

AD-A058 412

AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OHIO  
THE INTERACTIVE EFFECTS OF COGNITIVE STYLE AND LEARNER PREPARAT--ETC(U)  
JUN 78 J A GUERRIERI  
AFIT-CI-78-73

F/6 5/10

UNCLASSIFIED

NL

1 OF 2  
AD  
A058412



78 730

(P)

LEVEL II

ADA 058412

THE INTERACTIVE EFFECTS OF COGNITIVE STYLE AND  
LEARNER PREPARATION ON COGNITIVE LEARNING

by

John Anthony Guerrieri

AD No. 1  
DDC FILE COPY

DDC  
SEP 11 1978  
F

A Dissertation Presented to the  
FACULTY OF THE GRADUATE SCHOOL  
UNIVERSITY OF SOUTHERN CALIFORNIA  
In Partial Fulfillment of the  
Requirements for the Degree  
DOCTOR OF PHILOSOPHY  
(Education)

This document has been approved  
for public release and sale; its  
distribution is unlimited.

June 1978

78 08 31 004

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE   |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                     |
|---|-----------------------|---|
| 1. REPORT NUMBER<br><b>AFIT-CI-78-73</b>  | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER   |
| 4. TITLE (and Subtitle)<br><b>The Interactive Effects of Cognitive Style and Learner Preparation on Cognitive Learning.</b>   |                       | 5. TYPE OF REPORT & PERIOD COVERED<br><b>Dissertation</b>                       |
| 7. AUTHOR(s)<br><b>10</b> <b>thony</b><br>Captain John A. Guerrieri   |                       | 6. PERFORMING ORG. REPORT NUMBER  |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>AFIT Student at the University of Southern California                          |                       | 8. CONTRACT OR GRANT NUMBER(s)<br><b>9 Doctoral thesis,</b>                     |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>AFIT/CI<br>WPAFB OH 45433  |                       | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br><b>11 Jun 78</b> |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)   |                       | 12. REPORT DATE<br>1978   |
|   |                       | 13. NUMBER OF PAGES<br><del>102</del> Pages <b>12 113 p.</b>                    |
|   |                       | 15. SECURITY CLASS. (of this report)<br>Unclassified                            |
|   |                       | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE                                      |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for Public Release; Distribution Unlimited                        |                       |   |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                    |                       |   |
| 18. SUPPLEMENTARY NOTES<br><br><b>JOSEPH P. HIPPS, Major, USAF</b><br><b>Director of Information, AFIT</b> <b>AUG 15 1978</b> |                       |   |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)  |                       |   |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)   |                       |   |
| <b>012200</b> <i>James</i>  |                       |   |

UNIVERSITY OF SOUTHERN CALIFORNIA  
THE GRADUATE SCHOOL  
UNIVERSITY PARK  
LOS ANGELES, CALIFORNIA 90007

*This dissertation, written by*

JOHN ANTHONY GUERRIERI

*under the direction of his... Dissertation Com-  
mittee, and approved by all its members, has  
been presented to and accepted by The Graduate  
School, in partial fulfillment of requirements of  
the degree of*

DOCTOR OF PHILOSOPHY

*William Wray*

Dean

Date 5-17-78

DISSERTATION COMMITTEE

*Robert J. Casey*  
Chairman  
*Edward E. Lieb*  
*Orin Hazell*

|                                 |               |                                     |
|---------------------------------|---------------|-------------------------------------|
| ACCESSION for                   |               |                                     |
| NTIS                            | White Section | <input checked="" type="checkbox"/> |
| DDC                             | Buff Section  | <input type="checkbox"/>            |
| UNANNOUNCED                     |               | <input type="checkbox"/>            |
| JUSTIFICATION                   |               |                                     |
| BY                              |               |                                     |
| DISTRIBUTION/AVAILABILITY CODES |               |                                     |
| Dist.                           | Avail.        | SPECIAL                             |
| A                               |               |                                     |

78 08 31 004

for  
My Parents  
Gabriele and Inez Guerrieri

## ACKNOWLEDGMENTS

I wish to express my sincerest gratitude to: my committee, Dr. Robert J. Casey Jr., Dr. Edward E. Lieb, and Dr. David L. Russell for their timely assistance; Major James Snodgrass, Captain John Buzbee, and Noni Galpert for allowing me to use their classes for this study, Jeanne Hebein for her help in constructing the experimental materials; every one in the Department of Instructional Technology for their support and encouragement; and especially Anne Coyle for her encouragement, assistance in developing the materials, and help in conducting the experiment.

## LIST OF TABLES

## Table

1. Range, Means, and Standard Deviations on the Post-test and Cognitive Style Test for Each Treatment Group
2. Regression Analysis and ANOVA results for Cognitive Style, Treatments, and Interaction

## TABLE OF CONTENTS

|                                      |     |
|--------------------------------------|-----|
| DEDICATION                           | ii  |
| ACKNOWLEDGMENTS                      | iii |
| LIST OF TABLES                       | iv  |
| CHAPTER                              | 1   |
| I.    THE PROBLEM                    |     |
| Background of the Problem            |     |
| Statement of the Problem             |     |
| Importance of the Study              |     |
| Substantive Questions to be Answered |     |
| Research Hypotheses                  |     |
| Assumptions                          |     |
| Delimitations                        |     |
| Limitations                          |     |
| Definition of Terms                  |     |
| II.   REVIEW OF THE LITERATURE       | 12  |
| Introduction                         |     |
| Aptitude Treatment Interaction       |     |
| Cognitive Style                      |     |
| Learner Preparation                  |     |
| III.  METHODOLOGY AND DESIGN         | 43  |
| Experimental Variables               |     |
| Experimental Materials               |     |
| The Assessment Instruments           |     |
| Sample Population                    |     |
| Conduct of the Experiment            |     |
| Statistical Analysis                 |     |
| IV.   RESULTS                        | 49  |
| Hypotheses                           |     |
| Discussion                           |     |
| Summary                              |     |
| V.   SUMMARY                         | 55  |



|                        |    |
|------------------------|----|
|                        | vi |
| REFERENCES             | 58 |
| APPENDIXES             |    |
| A. TREATMENT MATERIALS | 71 |
| B. POSTTEST            | 96 |

## CHAPTER I

## THE PROBLEM

The purpose of this study was to investigate the extent to which an individual's cognitive style interacted with different types of learner preparation. More specifically, the investigator attempted to ascertain whether or not a specific preinstructional strategy was significantly more effective for a learner whose cognitive style had been identified. The investigator believed that the learning of new and meaningful information would be enhanced by matching the students cognitive style with the appropriate type of learner preparation.

Background of the Problem

The College Entrance Examination Board recently announced that freshmen entering American Colleges in fall 1977 received, on the average, the lowest scores on the scholastic aptitude test (SAT) ever recorded in the 51 years that it has been administered. Educational Testing Service commissioned a panel of 21 educators, foundation officials and other experts to study this phenomenon. In their report, On Further Examination (1977), these experts stated "The only right answer is to vary the instructional

process still more to take account of increased individual differences" (p. 47). Many others (Cronbach, 1967; Cronbach & Snow, 1977; Gagne, 1967; Glasser, 1967; Jensen, 1968; Merrill, 1975; Snow, 1976a, 1977) have stated that no single instructional strategy will be optimal for each student. Therefore, in their attempt to tailor instruction to the individual, the educator's search for generally superior methods should be supplemented by a search for specific ways to fit the instruction to each type of learner. One method of accomplishing this objective is through the study of aptitude-treatment interactions (ATI).

"One can expect interactions between learner characteristics and instructional method. Where these exists, the instructional approach that is best on the average is not best for all persons." (Cronbach & Snow, 1977, p. 1). The problem is to determine which individual differences interact with specific instructional treatments. Therefore, in educational media research, ATI studies have replaced the earlier focus on media comparisons (DiVesta, 1975; Salomon & Clark, 1977). Numerous traits have been studied, the most common being IQ and gender, and many interesting interactions with various treatments have been found (Allen, 1975; Cronbach & Snow, 1977; Parkhurst, 1975). However, many important traits are still relatively unexplored; foremost among these is cognitive style.

Cognitive style may be defined as the way people

process information. Since the definition is so pervasive, there are many dimensions of cognitive style. However, among the many facets that have been identified, the field-dependence-independence (global-analytic) dimension has been the most extensively studied and has the widest application to educational problems. "The evidence that research has already produced suggests that a cognitive style approach may be applied with profit to a variety of educational issues" (Witkin, Moore, Goodenough, & Cox, 1977a, p. 1).

Witkin et al. (1977a) identified the analytic (field-independent) person as one who experiences himself as separate and distinct from others and one who tends to rely on internal cues for processing information; whereas the global (field-dependent) individual tends to rely on external sources for structure and information. Therefore, the distinctive structure provided by various types of preinstructional strategies should have a profound effect on persons with differing cognitive styles. McClung (1976) also indicated that learner preparation should be considered when designing and developing instructional materials for individuals with particular cognitive styles because of the expected interaction between the two.

Greer and Blank (1977) stated that "previous research has found that the non-analytic child tends to lack the ability to discriminate important components of a problem

and to extract meaningful information. . . . The analytic child, on the other hand, has generally been found more capable in performing the necessary information-gathering and hypothesis testing skills . . ." (p. 310). This process is also critical in determining how a student will learn new material.

Also, "the sequencing and arrangement of subject material appears to influence not only what students learn, but also their attitudes towards the usefulness and importance of what has to be achieved. For this reason, any procedure which makes this arrangement or organization more obvious and striking is likely to facilitate the learning of meaningful material. Nowhere is this more important than in the preliminary phases of teaching and instruction" (Hartley & Davies, 1976, p. 239). Therefore, it seemed that an interaction should exist between cognitive style and preinstructional strategies that provide different types of organization and structure.

