Secondly, it appears entirely possible that had the experiment been continued, a composite aptitude grouping combining low ability, field-dependent subjects with high spatial subjects could have been trained on an instructional strategy combining the principles of strategy 2 and 3, so as to gain additional aptitude x instructional interaction power. If this were done, and the results compared to aptitude groupings 1 and 4 and instructional strategies 1 and 4 and the original 2 and 3 aptitude/instruction mix, additional interactions might have been identified. This is a good example of the type research envisioned to take place during phase IV, data analysis, and feedback into the system.

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At any rate, the approach used in this study appears very promising and, when integrated into the mature TEA process should serve to improve military training.

CHAPTER VII

CONCLUSIONS

While it is clear that the present and growing com-
plexity of military equipment, weapon systems, and opera-
tions is such as to severely strain the Army's ability
to provide adequately trained manpower, it is not clear
that the service will be able to implement training programs
based on individual soldier learning styles. Even though
present testing and classification procedures provide much
of the data needed to group trainees by cognitive apti-
tudes; even though the Army training system is oriented
towards individual proficiency based on rigorous task
analysis; and even though the educational and evaluation
agencies are in place and performing needed research, it
is not clear that the Army is in a position to implement
fully and successfully instructional strategies based all
or in part on the principles, theories, or methodologies
outlined in this paper. The reasons for this are twofold:
first,although great strides have been made in ATI research
in the last decade, much remains to be discovered. This
means that extensive, prolonged research will probably be
necessary to establish a body of knowledge, techniques,
and procedures that will enable the instructional developer
at the TRADOC school to effectively tailor resident in-
struction to each new class. This is precisely what

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TRASANA's TEA program is designed to do. Long term research
leading to basic, fundamental changes in the manner in
which instructional strategies are developed appears to
be the ultimate solution. The point is that this process
will take time and should not be hurried. Obviously then,
the service is a long way from being able to individualize
instruction in units. In fact this may never be feasible.
It may prove more practicable to develop soldier skills
and cognitive processes within the institution to the level
where unit training can rely more on less rigidly struc-
tured individual practice of SM/SQT skills, as opposed to
formal instruction more appropriate for low ability person-
nel. Secondly, and maybe more importantly, the Army's
and TRADOC's training mission must be accomplished every
day. The Army's trainers, in the school and the unit,
simply do not have either the time nor the resources to
experiment with unproven concepts. So the first conclusion
is obvious. ATI must remain a research concept until
specific, detailed procedures have been developed and vali-
dated so as to be useable within the ISD model.[1] This is
not to say that ATI research should not involve natural
"real world" training; it should. As mentioned previously,
operational testing of developing equipment and weapons
as well as basic and selected advanced individual training
courses would appear to offer superb settings for the

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conduct of ATI testing. It is important,however, to avoid placing the burden on organizations engaged primarily in other missions; ATI research is altogether too complex, time consuming and likely to be frustrating, to entrust to agencies that cannot devote full time to the problem. Other conclusions can be summarized as being:

● The ATI research program should be developed and conducted within the framework of the TEA process. Investigations should be integrated with ongoing instructional programs so as to ensure avaliability of adequate sample sizes (at least 100 subjects per test cell) and applicability of results to real world problems. This suggests that TRASANA should be the overall manager for Army ATI development as well as for TEA.

● Testing should be started at skill level 2 task complexity (skill level 2 refers to the SQT task listing for lower ranking soldiers, SL 3-4 delineate tasks for NCO's) to facilitate integration of the information processing model with the learning and abilities hierarchy in Chapter V, Figure 7. Testing can conceivably be scheduled for conduct with Advance Individual Training (AIT) classes for selected MOS in conjunction with TEA on fielded systems and for conduct during the pretest training prior to conduct of operational test I (OTI) for developing systems. Follow-up research can be accomplished in units and during OTI respectively, to validate treatment results by measuring levels of skill decay.

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● ATI research being conducted by TRASANA
should be supplemented by the efforts of the Army Research
Institute For the Behavioral and Social Sciences (ARI) to
develop more refined measures of general mental ability and
personality variables, to include motivation constructs and
attitudes. The ultimate products of this research would
appear to be appropriate for inclusion in the entry level
classification testing schema now represented by the
ASVAB. Such inclusion would ensure availability of data
Army wide and would assist Army trainers by more precise
placement of soldiers into training courses for which they
have appropriate aptitudes.