Two of the most frequently used examples of learner preparation are the overview and the advance organizer. Very little research has been done to examine the effectiveness of overviews. However, they are quite well defined. Air Force Manual 50-9 defines an overview as "a clear, concise presentation of the objective and key ideas" of the lesson (p. 80). Hartley and Davies (1976) stated that "generally speaking, overviews serve to introduce students

to new material by familiarizing them with the central argument. They may also emphasize key concepts, principles, and technical terms, as well as prepare students for the general structure or gestalt of the material to be mastered" (p. 244). Also, the overview is presented at the same level of abstraction, generality, and inclusiveness as the learning material itself (Ausubel & Robinson, 1969).

On the other hand, a plethora of research on the effectiveness of advance organizers has been done by Allen, (1970), Ausubel (1960), Ausubel and Fitzgerald (1961, 1962), Ausubel and Youssef (1963), Clawson and Barnes (1973), Munford (1972), and Weisberg (1970) just to name a few. However, the definition of an advance organizer is somewhat less operational than that of an overview. Ausubel (1963) defines the advance organizer as introductory material at a higher level of abstraction, generality, and inclusiveness. By deliberately introducing relevant concepts, the student is provided an ideational scaffolding which enhances his ability to incorporate and retain the more detailed material in the learning passage. Unlike overviews, which are content oriented, advance organizers are process oriented.

Therefore, it was the intent of this study to show that some form of learner preparation would enhance learning and that there would be a trait-treatment interaction between the various preinstructional strategies and the

global-analytic dimension of cognitive style.

#### Statement of the Problem

In order to effectively design individualized instruction one must ascertain the various traits of the student and use those treatments that are most appropriate to his style of learning. One of the most stable learning determinants is cognitive style (Witkin, Goodenough, & Karp, 1967). Also, learner preparation is an important and effective design factor (AFM 50-9, 1967; Ausubel & Robinson, 1969; Hartley & Davies, 1976). Therefore, it was the objective of this study to determine if there is a trait-treatment interaction between cognitive style and learner preparation.

More specifically, this study attempted to ascertain whether or not two specific types of learner preparation (advance organizer or overview) provided a more effective introduction, and therefore significantly greater cognitive learning, for students whose cognitive styles have been identified.

#### Importance of the Study

As indicated by Allen (1975) and Weisberg (1970) more research must be done to determine what type of pre-instructional strategy, if any, is most effective for a specific individual. Because an individual's cognitive style is a major factor in determining his ability to organize material (Goodenough, 1976; Shouksmith, 1970;

Witkin et al. 1977a) it is appropriate to expect an interaction between cognitive style and learner preparation.

Therefore, the identification of a specific type of learner preparation which is most effective for individuals with a particular cognitive style would enable educators to design materials to provide the most effective individualized instruction.

#### Substantive Questions to be Answered

This study attempted to answer the following questions:

1. Will there be significant interaction between learner preparations for subjects of distinctive cognitive styles?
2. Will subjects receiving either type of learner preparation perform significantly better than those subjects who receive no preparation regardless of the learner's cognitive style?

#### Research Hypotheses

In order to test for the effects of various pre-instructional strategies on cognitive style, and to ascertain whether a trait-treatment interaction exists, the following hypotheses were examined:

1. A global individual given the advance organizer will perform significantly better on the post-test than an analytic individual given the advance organizer.



2. An analytic individual given the overview will perform significantly better on the posttest than a global individual given the overview.
3. Subjects given either type of learner preparation will perform significantly better on the posttest than subjects receiving no preparation regardless of cognitive style.

#### Assumptions

The following assumptions were made in this study:

1. The Group Embedded Figures Test would distinguish between subjects having analytic and global cognitive styles.
2. The test for cognitive style would not affect performance on the posttest.
3. The pupils used in this study could all perform the task within the specified time interval.
4. The research design, data analysis procedure, and control methods selected for this study were appropriate.
5. The subjects in the experimental and control groups were of comparable socio-economic status, ethnic, and cultural backgrounds.

#### Delimitations

1. The population consisted of juniors, seniors, and first year graduate students at the University of Southern California.

2. The cognitive area treated by this study was on the properties of plain carbon steel.

#### Limitations

1. The reliability and validity of the test instruments designed and selected for use in this study effected the outcome of the study.
2. The cognitive styles treated in this study were those identified by the Group Embedded Figures Test. Generalizations, therefore, will not be valid relative to other dimensions of cognitive style.

#### Definition of Terms

Advance Organizer. Introductory material at a higher level of abstractness, generality, and inclusiveness (Ausubel, 1963).

Analytic. A dimension of cognitive style characteristic of an individual who: can perceive items as discrete from their background; can reorganize an already organized field; can provide structure to unstructured material; tends to be articulate when describing himself and his experiences; and tends to be independent. The term is used interchangeably with the terms field-independence and articulated.

Aptitude-Treatment Interaction (ATI). An ATI exists when, as a result of a given treatment, individuals at one end of an aptitude variable perform at one level on a criterion measure. Also, individuals at the other end of the aptitude

variable perform at a significantly different level on the criterion measure. This term is used interchangeably with trait-treatment interaction (TTI).

Aptitude. Any personological or organismic variable upon which individuals differ (Parkhurst, 1975).

Cognitive Style. The individual consistencies in cognitive behavior resulting from the individual's perceptual and conceptual organization of the external environment (Kagan, Moss, & Sigel, 1963).

Disordinal interaction. This type of interaction occurs when the interaction is statistically significant and the lines which represent the effect of the various treatments cross within the range of the measurement trait.

Field-dependent. See global.

Field-independent. See analytic.

Global. A dimension of cognitive style characteristic of an individual who: tends to have difficulty separating field from ground; is inclined to respond to a stimulus as a whole; tends to rely on external sources for structure and organization; tends to be dependent on others; and is socially oriented. The term is used interchangeably with the term field-dependence.

Ordinal interaction. This type of interaction occurs when the interaction is statistically significant and the lines which represent the effect of the various treatment levels across the levels of the personological variable do not

cross within the range of the measurement trait.

Overview. A clear, concise presentation of the objectives and key ideas that are to be covered in the lesson.

Treatment. The instructional strategy or strategies which structure information for the purpose of having students learn that information (Parkhurst, 1975).

## CHAPTER II

## REVIEW OF THE LITERATURE

Introduction

The intent of this chapter is to review the previous research that is pertinent to this study. It is divided into three sections. The first section examines one of the most promising approaches to the effective individualization of instruction--the study of aptitude-treatment interactions.

The second section is concerned with the concept of cognitive style. This construct is defined as the way people process information which is a pervasive and stable dimension of individual functioning. Although many facets of cognitive style have been identified, this section will deal mainly with the field-dependence-independence (global-analytic) dimension.

The third section discusses the various types of learner preparation. Each preinstructional strategy has a distinctive function and is representative of a different theory of learning. The four major strategies (pretests, behavioral objectives, overviews, and advance organizers) are analyzed with emphasis on the overview and advance

organizer.

#### Aptitude Treatment Interaction

Educators are becoming increasingly aware of the need to individualize instruction. Berlinger and Cahen (1973), Cronbach (1967), Cronbach and Snow (1977), Gagne (1967), Glasser (1967), Hebein (1978), Merrill (1975), Snow (1976a, 1977) and other educational researchers indicated that no single instructional strategy will be optimal for each student. Therefore, "researchers in the field of instruction are becoming more amenable to the idea of aptitude-treatment interactions as opposed to the search for the one 'best' method or instructional treatment." (Salomon, 1972, p. 327)

"An aptitude-treatment interaction exists whenever the regression of outcome from Treatment A, upon some kind of information about the person's pretreatment characteristics, differs in slope from the regression of outcome from Treatment B on the same information" (Cronbach & Snow, 1977 p. 5). Therefore, aptitude-treatment interactions occur when specific differences in learner traits interact with the instructional treatment. It is this interaction which theoretically explains the ability of certain students to learn more effectively when using a different type of instruction.

Some authors substitute "trait-treatment inter-

action" (TTI) or a phrase like it for aptitude-treatment interaction. This investigator uses these phrases interchangeably. As Cronbach and Snow (1977) stated "the world will be as well served by any label so long as the research itself goes forward" (p. 6).

Very little empirical evidence has been provided to support the trait-treatment interaction (TTI) concept. In his review of 90 research studies, Bracht (1970) stated that disordinal interactions were found in only five studies, and "ordinal or non-significant" interactions in all the others.

A statistically significant interaction is ordinal when the lines which represent the effect of the various treatment levels across the levels of the personological variable do not cross. When the interaction is statistically significant and the lines cross within the range of the measurement trait the interaction is disordinal.

Brocht's review is indicative of the disappointing history of interaction research. This history has caused many investigators to ask if aptitude-treatment interactions actually exist. Cronbach and Snow (1977) specifically addressed this question and stated:

Aptitude-Treatment interactions exist. To assert the opposite is to assert that whichever educational procedure is best for Johnny is best for everyone else in Johnny's school. Even the most commonplace adaption of instruction, such as choosing different books for

more and less capable readers of a given age, rests on an assumption of ATI that it seems foolish to challenge. (p. 492)

If ATI's exist, why were Bracht's conclusions so disappointing? Berlinger and Cahen (1973) took exception to his conservatism when they stated "We feel that the technique for detecting disordinal interactions proposed by Bracht and Glass (1968) is overly conservative and perhaps unnecessary. It should be noted here that we believe ordinal as well as disordinal interactions can be used to advantage in TTI research" (p. 61). Cronbach and Snow (1977) also disputed Bracht's findings. Unlike Bracht, they considered ordinal interactions important. They also took exception to his "unreasonably stringent test for disordinality" because it required him to discount some positive results.

Cronbach and Snow pointed out that in some cases Bracht used the abstract of the report instead of the full report which may have led him to inappropriate conclusions. Also Bracht tended to put studies into his category of "ordinal-or-no-interactions" if the abstract was obscure. These tactics necessarily contributed to the paucity of disordinal interactions. In fact, in their critique of his study, the authors indicated that "Bracht's reasoning was penurious rather than merely parsimonious" (Cronbach & Snow, 1977, p. 496).



Cronbach and Snow (1977), DiVesta (1975), Glasser (1972), Snow (1976a), and others have suggested various explanations for the lack of significance in ATI research. Some methodological difficulties included: 1) failure to provide for the possibility that traits interact with the treatments as well as the learner's information processing strategies, 2) lack of control of presentation stimuli, 3) inappropriate statistical analysis, 4) inadequate dissimilarity in alternative treatments, and 5) that the analysis of interaction effects was often an afterthought instead of an intentional and carefully planned part of the experiment.

Although there is no single design that can prevent all the difficulties listed above, Garrison (1977) identified three critical factors required for the detection of an ATI: 1) at least two different treatments with identical objectives must be monitored, 2) the criterion variable measure must be identical for alternative treatments, 3) the learner aptitude measure for subjects within alternative treatments must be identical.

Many studies designed to find aptitude treatment interactions have ignored these simple precepts which caused their results to be unuseable. Also, it is very seldom that research not specifically designed to isolate interactions meets the necessary requirements which thereby limits the usefulness of, such studies.

Salomon (1972) perceived ATI research as accomplishing two functions: 1) to develop better explanatory principles concerning the nature of instruction, and 2) to improve instruction.

The first function of ATI research, to develop better explanatory principles concerning the nature of instruction, is seen by some (Carroll, 1968; Cronbach, 1966; Cronbach & Snow, 1977; DiVesta, 1974) as the more practical approach in the long run. DiVesta (1974) indicated the need for a "renewed emphasis on basic research" explaining that "an educational psychology of instruction ought to be applied in the sense of answering questions about the nature of human knowledge, the process by which it is acquired, and how knowledge acquisition can be facilitated through instruction" (p. 367). Therefore, trait-treatment interaction research may facilitate the development of a theory of instruction by discovering the interaction of learning situations and learner characteristics.

The second function, improving instruction, is a very pragmatic goal; however, it is not an extremely realistic one at this time. There are numerous reasons for this phenomena, the most obvious is that any group of learners can be divided along numerous, uncorrelated lines. Consequently a myriad of alternative procedures may be developed, all of which are effective and some of which are contradictory. For these and other reasons, Cronbach and

Snow (1977) concluded that no aptitude-treatment interactions were sufficiently well confirmed that they could be used directly as guides to instruction.

Salomon (1972) further formalized three heuristic models for ATI studies in order to clarify their functional relationships to instructional practices. Although the three models are complementary, each emphasizes a different domain of treatments and aptitudes. These models are 1) remedial, 2) compensatory, and 3) preferential.

The remedial model deals mainly with attempts to overcome learning deficiencies and is the most commonly practiced one. In this model the assumption is made that some critical learning capability is deficient or missing and no learning can be anticipated unless the deficiency is overcome. Therefore, specific treatments are designed to assist the learners overcome inadequacies in prerequisite learning.

In the second model, the compensatory model, the treatments are designed to "compensate" for each individual's deficiency by providing the necessary structure or mediators that the learner cannot provide for himself. Unlike the first model, the deficiencies are not corrected but their debilitating effects are circumvented.

In the third, preferential model, the instructional treatments are designed to capitalize on what the student is capable of doing. This model exploits the available

strong points in the students characteristics. It is preferential because the treatments are adapted to the learner's preferred style or information-processing strategy.

It has been suggested by some (Merrill, 1975; Salomon, 1972) that the only practical way to assign students to different curricula, contents, modalities, and rates of presentation is to use computer based instruction. Merrill (1975) stated:

What is needed is a dynamic general strategy enabling learners to select at any moment the particular tactic that is optimal for their unique configurations of aptitudes at that moment in time. Furthermore, they must be able to select a new tactic on a moment's notice. They must not be required to anticipate their aptitude configuration or the tactic needed more than one step ahead. They must be able to make the change with a minimum of effort. (p. 222)

Merrill's solution was the incorporation of a learner-controlled computer-assisted instruction system that was developed at Brigham Young University. The system was called TICCIT (Two-way Interactive Computer Controlled Informative Television). Even though the acceptance of TICCIT has been somewhat tentative and disappointing, this approach is indicative of the need to ascertain what aptitudes interact with which treatments, and the need to appropriately tailor materials for the individual based on that knowledge.

The study of aptitude-treatment interactions has

come of age. Future research on instruction will need to incorporate its implications in theory and in practice, regardless of how one ultimately adapts instruction. ATI methods and ideas have a fundamental role to play in educational design and evaluation. As this role continues to unfold, new lines of research will reopen old questions, as well as to define issues not considered by the traditional experimental and correlational studies (Cronbach & Snow, 1977).

In summary, despite the dearth of empirical evidence supporting aptitude-treatment interactions, researchers are becoming more amenable to the concept. The practical interest stems from the possibility that these interactions can be used to adapt instruction to fit different learners optimally because previous attempts at individualizing instructions have been generally ineffective in eliminating individual differences in learning (Snow, 1976b). Cronbach and Snow (1977) have shown that aptitude-treatment interactions do exist, and that any attempt to individualize instruction rests explicitly or implicitly on hypothesized ATI. However, since few studies are well understood and none are yet directly applicable to instructional design, more in-depth and systematic research is required for ATI to reach its full practical potential.

### Cognitive Style

The concept of cognitive style has appeared in the literature since the beginning of this century. Its foundation is in perception theory and became a psychological construct through Gestalt psychology. An initial problem for researchers in perception (Rubin, 1915; Wertheimer, 1923) was to determine how objects are distinguished from their surroundings (figure-ground phenomenon). It was discovered that small areas enclosed in larger areas are taken as figure, or object. A repeated pattern is taken as belonging either to figure or ground but not to both. Straight lines are attributed to figure as are emotionally-toned shapes. These latter shapes, when present, tend to make the figure dominant. In addition, the observer's perceptual set and his individual interests tend to bias the situation (Gregory, 1970).

Koffka (1935) applied four major principles or laws of perception research to learning which he derived from the works of Max Wertheimer (1923): 1) the law of similarity, 2) the law of proximity, 3) the law of closure, and 4) the law of good continuation.

The first law, similarity, stated that items similar in form or color, or similar transitions (e.g., alike in the steps separating them) tend to form groups in perception. The law of proximity stated that perceptual groups are favored according to the nearness of the parts.

The closure law stated that closed areas are more stable than unclosed ones and therefore more readily form figures in perception.

The fourth law, good continuation, is the one of most practical concern to this study. This principle dealt with perceptual organization and stated that organization in perception tends to occur in such a manner that a straight line appears to continue as a straight line, a part of a circle appears as a whole, even though many other kinds of perceptual structuring would be possible. "Closure and continuation are aspects to articulate organization. Organization applies to learning as well as perception" (Hilgard & Bower, 1966, p. 235).

The Gestalt psychologists were extremely concerned with the idea of perceptual organization and the innate style by which individuals organize stimulus patterns into wholes.

Allport (1937) first used the term style when describing consistencies and patterns demonstrated by individuals in their daily activities. Since that time, numerous researchers have used the term cognitive style to denote individual differences in modes of cognitive functioning. Because of the comprehensive definition of cognitive style, investigators have delineated numerous dimensions. The three major researchers involved in this area are Gardner, Kagan, and Witkin.

### Gardner's Interpretation of Cognitive Style

A major project involving cognitive style was performed by Riley Gardner and others at the Menninger Foundation. Their work stressed perceptual tasks and were based on principles of cognitive organization. Eventually they blended the ego functioning aspect of cognitive organization with Gestalt psychology and identified six dimensions of cognitive style. Gardner's dimensions were: 1) field articulation, 2) leveling-sharpening, 3) conceptual differentiation, 4) extensiveness of scanning, 5) tolerance for unrealistic experiences, and 6) constricted-flexible control.

Gardner (1962) stated that the first dimension, field articulation, governs individual differences in the ability to overcome illusions requiring selective attention, or the ability to differentiate complex stimulus fields. The second dimension, leveling-sharpening, is the tendency to perceive a series of gradually changing stimuli as the same. Conceptual differentiation measures an individual's ability to differentiate categories of similar objects. Extensiveness of scanning is concerned with the amount the individual shifts attention when attempting to assess a stimulus. Tolerance for unrealistic experiences accounts for a common factor measured in tests involving the illusion of apparent movement (field-ground reversal) and mode of approach to Rorschach inkblots. The final



dimension, constructed-flexible control, is concerned with subjects ability to overcome interfering stimuli such as the word blue written in green.

#### Kagan's Interpretation of Cognitive Style

A second area of research intended to delineate the dimensions of cognitive style is represented by the work of Kagan, Moss and Segil (1963). Unlike Gardner, Kagan and his associates stressed conceptual activities rather than perceptual tasks. They described three basic categories of cognitive style: 1) descriptive-analytic, 2) relational-contextual, and 3) inferential-categorical.

The descriptive-analytic dimension identifies those individuals who prefer to split their environmental stimuli into parts and respond to them as separate entities. The relational-contextual dimension is illustrated by a preference for characterizing objects on the basis of functional or thematic relationships which may exist among the objects. The inferential-categorical dimension is exemplified by an individual who categorizes the object on the basis of inferences made about the stimuli that he groups together (Coop & Siegel, 1971; Kagan et al., 1963).

Kagan et al. (1963) not only determined that cognitive style is a rather pervasive and stable individual preference for dealing with environmental stimuli, but also isolated consistent patterns of psychological functioning in other areas that are related to the individual's

cognitive style. Descriptive-analytic subjects appear to attend to more factual detail during concept acquisition and tend to score higher on performance tests than on verbal tests (Kagan, Rosman, Day, Albert, and Phillips, 1964).

#### Witkin's Interpretation of Cognitive Style

The third major investigation of cognitive style and the one which seems to have the clearest implication for educational issues is the work of Herman Witkin and his colleagues (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962; Witkin et al., 1977a).