Summary

Individual differences in learning become important
upon situational demand. Individuals seek to meet these
demands by exploiting their mental, physical, and person-
ality aptitudes and by compensating for a lack of aptitude.
When possible, people substitute a developed aptitude for
those that are underdeveloped or lacking. In the same way,
instructional strategies should seek to exploit identifi-
able individual differences and compensate for the lack
of aptitudes where necessary. The practical problem is
simply to design instructional events in such a manner as
to exploit or compensate for individual differences as
appropriate. Research on aptitude-treatment interactions

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can best be accomplished within a framework of the conduct of TEA using a multidisciplinary approach which draws on the combined skills available to ARI and TRASANA. The implementation of specific aptitude and task measures, and instructional treatment variations can and should be accomplished within the context of the present Army training system to ensure maximum coordination and to capitalize on the instructional and training skills already in being.

There is no neat, concise conclusion for this paper. It has attempted a synthesis of the present Army training system, to include in process changes represented by the TEA program, and suggests further research based on several views as to the location of the starting point. That there are other views and other starting points is indisputable--the proof however will be in the doing, in the conduct of TEA wherein a useful, coherent theory of aptitude-treatment interactions is formulated, tested and used to improve the training of the soldier.

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APPENDIX I

SUMMARY DISCUSSION OF APTITUDE AREA COMPOSITES

APPENDIX I

SUMMARY DISCUSSION OF APTITUDE AREA COMPOSITES

The purpose of this appendix is to provide a summary discussion of the Armed Services Vocational Aptitude Battery (ASVAB) of tests and the composite aptitude areas that are used for classification and assignment purposes within the Army.

The appendix is in two parts. Part I is a general discussion as to the evolution of the ASVAB and the ASVAB 5, High School aptitude area composites, to familiarize the reader with the type and extent of aptitude measuring used by the armed forces today.[1] This information can be contrasted with the type and scope of aptitude measurement deemed necessary to support ATI research and curriculum development. Part II is a summary discussion of the aptitudes required for classification into the various Army Career Management Fields (CMF) and the tests used to measure these aptitudes.[2]

PART I ASVAB DEVELOPMENT

In 1966, the military services drew upon 25 years of experience in aptitude testing to begin development of a vocational aptitude battery which could be used in high school counseling programs. The new battery was designed to measure a student's aptitudes for specific types of

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job training. In 1968, the ASVAB was administered in high schools for the first time.

By 1974, the ASVAB had demonstrated its value as a potential replacement for several personnel selection/classification tests then in use by the military services. Accordingly, the content of the ASVAB was expanded from 9 to 12 tests; and, on January 1, 1976, its use throughout the Department of Defense was instituted. Since the beginning of school year 1976-1977, the ASVAB has been admin tered to high school students and military applicants alike within the United States and its territories.

A summary of the ASVAB forms and their use is shown in Table 1.

TABLE 1

FORMS OF THE ARMED SERVICES
VOCATIONAL APTITUDE BATTERY (ASVAB)

Form No.	Use
ASVAB-1	High School Testing Program (SY 1973/74 and earlier)
ASVAB-2	High School Testing Program (SY's 1974/75 and 1975/76)
ASVAB-3	Air Force and Marine Corps Selection and Classification Test
ASVAB-4	Back-up to ASVAB-2 (never released)
ASVAB-5	High School Testing Program beginning July 1976
ASVAB-6/7	All Services Selection and Classification Test Beginning January 1976

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TABLE 2

CONTENT -- FORM 5 OF ASVAB*

Test	Number of Items
General Information (GI)	15
Numerical Operations (NO)	50
Attention to Detail (AD)	30
Word Knowledge (WK)	30
Arithmetic Reasoning (AR)	20
Space Perception (SP)	20
Mathematics Knowledge (MK)	20
Electronics Information (EI)	30
Mechanical Comprehension (MC)	20
General Science (GS)	20
Shop Information (SI)	20
Automotive Information (AI)	20
Totals	295

Summary Discussion of ASVAB Test Measures

GENERAL INFORMATION (GI)--Measures a portion of a student's
    developed ability to recognize factual information
    characterized by the cumulative influences of his or
    her learning experiences.

NUMERICAL OPERATIONS (NO)--Measures an individual's devel-
    oped ability to rapidly and accurately compute simple
    number computations.

ATTENTION TO DETAIL (AD)--Designed to measure the ability
    of an individual to perceive simple relationships,
    to retain these relationthips mentally, and to make
    decisions based upon the relationships involved
    quickly and accurately.

WORD KNOWLEDGE (WK)--Measures verbal comprehension which
    entails the ability to understand written and spoken
    language.

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* Note ASVAB 6 and 7 are parallel forms of ASVAB 5
Adminstered at the Armed Forces entrance and examining
station.