Originally Witkin and his associates were concerned with the perceptual problem of maintaining a correct vertical orientation. They discovered that individuals vary considerably, especially in extreme cases, in their ability to ignore conflicting visual cues when attempting to perceive the upright or vertical (Witkin & Asch, 1948).

On the basis of evidence obtained in an extensive series of figure-ground related studies, Witkin and his colleagues hypothesized a general cognitive style by which performance in many perceptual and intellectual situations might be characterized. They identified this style as the ability to separate figure from ground when conflicting cues are present in the perceptual field. Those who were unable to overcome the conflicting context were designated field-dependent individuals, those who mastered the task

were designated field-independent (Karp, 1963).

Witkin postulated that the field-dependent-independent cognitive styles were process variables rather than content variables. They are concerned with the form rather than the content of cognitive activity. They refer to individual differences in perception, thinking, problem solving, etc. Cognitive styles are also pervasive dimensions of individual functioning. They cut across the boundaries traditionally used in compartmentalizing the human psyche and therefore have important implications for the educational setting. Another characteristic of cognitive styles is that they are stable over time. They are also bipolar and value neutral. Each pole has adaptive value under specified circumstances, and so may be judged positively in relation to those circumstances. (Witkin et al., 1962; Witkin et al., 1977a; Witkin, Moore, Oltman, Goodenough, Friedman, Owen & Raskin, 1977b.)

Field-dependent individuals tend to perceive a stimulus globally or holistically and are strongly influenced by the organization already present in the "field." Field-independent individuals tend to perceive a stimulus analytically, experience items as discrete from their background, and are able to restructure already structured field and organize an unstructured field (Witkins et al., 1962). "The 'global vs. analytic mode of field approach' thus becomes a designation for a cognitive style which

expresses itself in both perceptual and intellectual functioning" (Fateron, 1962, p. 183).

#### Field-Dependent-Independent Styles

The global-analytic dimension of cognitive style was selected for this study because the Witkin construct requires that the subjects exhibit a particular type of ability which is highly perceptual in nature (Coop & Siegel, 1971). This construct requires shifting between the perceptual and cognitive domains but is undoubtedly the most perceptually-oriented dimension of those that have been discussed. Also, it is more indicative of an individual's ability to perform a specific operation than his preference for the selection of a particular response from his repertoire of useable responses.

A factor analysis provides a common denominator underlying individual differences in performance on figure-ground related tasks which indicates the extent to which the person perceives part of a field as discrete from the surrounding field as a whole, rather than embedded in the field. It also indicates the extent the organization of the prevailing field determines perception of its components (Bergman & Engelbrekton, 1973; Fine & Danforth, 1975; Vernon, 1972). Since one extreme of the performance range is dominated by the prevailing field, that mode is designated "field-dependent." Since the individual at the other extreme experiences items as separate from the

surrounding field that mode is designated "field-independent" (Witkin et al., 1962; Witkin et al., 1977a).

A synthesis of the research provides a deliniation of the attributes of global and analytic individuals.

Field-dependent persons:

1. Tend to adhere to the organization of the field as given.
2. Are likely to rely on external referents as guides in information processing.
3. Favor interpersonal domains which are primarily social in content, require interpersonal relations for their conduct, and do not require cognitive restructuring skills.
4. Are better able to learn socially relevant material.
5. Tend to assume a passive or spectator role in learning.
6. Are much more affected by negative reinforcement.
7. Are inclined to be influenced by authority and the opinions of others.
8. Are likely to have lower performance expectations.
9. Favor interactive teaching methods.
10. Tend to be more considerate managers.
11. Are inclined to assume a more stereotyped role.
12. Favor nonspecific defenses, such as repression.

These persons tend to prefer professions such as nursing, social work, and elementary education.

Field-independent individuals:

1. Are likely to overcome the organization of the field, or restructure it, when presented with a field having a dominant organization.
2. Tend to give greater credit to internal referents.
3. Favor domains which emphasize cognitive restructuring skills, are primarily abstract and nonsocial in content.
4. Prefer to learn general principles rather than specific information.
5. Assume a more active or participant learning role.
6. Learn more effectively when the motivation is intrinsic.
7. Are inclined to attend to nonsalient attributes in concept learning tasks.
8. Favor expository teaching methods.
9. Are inclined to be less considerate managers.
10. Are likely to use specialized defenses such as intellectualization.
11. Tend to be independent.
12. Tend to be articulate when describing themselves and their experiences.

These individuals tend to prefer professions such as: mathematics, engineering, and experimental psychology (Ferrell, 1971; Fitz, 1971; DiStefano, 1970; Goodenough, 1976; Karp, 1963; Schimek, 1968; Rosenberg, Mintz, & Clark,

1977; Weissenberg & Gruenfeld, 1966; Witkin et al., 1962; Witkin et al., 1977a; Witkin et al., 1977b).

Schimek (1968) stated that any approach to the study of cognitive style requires the assumption that individual differences in style have long range stability.

Witkin et al., (1967) used a battery of tests of field-dependence-independence to ascertain the extent of differentiation in perceptual functioning of subjects. They determined that there was a progressive increase in analytic performance up to age 17, with no further change until late in life, at which point the individual becomes progressively more global. However, at each age, each subject maintained the same position relative to his peers even though the entire group became more field-independent.

Faterson and Witkin (1970, Holtzman (1965), Kagan et al. (1963), Kagan et al. (1964), Witkin et al. (1977a) and others point out that cognitive styles are stable individual differences in mode of perceptual organization and conceptual categorization of the external environment.

#### Educational Implications of Cognitive Style

Goodenough (1976), and Witkin et al. (1977a) stated that analytic and global individuals do not seem to be appreciably different in learning or memory abilities, but do seem to employ different learning strategies and tend to be better at learning various types of material.

The initial difference is the individual's ability to structure material. The analytic person is likely to

analyze a field when the field is organized and to impose structure on a field when it lacks inherent organization. In contrast, the person who perceives globally is likely to take the organization of the field in perceptual tasks as given. Therefore, the field-independent person is likely to perform better in a situation which requires the individual to provide the organization necessary to learn the material. On the other hand, when the material is presented in an organized form, such that structuring is not required, analytic and global types perform equally well (Goodenough, 1976; Grieve & Davis, 1971; Koran, Snow, & McDonald, 1971; Renzi, 1974; Schwen, 1970; Witkin et al., 1962; Witkin et al., 1977a).

Another difference between analytic and global individuals is their use of mediators. Field-independent persons are more likely to use mediators, of their own design, when dealing with a learning task. The field-dependent person is more likely to rely on the characteristics of the learning task itself. The evidence suggests that global individuals use a passive approach to learning and concept attainment whereas the analytic individual uses a more active, hypothesis testing, approach. Field-dependent students require explicit instructions in problem solving strategies or a more exact definition of performance outcomes than analytic persons, who tend to perform better when allowed to develop their own strategies (Bruner,



Goodnow, & Austin, 1956; Greer & Blank, 1977; Grippin, 1972; Nebelkopf & Dryer, 1973; Nelson, 1972; Witkin et al., 1977a).

It has also been noted that global subjects are dominated by the salient, most obvious, attribute of the stimulus, which tends to provide a figural quality against the ground provided by the remaining aspects of the stimulus configuration. Global subjects are also inclined to ignore nonsalient cues when constructing hypotheses in problem solving and concept attainment. In contrast, analytic subjects restructure the field to meet the requirements of the task. Therefore, the performance of the field-dependent individuals is impaired if the salient cues are irrelevant to the concept definition. However, performance is more rapid if the cues are relevant. Field-independent persons are better at concept attainment because they are able to sample more fully from the sets of cues available (Dickstein, 1968; Goodenough, 1976; Kirchenbaum, 1968; Ruble & Nakamura, 1972; Witkin et al., 1977a).

Another educational consideration is the effect of interference on individuals with differing cognitive styles. Analytic people tend to be less susceptible to interference effects because of their more active participation in organizing the material. Since interference is an important cause of forgetting, analytic individuals

seem to be better learners in general (Gollin & Baron, 1954; Goodenough, 1976; Witkin et al., 1962; Witkin et al., 1977a)

The effect of different types of reinforcement is another way in which an individual's cognitive style influences learning. Global learners tend to require externally defined goals and reinforcements whereas analytic learners tend to have self-defined goals and reinforcements; therefore, field-independent individuals perform better than field-dependent individuals under conditions of intrinsic motivation. However, this difference disappears when extrinsic rewards are introduced regardless of the nature of the rewards. The global person is also inclined to be more affected by criticism than the analytic person (Ferrell, 1971; Fitz, 1971; Goodenough, 1976; Konstadt & Forman, 1965; Randolph, 1971; Steinfeld, 1973; Witkin et al., 1977a).

Numerous researchers (Coop & Brown, 1970; DiStefano, 1970; Grieve & Davis, 1971; Witkin et al., 1962; Witkin et al., 1977a) have studied the concept of student-teacher interaction. Although the results are somewhat conflicting, the evidence suggests that the cognitive style match-mismatch is an important factor in learning.

In summary, it appears quite evident that the individuals at the extremes of the analytic global dimension of cognitive style favor different learning

approaches. Analytic individuals learn or remember better under conditions such as intrinsic motivation, or discrimination learning when nonsalient cues are relevant; whereas global individuals are superior under conditions such as negative reinforcement or learning socially relevant information. It can also be concluded from the research that field-dependence-independence is more related to how the learning or memory process occurs than how efficient the process is (Goodenough, 1976; Witkin et al., 1977a).

#### Learner Preparation

The most pervasive information resource available to educators is printed material. Therefore, a major concern of instructional developers is the effective design of these materials in order to maximize learning. Hartley and Davies (1976) noted that

The sequencing and arrangement of subject material appears to influence not only what students learn, but also their attitudes towards the usefulness and importance of what has to be achieved. For this reason, any procedure which makes this arrangement or organization more obvious and striking is likely to facilitate the learning of meaningful material. Nowhere is this more important than in the preliminary phases of teaching and instruction. (p. 238)

An introduction provides the student with a preview of the salient concepts or with a perceptual structure for organizing the new material (AFM 50-9, 1967; Ausubel, 1963; Ausubel & Robinson, 1969; Christensen & Stordahl, 1955;

Prothero, 1973; Hartley & Davies, 1976).