ARITHMETIC REASONING (AR)--Designed to measure general
reasoning. It is concerned with the ability to
generate solutions to problems. It is different from
Numerical Operations in that the student must con-
struct a solution by some principle in order to solve
the given problem.

SPACE PERCEPTION (SP)--Measures an individual's spatial
aptitude. This infers an ability of an individual
to visualize and manipulate objects in space.

MATHEMATICS KNOWLEDGE (MK)--Measures functional ability in
the use of learned mathematical relationships. Factors
measured by this area tend to overlap the areas of
numerical operations and arithmetic reasoning. The
similarities are in the functions performed. The
differences lie in the complexities of the functions.

ELECTRONIC INFORMATION (EI)--Measures functional ability
in the use of learned electronic relationships. A
number of factors appear to be measured by this test:
arithmetic reasoning in the form of simple electronic
calculations; verbal comprehension in terms of the
person's reading level with respect to electronic
terminology; and a level of general reasoning is
indicated by having the individual make use of elec-
tronic principles in order to arrive at the correct
answer.

MECHANICAL COMPREHENSION (MC)--Measures the ability of
an individual to learn, comprehend, and reason with
mechanical terms. Even though familiarity with com-
mon tools and mechanical relations is a prerequisite,
further technical knowledge is not necessary other
than that acquired through day-to-day experiences.
This test has pictures of mechanisms whose functions
call for comprehension.

GENERAL SCIENCE (GS)--Measures a level of verbal compre-
hension in the general area of science. This test
was designed to measure a form of reasoning which
involves the ability to see the relationship between
two factors or scientific ideas. Some arithmetic
reasoning may also be involved.

SHOP INFORMATION (SI)--Measures the functional ability of
an individual who has had experience with and is
knowledgeable about the use of a variety of tools
found in a shop. In addition, it appears that a level
of verbal comprehension is also measured as indicated
by the understanding needed of the terminology used.

AUTOMOTIVE INFORMATION (AI)--Measures the functional ability
    of an individual who has had some experience working
    with automobiles. This test also relies upon an indi-
    vidual's reading ability and verbal comprehension.
    The questions may pertain to diagnosing malfunctions
    of a car, the use of a particular part(s) of a car,
    or meaning of terminology.

The scores on the ASVAB are used to construct aptitude

composites in five human ability areas as well as to provide

an indication of academic ability. These composites are

not intended to provide the student with job-specific

information, but rather to encourage students to make

further exploration into their own abilities. Scores on

the ASVAB test are combined to form the composite scores

as follows:

DEFINITION OF ASVAB COMPOSITES

VERBAL (VE). Measures knowledge of words, ability to under-
    stand written materials, and to deal with verbal con-
    cepts. The composite is a combination of the scores
    on the Word Knowledge, General Information, and Gen-
    eral Science tests.

ANALYTIC/QUANTITATIVE (AQ). Measures reasoning abilities
    as well as those relevant to understanding quantita-
    tive concepts. The composite is a combination of the
    scores on the Arithmetic Reasoning and Mathematics
    Knowledge tests.

CLERICAL (CL). Measures speed and accuracy in using let-
    ters and numbers. These are abilities relevant to
    clerical type activities. The composite is a com-
    bination of the scores on the Attention to Detail and
    Numerical Operations tests.

MECHANICAL (ME). Measures understanding of mechanical
    principles as well as the ability to visualize objects
    in three-dimensional space. The composite is a com-
    bination of the scores on the Space Perception and
    Mechanical Comprehension tests.

TRADE TECHNICAL (TT). Measures information relevant to automotive and various shop practices. The composite is a combination of the scores on the Automotive Information and Shop Information tests.

ACADEMIC ABILITY (AA). Measures abilities needed to do well in school and formal types of training. The composite is a combination of the scores on the Word Knowledge and Arithmetic Reasoning tests.

PART II

Aptitude Area Composites for the Active Army differ from those used in the high school, even though they are based on the same tests. Army aptitude area composites are as shown in Table 3 below:

TABLE 3

APTITUDE AREA COMPOSITES	
CO = Combat	MM = Mechanical Maintenance
FA = Field Artillery	GM = General Maintenance
EL = Electronics Repair	CL = Clerical
OF = Operators and Food	ST = Skilled Technical
SC = Surveillance and Communications	

The scores on the ASVAB are used to measure aptitudes as listed below. In addition, soldiers are also adminstered the Army classification inventory which determined their specific areas of interest.