The most common preinstructional strategies are: 1) pretests, 2) behavioral objectives, 3) overviews, and 4) advance organizers. Each of these strategies help to prepare the learner for the instruction that is to follow. However, there are essential differences between them: they are distinctive in appearance and role, their psychological foundations rest in different learning theories, and they are indicative of the sundry assumptions of educational researchers.

Pretests are unique because they are well founded in test theory. For this reason, they have a stronger statistical and theoretical base than the other types of learner preparation. A pretest is defined as a set of questions that are directly relevant to the skill or knowledge to be acquired which is given prior to instruction. Pressey (1926) determined that tests are a valid instructional instrument. Therefore, a pretest can aid the student by alerting him to salient or unfamiliar information, it can provide him an opportunity to ascertain the relevancy of the material, and it can serve as a categorization of the learning task so that some generalization is possible (Campbell & Stanley, 1966; Frase, 1970; Rothkopf, 1970; Hartley & Davies, 1976).

A second preinstructional strategy (one which is somewhat more relevant to this study) is the use of

behavioral objectives. Mager (1962) stated that an objective should identify the acceptable behavior required to show that the objective has been met, define the important conditions under which the behavior is to occur, and specify the acceptable criterion to which the student must perform.

It is suggested by some (Duchastel & Merrill, 1973; Hartley & Davies, 1976; Prothero, 1973; Rothkopf, 1970; Rothkopf & Kaplan, 1972) that behavioral objectives provide the student with a goal that can be used to efficiently organize learning activities, indicate which concepts are important and which are irrelevant, and they give him a way to objectively evaluate his own performance.

The overview is the most common form of learner preparation and is the most intuitively attractive. Although little empirical research has been done to ascertain the actual effectiveness of the overview, it is still the most ubiquitous preinstructional strategy.

Hartley and Davies (1976) postulated that "overviews serve to introduce students to new material by familiarizing them with the central argument. They may also emphasize key concepts, principles, and technical terms, as well as prepare students for the general structure or gestalt of the material to be mastered. For this reason, overviews may be particularly powerful in establishing a learning set" (p. 244).

Most educators believe that an overview or some type of preview of the main ideas in a printed passage will have a beneficial effect on comprehension. This concept is often expressed in terms of the "whole-part-whole" method of learning which states that individuals will learn more efficiently if they get a clear picture of the structure of the material prior to learning the details (Christensen & Stordahl, 1955).

Overviews are designed to be written at the same level of generality, abstraction, and inclusiveness as the learning passage. Their vocabulary and sentence structure are simple, direct and to the point. Their effectiveness is considered to be a result of the repetition they provide as well as their emphasis on the salient points (Ausubel, 1963; Ausubel & Robinson, 1969).

Although the overview has long been accepted by educators as an effective learning aid, very little rigorous research has been performed to support its use. The majority of the studies in this area have been carried out in the context of research on the utilization of film. An analysis of this research indicated that in the majority of cases, overviews had a positive effect upon learning and retention. In those studies where the overview had no significant effect, they did not hinder learning. Also, it appeared that overviews were most effective when factual information was presented to lower-ability students, or

when concepts and principles were going to be presented to students of higher ability (Christensen & Stordahl, 1955; Earle, 1970; Hartley & Davies, 1976; May & Lumsdaine, 1958; Reynolds, 1966; Rosenshine & Furst, 1971; Weiss & Fine, 1956).

Some instructional designers (AFM 50-9, 1967) proposed a combination of the overview and behavioral objectives to provide the most effective introductory sequence. They indicated that the introduction should contain "a clear, concise presentation of the objective and the key ideas" (p. 81). Since this approach prepares the student to attend to the important information and informs him of what is expected of him, it appears to provide a combination of the best aspects of both strategies.

The fourth type of preinstructional strategy is the advance organizer. Numerous studies have been performed to ascertain the effectiveness of this type of learner preparation (Ausubel, 1960; Ausubel & Fitzgerald, 1961, 1962; Ausubel & Youssef, 1963; Berton, Clasen, & Lambert, 1972; Clawson & Barnes, 1973; Coyle, in press; Kalt & Barrett, 1973; Lawton, 1977; Munford, 1972; Scandura & Wells, 1967; Weisberg, 1970). However, the results of these studies are somewhat conflicting.

Ausubel's subsumption theory is the basis for the advance organizer. This theory takes into account the existing hierarchical organization of meaningful infor-

mation in the cognitive structure, the incorporation of new information within that structure, and the tendency for the new material to be reduced to a least common denominator of relevant established meanings (Ausubel, 1962).

Ausubel's model of cognitive organization, for learning new, meaningful materials, assumes the existence of a hierarchically organized cognitive structure in which highly general and inclusive concepts are subsumers for less inclusive subconcepts under which are subsumed specific informational data. Therefore, meaningful reception learning occurs as potentially meaningful material enters the cognitive field and is subsumed under the appropriate and more inclusive conceptual system. The existing cognitive structure then becomes the major factor affecting meaningful learning and retention (Ausubel, 1962; Ausubel & Robinson, 1969).

The initial effects of subsumption appear to be a facilitation of both learning and retention. Also, the subsumption of the new information by an established ideational system provides anchorage for the new material and thus constitutes an efficient, orderly, and stable way of retaining it for future availability. Therefore, the existing cognitive structure, which is the individual's organization stability and clarity of knowledge in a particular subject-matter field, is regarded as a major factor influencing the learning and retention of meaningful new



material. For this reason, efficient learning and functional retention of ideas and information are extremely dependent upon the adequacy of the individual's cognitive structure (Ausubel, 1963).

A major variable which affects the incorporability of new, meaningful material is the availability of relevant subsuming concepts at an appropriate level of inclusiveness in the cognitive structure in order to provide optimal anchorage. The more unfamiliar the learning task the more inclusive and highly generalized the subsuming concepts must be in order to be effective (Ausubel, 1963).

Ausubel postulated that for learning in areas where the existing cognitive structure may not contain available subsumers, advance organizers could facilitate learning. They would associate the new material with the appropriate, more inclusive concept and provide anchorage or a subsumption base for subsequent instruction (Ausubel, 1963; Novak, Ring & Tamir, 1971).

Ausubel (1965) stated that "the advantage of deliberately constructing a special organizer for each new unit of material is that only in this way can the learner enjoy the advantages of a subsumer which both (a) gives him a general overview of the more detailed material in advance of his actual confrontation with it, and (b) also provides organizing elements that are inclusive of and take into account most relevantly and efficiently the particular

content contained in this material" (p. 111).

The preceding paragraphs indicate that advance organizers are more complex than the other types of learner preparation and serve a different function. These organizers are introduced prior to the learning material itself and are presented at a higher level of abstraction, generality, and inclusiveness. They are intended to provide a conceptual framework that students can use to clarify the task ahead. They are process-oriented and emphasize context, whereas the other strategies are intended to alert or prepare the student. The ultimate goal of an advance organizer is to aid the learner fit new meaningful material into his or her existing cognitive structure (Ausubel, 1963).

Hartley and Davies (1976) indicated that the major problem is the design and writing of advance organizers. "There is, at present, no procedure publicly agreed upon for writing advance organizers, no operationally defined steps for generating them (p. 245).

Numerous research studies using advance organizers have been performed since Ausubel conducted the first study in 1960, and the results are confusing and inconclusive.

Allen (1970), Anderson (1973), Andrews (1971, 1972), Ausubel (1960), Ausubel and Fitzgerald (1961, 1962), Ausubel and Youssef (1963), Baylis (1975), Kalt and Barrett (1973), Kuhn and Novak (1971), Lawton (1977), Merrill and Stolurou

(1966), Ring and Novak (1971), Scandura and Wells (1967), Schnell (1972), Thelen (1971), and Weisberg (1970) among others have found that advance organizers facilitated learning.

Conversely, Andreozzi (1975), Atwood (1976), Berton et al. (1972), Christensen and Stordahl (1955), Clawson and Barnes (1973), Graber, Means, and Johnsten (1972), Parisi (1976), Pella and Triezenberg (1969), Proger, Taylor, Mann, Coulson, and Bayuk (1970), and Schulz (1966) and others have found that advance organizers did not significantly facilitate learning or retention.

Because of the strong theoretical base of the advance organizer, these conflicting results are quite disappointing. Apparently what is needed to obtain more pragmatic results is a clear operational definition of the concept.

In summary, each type of learner preparation is distinctive in function and form. The pretests alert, behavioral objectives inform, overviews prepare, and advance organizers clarify. Each, in its own way, gives direction to learning through its introductory or anticipatory role, providing an overall learning set or psychological expectation for what is to follow (Hartley & Davies, 1976).

## CHAPTER III

### METHODOLOGY AND DESIGN

The purpose of this study was to investigate the interactive effects of the global-analytic dimension of cognitive style and two different preinstructional strategies on criterion test scores.

The research design employed in this study was the Posttest-only Control Group Design (Campbell & Stanley, 1966, p. 25).

#### Experimental Variables

The study measured the interaction of the independent variables cognitive style and learner preparation.

#### Cognitive Style

Cognitive style has been defined as the way people process information and it is a pervasive and stable dimension of individual functioning. The field-dependent-independent (global-analytic) dimension of cognitive style was used for this study and was measured by the Group Embedded Figures Test (Witkin, Oltman, Raskin, & Karp, 1971).

The Group Embedded Figures Test (GEFT) identifies individuals along a continuum ranging from global at one end to analytic at the other. The global person is one who tends to rely on external sources for structure and

information. Whereas the analytic individual experiences himself as separate and distinct from others and one who tends to rely on internal cues for processing information.

#### Learner Preparation

This study utilized two preinstructional strategies as the second independent variable: 1) an overview, which was a clear, concise presentation of the behavioral objectives and the key concepts covered in the lesson; and 2) an advance organizer, which was introductory material written at a higher level of abstractness, generality, and inclusiveness than the lesson material.

#### Experimental Materials

The experimental treatments consisted of a learning passage of approximately 2750 words and an introductory passage of approximately 500 words (Appendix A). Three different introductions were used. The first was an overview, the second was an advance organizer, and the third was historical information.

The overview was a preview of the key ideas contained in the learning passage. It also included a list of four general behavioral objectives. The advance organizer supplied background material for the learning passage and was presented at a higher level of abstraction, generality, and inclusiveness than the learning passage itself. The historical introduction consisted of material

of an historical nature. It was not intended to provide any conceptual materials that could serve as an ideational framework for organizing the concepts and facts presented in the learning passage.

The advance organizer and the historical passages were exactly the same as those used by Ausubel (1960) and Munford (1972) to insure that the advance organizer fulfilled Ausubel's definition. The overview was designed by the investigator to fulfill the requirements of Air Force Manual 50-9 (1967).

The learning passage, on plain carbon steel, covered the same concepts and information as the Ausubel (1960) and Munford (1972) materials. However, the readability of the passage was made less difficult to insure that readability was not an intervening variable. The original materials were determined to be at the 16th grade level using the Dale and Chall (1948) measure. The revised materials were determined to be at approximately the 11th grade level using the same measure. This measure of readability was used because it was determined to be the most accurate by Klare (1974).

#### The Assessment Instruments

The independent variable, cognitive style, was measured by the Group Embedded Figures Test. The manual for the GEFT (Witkin et al., 1971) indicated that the test

has a reliability estimate, using the Spearman Brown prophecy formula, of .82 for both males and females.

The measure of cognitive learning, dependent variable, was a 35 question multiple choice posttest (Appendix B). The posttest was created by using the 35 most discriminating and representative questions from the original 42 question pool used by Ausubel (1960) and Munford (1972). The reliability estimate for the revised posttest was .81, using the Kuder-Richardson formula 21.

#### Sample Population

The population selected for this experiment was from the University of Southern California. A total of 110 subjects were administered the Group Embedded Figures Test. The subjects were obtained from four different sources. One class of 20 graduate students enrolled in an initial Instructional Technology class was used. Another 25 subjects were seniors in the school of Education enrolled in an Instructional Technology class. The remaining subjects were undergraduate students enrolled in the junior and senior classes of the Air Force Reserve Officer Training Corps (ROTC). The two junior classes accounted for 28 subjects and the three senior classes accounted for the remaining 37 subjects.

All of the graduate students returned for the treatment and none had studied the material before so all 20

subjects were included in the study. None of the seniors in the education class had studied the material before, but four were unable to return for the treatment so 21 subjects were included in the study. The junior ROTC classes provided 19 subjects for the final study because five had studied similar material before, and four did not return for the treatment. The senior ROTC classes provided 21 subjects for the study because 13 had previously studied similar materials, and three students were unable to return for the treatment. Therefore, the results from a total of 81 students were utilized in this study.

#### Conduct of the Experiment

One week prior to the actual treatment, the GEFT was administered to all subjects. Instructions, as given in the manual, were presented orally by the investigator; time was allotted for questions.

The subjects were then stratified according to cognitive style, by class, and randomly assigned to treatment groups. One week after taking the GEFT the subjects were given the treatment. They were given the appropriate introductory passage along with the learning passage. Oral instructions were presented by the investigator which directed the subjects to read both passages as if they were preparing for an examination. The subjects were given 30 minutes to complete the reading assignment.



Immediately upon completion of the reading period, the subjects were given a 35 item posttest. Since it was a power test, there was no time limit. The test was hand-scored by the experimenter; one point was given for a correct answer and zero points for an incorrect one.

#### Statistical Analysis

Any significant influence of the independent variables (cognitive style and learner preparation) on the dependent variable (posttest scores), and any significant interaction between cognitive style and preinstructional strategies was to be detected by means of a regression analysis.

Cronbach and Snow (1977) stated that in ATI research, "regression analysis is always the method of choice. Past studies have often relied on analysis of variance and have clouded their results in so doing. Even in the extreme-groups design to which it is logically appropriate, ANOVA has no advantage" (p. 515).

The regression analysis was performed using the Statistical Package for the Social Sciences (SPSS) program H, version 7. An IBM 370 computer was used for processing the data.

## CHAPTER IV

## RESULTS

This chapter presents a summary of the raw score data, and the results of the regression analysis.

The range, mean and standard deviation of the post-test and GEFT scores are listed by treatment in Table 1. The results of the regression analysis are listed in Table 2. Since the order of entry of variables into the regression equation is very important in determining the amount of variance that each variable accounts for, Table 2 shows the results obtained by entering each variable into the regression equation in the first, second, and third position. The findings indicate that there was no significant interaction between cognitive style and learner preparation. The findings also indicate that neither pre-instructional strategy significantly improved learning. Cognitive style, however, did account for a significant ( $p < .001$ ) amount of the variance in posttest scores. Due to a lack of significance relative to the hypotheses, no further statistical analysis was performed.

## Hypotheses

### Null Hypothesis 1

There will be no significant difference in mean posttest scores between analytic and global individuals receiving the advance organizer introduction.

Since analytic and global individuals performed equally well using the advance organizer, the null hypothesis was accepted.

### Null Hypothesis 2

There will be no significant difference in mean posttest scores between analytic and global individuals receiving the introductory passage containing the overview.

The data analysis showed no evidence of an interaction between cognitive style and learner preparation (overview); therefore the null hypothesis was accepted.

### Null Hypothesis 3

There will be no significant difference in mean posttest scores between individuals receiving either the advance organizer or overview and those in the control group regardless of cognitive style.

The analysis of the data indicated that there was no significant difference between treatment and control groups; therefore the null hypothesis was accepted.

## Discussion

This study clearly indicated that the use of pre-instructional strategies did not facilitate learning nor was there any significant interaction between cognitive style and learner preparation. Of course, one can only

TABLE 1

Range, Means, and Standard Deviations on the Posttest  
and Cognitive Style Test for Each Treatment Group

| Treatment         | Posttest |       |       | Cognitive Style |       |       |      |
|-------------------|----------|-------|-------|-----------------|-------|-------|------|
|                   | N        | Range | Mean  | S.D.            | Range | Mean  | S.D. |
| Advance Organizer | 27       | 6-27  | 16.82 | 5.9             | 0-18  | 13.07 | 5.2  |
| Overview          | 27       | 5-32  | 17.04 | 7.3             | 3-18  | 13.33 | 5.1  |
| Control           | 27       | 7-29  | 16.78 | 6.2             | 1-18  | 12.85 | 4.5  |
| Total             | 81       | 5-32  | 16.88 | 6.4             | 0-18  | 13.08 | 4.9  |

TABLE 2

Regression Analysis and ANOVA Results for Cognitive Style, Treatments, and Interaction

| Variable        | Regression Analysis |            |           |                              | ANOVA |             |        |
|-----------------|---------------------|------------|-----------|------------------------------|-------|-------------|--------|
|                 | Step Entered        | Multiple R | R Squared | Increase in Sum of Squared R | d/f   | Mean Square | F      |
| Cognitive Style | 1                   | .559       | .312      | Sig                          | 1/79  | 1024.50     | 35.84* |
| Interaction     | 2                   | .559       | .312      | N.S.                         | 3/77  | 341.63      | 11.65  |
| Treatment       | 3                   | .601       | .361      | N.S.                         | 5/75  | 237.20      | 8.48   |
| Residual        |                     |            |           |                              |       | 2096.74     |        |
| Interaction     | 1                   | .051       | .003      | N.S.                         | 2/78  | 4.32        | 0.10   |
| Treatment       | 2                   | .229       | .052      | N.S.                         | 4/76  | 172.25      | 1.05   |
| Cognitive Style | 3                   | .601       | .361      | Sig                          | 5/75  | 237.20      | 8.48   |
| Residual        |                     |            |           |                              |       | 2096.74     |        |
| Treatment       | 1                   | .080       | .006      | N.S.                         | 2/78  | 10.64       | 0.25   |
| Cognitive Style | 2                   | .562       | .316      | Sig                          | 3/77  | 346.32      | 11.89  |
| Interaction     | 3                   | .601       | .361      | N.S.                         | 5/75  | 237.20      | 8.48   |
| Residual        |                     |            |           |                              |       | 2096.74     |        |

\* significant effect at  $p < .001$

generalize to the specific population studied and the kinds of materials used.

Numerous plausible explanations may account for the results;

1. Since the population consisted of college students it is reasonable to assume that they are capable of compensating for any learning deficiencies caused by their specific cognitive style (Coop & Sigel, 1971).

2. The introductory passages may have been ineffective as initial structuring agents because the learning passage was sufficiently structured.

3. Since the subjects were allowed only a single exposure to the preparatory passage, it is possible that they were unable to effectively utilize the various pre-instructional strategies because they were not sufficiently familiar with their use.

4. Cronbach and Snow (1977) suggested that any aptitude-treatment interaction study should have at least 100 subjects per cell; therefore, the findings may have been nonsignificant because of the population size.

5. Because of early experiences with introductions that did not facilitate learning, the subjects may not have paid sufficient attention to the overview and advance organizer for them to be useful.

It is notable, however, that cognitive style accounted for a significant ( $p < .001$ ) amount of the variance

in performance on the posttest. The use of scientific subject matter may have accounted for this result. Also, the analytic person may be better at structuring, and internalizing new information than the global person. Therefore, it would seem that cognitive style is an effective predictor of performance for individuals studying scientific materials.

#### Summary

A regression analysis was performed and no significant interaction between cognitive style and learner preparation was discovered. Nor was either the advance organizer or the overview found to significantly facilitate learning. However, cognitive style accounted for a significant ( $p < .001$ ) amount of the variance on the criterion test.