The Combat (CO) Aptitude Area test a complex combination of aptitudes. The good combat soldier needs general ability, measured by the Arithmetic Reasoning Test. He needs mechanical ability, measured by the Trade Information

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Test, to handle his weapons and equipment. Perceptual ability is important--he has to orient himself in the terrain and observe his environment. This capability is measured by the Pattern Analysis and Attention-to-Detail tests. Finally, an interest in outdoor masculine activities, coupled with self-confidence, is associated with good combat performance. The Combat (CC) scale of the Classification Inventory yields a measure of this interest.

The artilleryman, in comparison, requires more mathematical ability. Therefore, scores from both the Arithmetic Reasoning Test and the Mathematics Knowledge Test enter into the Field Artillery (FA) Aptitude Area. A further measure of general ability is contributed by the General Information Test. Mechanical ability, measured by the Electronics Information Test, and an interest in details, measured by the Attentiveness (CA) scale of the Classification Inventory, complete the picture for the artilleryman.

Jobs for which the Electronics (EL) aptitude area is designated as selector require some general ability (Arithmetic Reasoning), a heavy concentration of mechanical ability (Electronics Information, Shop Mechanics, and Mechanical Comprehension), and an interest in electronics, measured by the Electronics (CE) scale of the Classification Inventory.

Operators and Food (OF), the aptitude area for the selection of operators of vehicles and missile equipment

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and food handler personnel, resulted as one of the simplest composites. The General Information and Automotive Information tests and the Attentiveness (CA) scale of the Classification Inventory represent a combination of requirements applying to this group of MOS.

Components of the Surveillance and Communications (SC) Aptitude Area include general ability, represented by the Arithmetic Reasoning and Word Knowledge tests, mechanical ability, measured by the Mechanical Comprehension Test, and perceptual ability, measured by the Pattern Analysis and Auditory Perception tests. Inclusion of general ability and perceptual skills in the aptitude area is consistent with the tasks of information acquisition, processing, and transmission common to the MOS in the group.

Two areas involve maintenance primarily--mechanical and general. The MOS for which the Mechanical Maintenance (MM) Aptitude Area is a selector require heavy concentration of mechanical ability, measured by the Automotive Information, Electronics Information, and Trade Information tests, plus mathematics ability (Mathematics Knowledge) and an interest in mechanics, measured by the Maintenance (CM) scale of the Classification Inventory. The General Maintenance (GM) Aptitude Area reflects a heavier requirement for general ability, measured by the Arithmetic Reasoning and Science Knowledge tests. The mechanical

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requirements are less than for the mechanical maintenance
MOS, and only the Mechanical Comprehension and Automotive
Information test are included. These differences are con-
sistent with the MOS areas for which these aptitude areas
are used. The mechanical maintenance MOS are almost entirely
concerned with motors and equipment, while the general
maintenance MOS cover operators and more specialized re-
pair work.

In the Clerical (CL) Aptitude Area, the general
ability requirement for jobs is measured by the Arithmetic
Reasoning and Word Knowledge tests. Perceptual speed is
covered by the Attention-to-Detail Test, and pertinent
interest in detail by the Attentiveness (CA) scale of the
Classification Inventory.

The MOS in the skilled technical group are generally
the most technical and academically oriented of all the
enlisted MOS. The Skilled Technical (ST) Aptitude Area
therefore consists entirely of tests in the general
ability domain--Arithmetic Reasoning, Mathematics Knowl-
edge, and Science Knowledge.

A final composite is the familiar General Technical
(GT) Aptitude Area, composed of the Arithmetic Reasoning
and Word Knowledge (Verbal) tests. In the old system,
the GT score is used both to select men for general tech-
nical MOS and to determine which men are eligible to take

additional tests such as the Officer Candidate Test. In the new system, the function of selector for MOS group is shifted to the ST composite. The function of determining eligibility for additional testing continues to be filled by the combination of Arithmetic Reasoning and Word Knowledge tests. The label GT is retained.

Unit weights for the tests entering into the composite scores were decided upon following evaluation of several weighting schemes to determine their effect on the total effectiveness of the aptitude area structure in predicting soldier performance. A full account of the evaluation research is presented in BESRL Technical Research Note 239.[*]

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[*] Maier, Milton H. and Edmund F. Fuchs."Development and Evaluation of a New ACB and Aptitude Area System." Technical Research Note 239. Behavior and Systems Research Laboratory, Arlington, VA. February 1972.