## CHAPTER V

## SUMMARY

Purpose

The purpose of this study was to determine if an interaction between the field-dependence-independence dimension of cognitive style and learner preparation existed. The two preinstructional strategies utilized were the advance organizer, as defined by Ausubel, and the overview. The study also attempted to ascertain if these preinstructional strategies (overview and advance organizer) were more effective than a placebo introduction.

Procedures

One week prior to the presentation of the actual treatment, the Group Embedded Figures Test was administered to 81 subjects. Subjects were stratified by cognitive style and randomly assigned to treatment groups. The treatments consisted of an introductory passage which contained either an advance organizer, an overview, or historical information, the control group, and a learning passage. Immediately after reading the material, which discussed plain carbon steel, the subjects were given a 35 question posttest. The posttest-only control group experimental design was used. The interactive effects of



cognitive style and learner preparation and the effects of learner preparation were ascertained using a regression analysis.

#### Results and Conclusions

The results of the study indicated that the use of preinstructional strategies did not significantly affect the cognitive learning of college students; and no interactive effects of cognitive style and learner preparation were found. Therefore it was concluded that the experimental treatments were no more effective than the control, and that cognitive style had no effect upon treatment. However, it was determined that cognitive style accounted for a significant ( $p < .001$ ) amount of the variance in performance on the posttest. Although the significant effect of cognitive style was not hypothesized, it is an important finding which should be considered when planning future research.

#### Recommendations

The following recommendations for future research were made, based on the results of this study:

1. Provide a better operational definition of advance organizers before any further research is initiated which includes their use.
2. Investigate the interactive effects of cognitive style and subject matter, such as social versus scientific subjects.

3. Determine if individuals with identified cognitive styles perform better on questions which test specific facts or questions which require synthesis.

4. Ascertain if an overview or any other specific preinstructional strategy is more effective in preparing students to learn specific facts or general concepts.

5. Replicate this study utilizing a different subject matter.

6. Replicate this study on different populations.

7. Expand the study to include retention tests.

8. Investigate the difference in the effect of overviews with and without behavioral objectives.

## REFERENCES

- Allen, D. Some effects of advance organizers and level of question on the learning and retention of written social studies material. Journal of Educational Psychology, 1970, 61, 333-339.
- Allen, W.H. Intellectual abilities and instructional media design. AV Communications Review, 1975, 23, 139-170.
- Allport, G.W. Personality: A psychological interpretation. New York: Holt, 1937.
- Anderson, B.S. The effect of pre-versus-post organizers upon retention of economic concepts at the collegiate level. (Doctoral dissertation, University of Iowa, 1973). Dissertation Abstracts International, 1973, 34, 3819A. (University Microfilms No. 73-30, 894).
- Andreozzi, P.P. The effects of advance organizers and written verbalizations on learning and retention of selected algebraic concepts. (Doctoral dissertation, George Peabody College for Teachers, 1975). Dissertation Abstracts International, 1976, 35, 2154A. (University Microfilms No. 75-22, 247).
- Andrews, L. Reading comprehension and three modes of pre-reading assistance. Journal of Reading Behavior, 1973, 5 (4), 237-241.
- \_\_\_\_\_. Directed reading question and cognitive organizer: Comparative effect on reading comprehension. Research in the Teaching of English, 1971, 5, 79-82.
- Arbuthnot, J. Cautionary note on measurement of field independence. Perceptual and Motor Skills, 1972, 35, 479-488.
- Atwood, J.R. A test of two instructional systems based on Ausubel's theory of meaningful verbal learning and Gagne's theory of instruction. (Doctoral dissertation, University of Arizona, 1976). Dissertation Abstracts International, 1977, 37, 5068A. (University Microfilms No. 77-2782).

- Ausubel, D.P. The use of advance organizers in the learning and retention of meaningful verbal material. Journal of Educational Psychology, 1960, 51, 267-272.
- \_\_\_\_\_. A subsumption theory of meaningful learning and retention. Journal of General Psychology, 1962, 66, 213-224.
- \_\_\_\_\_. The psychology of meaningful verbal learning. New York: Grune and Stratton, 1963.
- Ausubel, D.P. & Fitzgerald, D. The role of discriminability in meaningful verbal learning and retention. Journal of Educational Psychology, 1961, 52, 266-274.
- \_\_\_\_\_. Organizer, general background, and antecedent learning variables in sequential verbal learning. Journal of Educational Psychology, 1962, 53 (6), 243-249.
- Ausubel, D.P. & Robinson, F.G. School learning. New York: Holt, Rinehart and Winston, 1969.
- Ausubel, D.P. & Youssef, M. Role of discriminability in meaningful parallel learning. Journal of Educational Psychology, 1963, 54 (6), 331-336.
- Barnes, B.R., & Clawson, E.J. Do advance organizers facilitate learning? Recommendations for further research based on an analysis of 32 studies. Review of Educational Research, 1975, 45, 637-659.
- Baylis, C.A. Investigating the facilitative effects of advance cognitive organizers on readiness for a college level unit in science. (Doctoral dissertation, University of Pittsburgh, 1975). Dissertation Abstracts International, 1976, 36, 6035A-6036A. (University Microfilms No. 76-5414).
- Beardslee, D.C. & Wertheimer, M. (eds), Readings in Perception. Princeton: Van Nostrand 1958.
- Bergman, H. & Englebretson, K. An examination of factor structure of rod-and-frame test and embedded-figures test. Perceptual and Motor Skills, 1973, 37, 939-947.

- Berliner, D.C. & Cahen, L.S. Trait-treatment interaction and learning. In F.N. Kerlinger (Ed.) Review of research in education (Vol. 1), Itasca, Illinois: F.E. Peacock Publishers, Inc., 1973.
- Berton, D.P., Clasen, R.E., & Lambert, P. An analysis of the relative efficiency of advanced organizers, post organizers, interspersed questions and combinations thereof in facilitating learning and retention from a televised lecture. Journal of Educational Research, 1972, 65 (7), 329-333.
- Bracht, G.H. Experimental factors related to aptitude-treatment-interactions. Review of Educational Research, 1970, 40, 627-648.
- Bracht, G.H., & Glass, G.V. The external validity of experiments. American Educational Research Journal, 1968, 5, 437-474.
- Bruner, J.S., Goodnow, J.J., & Austin, G.A. A study of thinking. New York: Wiley, 1956.
- Campbell, D.T. & Stanley, J.C. Experimental and quasi-experimental designs for research. Chicago: Rand McNally, 1966.
- Carroll, J.B. Basic and applied research in education. Harvard Educational Review, 1968, 38, 263-276.
- Coyle, A.F. The effect of organizing features and readability levels on the cognitive learning of college undergraduates studying print materials. Unpublished doctoral dissertation, University of Southern California, in press.
- Christensen, C.M. & Stordahl, K.E. The effect of organizational aids on comprehension and retention. Journal of Educational Psychology, 1955, 46 (2), 65-74.
- Clawson, E.U. & Barnes, B.R. The effects of organizers on the learning of structured anthropology materials in the elementary grades. Journal of Experimental Education, 1973, 42, 11-15.
- Coop, R.H., & Brown, L.D. Effects of cognitive style and teaching method on categories of achievement. Journal of Educational Psychology, 1970, 61, 400-405.

- Coop, R.H. & Sigel, I.E. Cognitive style: Implications for learning and instruction. Psychology in the Schools, 1971, 8, 152-161.
- Cronbach, L.J. How can instruction be adapted to individual differences? In R.M. Gagné (Ed.), Learning and individual differences. Columbus, Ohio: Merrill Books, 1967.
- \_\_\_\_\_. The role of the university in improving education. Phi Delta Kappan, 1968, 38, 539-545.
- Cronbach, L.J. & Snow, R.E. Aptitudes and instructional methods. New York: Irvington Publisher, Inc, 1977.
- Dale, E., & Chall, J. A formula for predicting readability. Educational Research Bulletin, 1948, 27, 11-20, 37-54.
- Di Stefano, T.J. Interpersonal perceptions of field independent and field dependent teachers and students. (Doctoral dissertation, Cornell University, 1969). Dissertation Abstracts International, 1970, 31, 463A-464A. (University Microfilms No. 70-11, 225).
- DiVesta, F.J. Cognitive structures and symbolic processes. Teachers College Record, 1974, 75 (3), 357-370.
- \_\_\_\_\_. Trait-treatment interactions, cognitive processes and research on communication media. AV Communications Review, 1975, 23, 187-196.
- Dickstein, L.S. Field independence in concept attainment. Perceptual and Motor Skills, 1968, 27, 635-642.
- Duchastel, P.C. & Merrill, P.F. The effects of behavioral objectives on learning: A review of empirical studies. Review of Educational Research, 1973, 75, 250-266.
- Earle, R.A. The use of vocabulary as a structural overview in seventh grade mathematics. (Doctoral dissertation, Syracuse University, 1970) Dissertation Abstracts International, 1971, 31, 5929A. (University Microfilms No. 71-10, 909).