APPENDIX II

A COMPILATION OF DEFINITIONS OF

MAJOR HUMAN MENTAL ABILITIES

APPENDIX II

A COMPILATION OF DEFINITIONS OF
MAJOR HUMAN MENTAL ABILITIES*

The purpose of this Appendix is to provide the reader with a compilation of definitions to be used in conjunction with Figure 6.[1]

General Mental Ability (G)

Binet (in Terman, 1916, p. 45)	"The tendency to take and maintain a definite direction; the capacity to make adaptations for the purpose of attaining a desired end; and the power of auto-criticism."
Binet and Simon (1916, pp. 42-43)	"... judgement, otherwise called good sense, practical sense, initiative, the faculty of adapting one's self to circumstances. To judge well, to comprehend well, to reason well, these are the essential activities of intelligence."
Spearman (1923)	"... everything intellectual can be reduced to some special case...of educing either relations or correlates." (p. 300) Eduction of relations--"The mentally presenting of any two or more characters...tends to evoke immediately a knowing of relation between them." (p. 63) Eduction of correlates--"The presenting of any character together with any relation tends to evoke immediately a knowing of the correlative character." (p. 91)

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* Source: Snow, R.E., Theory and Method for Research on Aptitude Processes: A Prospectus, OFC of Naval Research Arlington, VA. Oct 1976. p.

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Stoddard (1943, p. 4)	"...the ability to undertake activities that are characterized by (1) difficulty, (2) complexity, (3) abstractness, (4) economy, (5) adaptiveness to a goal, (6) social value, and (7) the emergence of originals, and to maintain such activities under conditions that demand a concentration of energy and a resistance to emotional forces."
Freeman (1955, pp. 60-61)	"...adjustment or adaptation of the individual to his total environment, or to limited aspects thereof. ... the capacity to reorganize one's behavior patterns so as to act more effectively and more appropriately in novel situations. "... the ability to learn. ...the extent to which (a person) is educable. "... the ability to carry on abstract thinking... the effective use of concepts and symbols in dealing with...a problem to be solved."
J. McV. Hunt (1961, p.362)	"...conceived as intellectual capacities based on central processes hierarchically arranged within the intrinsic portions of the cerebrum. These central processes are approximately analogous to the strategies for information processing and action with which electronic computers are programmed."
Jenson (1969, p.9)	"When the term 'intelligence' is used it should refer to (Spearman's) g, the factor common to all tests of complex problem-solving"
(1970. pp.147-148)	"...mental tests can be ordered along a continuum going from simple to complex. ...The intercorrelations among tests are roughly related to their degree of proximity on the complexity continuum, and tests which are intended to identify g... show increasing correlations with other tasks as one moves along the continuum from simple to complex."

Crystallized Ability (G_c)

Cattel
(1963, p. 2)

"Crystallized ability loads more highly
those cognitive performances in which
skilled judgement habits have become
crystallized (whence it's name) as the
result of earlier learning application
of some prior more fundamental ability
in these fields. Thurstone's Verbal
and Numerical primaries, or achieve-
ment in geography or history, would be
examples of such products."

Horn
(1976, p. 455)

"Awareness of concepts and terms per-
taining to a broad variety of topics,
as measured in general information and
vocabulary tests and in tests which
measure knowledge in science, mechan-
cis, social studies, English literature
mathematics, and a variety of other
areas. It is also manifested in the
Information, Vocabulary, Comprehension,
Similarities and, to a lesser extent,
Arithmetic subtests of the Wechsler
Scales... . In much of the British'
work it is labeled verbel-educational
(v:ed) intelligence."

Fluid-Analytic Ability (G_f)

Cattell
(1963, p. 3)

Fluid general ability, on the other
hand, shows more in tests requiring
adaptation to new situations, where
crystallized skills are of no parti-
cular advantage."

Horn
(1976, p. 445)

"Facility in reasoning, particularly
in figural and non-word symbolic mater-
ials, as indicated in tests such as
letter series, matrices, mazes, figure
classifications, and word groupings,
as well as the block designs, picture
arrangements, object assembly, and
picture completion subtests of the
Wechsler Scales... . Some character-
ize it as non-verbal intelligence
(although verbal tests can measure it)
or performance IQ. In the British work
it is known as spatial-perceptual-
practical intelligence (k:m)."

Visualization Ability (G_v)

Horn
(1976, p. 448)

"When analyses pertain to concepts
more general than the primary abil-
ities, the various spatial tasks...
(involving ability to perceive and
transform images of spatial patterns,
maintaining orientation in spatial
arrangements) tend to hang together
in what can be referred to as a general
visualization dimension which seems
to be as least somewhat distinct from
G_f, and is clearly distinct from G_c...."