- Erginel, A. The relation of cognitive style and intelligence to achievement and errors in thinking. (Doctoral dissertation, Lehigh University, 1969). Dissertation Abstracts International, 1970, 31, 216A-217A. (University Microfilms No. 70-1719).
- Faterson, H.F. Articulateness of experience: An extension of the field-dependence-independence concept. In S. Messick & J. Ross (Eds.), Measurement in personality and cognition. New York: John Wiley & Sons, 1962.
- Faterson, H.F., & Witkin H.A. A longitudinal study of development of the body concept. Developmental Psychology, 1970, 2, 429-438.
- Ferrell, J.G. The differential performance of lower class preschool, Negro children as a function of the sex of E, sex of S, reinforcement condition, and the level of field dependence. (Doctoral dissertation, University of Southern Mississippi, 1971). Dissertation Abstracts International, 1971, 32, 3028B-3029B. (University Microfilms No. 71-28,831).
- Fine, B.J. & Danforth, A.V. Field-dependence, extraversion and perception of the vertical: Empirical and theoretical perspectives of the rod-and-frame test. Perceptual and Motor Skills, 1975, 40, 683-693.
- Fitz, R.J. The differential effects of praise and censure on serial learning as dependent on locus of control and field dependency. (Doctoral dissertation, Catholic University of America, 1970). Dissertation Abstracts International, 1971, 31, 4310B. (University Microfilms No. 71-1457).
- Flesch, R. How to test readability. New York: Harper & Brothers, 1951.
- Frase, L.T. Boundry conditions for Mathemagenic behaviors. Review of Educational Research, 1970, 40, 337-348.
- Gagné, R.M. Learning and Individual Differences, Columbus, Ohio: Merrill, 1967.
- Gardner, R.W. Cognitive congrols in adaptation: Research and measurement. In S. Messick & J. Ross (Eds.), Measurement in personality and cognition. New York: John Wiley & Sons, 1962.

- Garrison, T.S. An investigation of aptitude-treatment interaction between student-preferred learning modality and presentation method. Unpublished doctoral dissertation, University of Southern California, 1977.
- Glaser, R. Some implications of previous work on learning and individual differences. In R.M. Gagné (Ed.), Learning and individual differences. Columbus, Ohio: Merrill Books, 1967.
- \_\_\_\_\_. Individuals and learning: The new aptitudes. Educational Researcher, June, 1972, 5-13.
- Gollin, E.S. & Baron, A. Response consistency in perception and retention. Journal of Experimental Psychology, 1954, 47, 259-262.
- Goodenough, D.R. The role of individual differences in field dependence as a factor in learning and memory. Psychological Bulletin, 1976, 83, 675-694.
- Goodenough, D.R., & Karp, S.A. Field dependence and intellectual functioning. Journal of Abnormal and Social Psychology, 1961, 63, 241-246.
- Graber, R.A., Means, R.S., & Johnsten, T.D. The effect of subsuming concepts on student achievement on unfamiliar science learning material. Journal of Research in Science Teaching, 1972, 9 (3), 277-279.
- Greer, N.R. & Blank, S.S. Cognitive style, conceptual tempo and problem solving: modification through programmed instruction. American Education Research Journal, 1977, 14, 295-315.
- Gregory, R.L. The intelligent eye. New York: McGraw-Hill, 1970.
- Grieve, T.D. & Davis, J.K. The relationship of cognitive style to performance in ninth grade geography. Journal of Educational Research, 1971, 65, 137-141.
- Grippin, P.C. Field independence and reflection-impulsivity as mediators of performance on a programmed learning task with and without strong prompts. (Doctoral dissertation, State University of New York at Albany, 1972). Dissertation Abstracts International, 1973, 34, 2387A-2388A. (University Microfilms No. 73-19, 674).



- Hebein, J.M. The interactive effects of cognitive style and selected instructional strategies on a complex psychomotor skill. Unpublished doctoral dissertation, University of Southern California, 1978.
- Hilgard, E.R. & Bower, G.H. Theories of learning (3rd ed.). New York: Meredith, 1966.
- Holzman, W.H. Intelligence, cognitive style, and personality: A Developmental approach. In O.G. Brim, R.S. Crutchfield, & W.H. Holzman, Intelligence Perspectives, 1965. New York: Harcourt, Brace, & World, Inc., 1966.
- Jensen, A.R. Social class, race, and genetics: implications for education. American Education Research Journal, 1968, 5, 1-42.
- Jerrolds, B.W. The effects of advance organizers in reading for the retention of specific facts. Doctoral dissertation, University of Wisconsin, 1967). Dissertation Abstracts International, 1968, 28, 4532A. (University Microfilms No. 67-16 963).
- Kagan, J., Moss, H.A., & Sigel, I.E. Psychological significance of styles of thinking. Monograph of the Society for Research in Child Development, 1963, 28 (2), 73-112.
- Kagan, J., Rosman, B., Day D., Albert, J., & Phillips, W. Information processing in the child: Significance of analytic and reflective attitudes. Psychological Monographs, 1964, 578, 1-37.
- Kalt, N.C. & Barrett, K.M. Facilitation of learning from a technical manual: An exploratory investigation. Journal of Applied Psychology, 1973, 58 (3) 357-361.
- Karp, S.A. Field dependence and overcoming embeddedness. Journal of Consulting Psychology, 1963, 27, 294-302.
- Kerlinger, F.N. and Pedhazur, E.J. Multiple regression in behavioral research. New York: Holt, Rinehart and Winston, Inc. 1973.
- Kirschenbaum, J. Analytic-global cognitive style and concept attainment strategies. (Doctoral dissertation, Claremont Graduate School, 1968). Dissertation Abstracts International, 1969, 29, 4868B-4869B. (University Microfilms No. 68-18, 276).

- Klare, G. Assessing readability. Reading Research Quarterly, 1974, 10 (1), 62-102.
- Koffka, K. Principles of gestalt psychology. New York: Harcourt, Brace & World, Inc. 1935.
- Konstadt, N., & Forman, E. Field dependence and external directedness. Journal of Personality and Social Psychology, 1965, 1, 490-493.
- Koran, M.L., Snow, R.E., & McDonald, F.S. Teacher aptitude and observational learning of a teaching skill. Journal of Educational Psychology, 1971, 62, 219-228.
- Kuhn, D.J., & Novak, J.D. A study of cognitive subsumption in the life sciences. Science Education, 1971, 55 (3), 309-320
- Lawton, J.T. The use of advance organizers in the learning and retention of logical operations and social studies concepts. American Education Research Journal, 1977, 14, 25-43.
- Lawton, J.T. & Wanska, S.K. Advance organizers as a teaching strategy: a reply to Barnes and Clawson. Review of Educational Research, 1977, 47, 233-244.
- Livingston, S.A. Simulation games as advance organizers in the learning of social science materials: Experiments 1-3 (Report No. 64). Baltimore: John Hopkins University, April 1970.
- Lucas, S.B. The effects of utilizing three types of advance organizers for learning a biological concept in seventh grade science. (Doctoral dissertation, Pennsylvania State University, 1972). Dissertation Abstracts International, 1973, 33, 3390A (University Microfilms No. 72-33, 188).
- May, M.A., & Lumsdaine, A.A. Learning from films. New Haven: Yale University Press, 1958.
- Mager, R.V. Preparing instructional objectives. Palo Alto: Feason, 1962.
- Maginn, M.D. The effects of cognitive style on criterion test performance of high school students after instruction by audio tape treatments differing in rate and difficulty level. Unpublished doctoral dissertation, University of Southern California, 1975.

- Mayo, P.R., & Bell, J.M. A note on the taxonomy of Witkin's field independence measures. British Journal of Psychology, 1972, 63, 255-256.
- McClung, C.J. The effects of cognitive style on type of practice. Unpublished doctoral dissertation, University of Southern California, 1976.
- Merrill, M.D. Learner control: beyond aptitude-treatment interactions. AV Communications Review, 1975, 23, 217-226.
- Merrill, M.D., & Stolurow, L.M. Hierarchical preview versus problem oriented review in learning an imaginary science. American Education Research Journal, 1966, 3, 251-262.
- Munford, P.R. Advance organizers and the enhancement of meaningful verbal learning and retention. Unpublished doctoral dissertation, University of Southern California, 1972.
- Nebelkopf E.B., & Dreyer, A.S. Continuous-discontinuous concept attainment as a function of individual differences in cognitive style. Perceptual and Motor Skills, 1973, 36, 655-662.
- Nelson, B.A. Effects of the analytic-global and reflectivity-impulsivity cognitive styles on the acquisition of geometry concepts presented through emphasis or no emphasis and discovery or expository lessons. (Doctoral dissertation, University of Wisconsin, 1972). Dissertation Abstracts International, 1973, 33, 4949A. (University Microfilms No. 72-31,693).
- Novak, J.D., Ring, D.G., & Tamur, P. Interpretation of research findings in terms of Ausubel's theory and implications for science education. Science Education, 1971, 55 (4), 483-526.
- On Further Examination (Report of the advisory panel on the scholastic aptitude test score decline). New York: College Entrance Examination Board, 1977.
- Parisi, A.J. Advance organizer and knowledge-of-results in a self-instructional program in the health sciences. (Doctoral dissertation, Syracuse University, 1976). Dissertation Abstracts International, 1977 38, 2730A. (University Microfilms No. 77-24, 570).

- Parkhurst, P.E. Generating meaningful hypotheses with aptitude-treatment interactions. AV Communications Review, 1975, 23, 171-183.
- Pella, M.O., & Triezenberg, H.J. Three levels of abstraction of the concept of equilibrium and its use as an advance organizer. Journal of Research in Science Teaching, 1969, 6, 11-21.
- Pressey, S.L. A simple apparatus which gives tests and scores--and teaches. School & Society, 1926, 23, 373-376.
- Proger, B.B., Taylor, R.G., Mann, L., Coulson, J.M. & Bayak, R.J. Conceptual pre-structuring for detailed verbal passages. Journal of Educational Research, 1970, 64 (1), 28-34.
- Prothero, J.C. Analysis of the effects of instructional objectives upon the learning and retention of structured and unstructured material. Educational Technology research No. 58. Engelwood Cliffs, New Jersey: Educational Technology Publications, 1973.
- Randolph, L.C. A study of the effects of praise, criticism and failure on the problem solving performance of field-dependent and field-independent individuals. (Doctoral dissertation, New York University, 1971). Dissertation Abstracts International, 1971, 32, 3014B-3015B. (University Microfilms No. 71-28,555).
- Renzi, N.B. A study of some effects of field dependence-independence and feedback on performance achievement. (Doctoral dissertation, Hofstia University, 1974). Dissertation Abstracts International, 1974, 35, 2059A.
- Reynolds, J.H. Cognitive transfer in verbal learning. Journal of Educational Psychology 1966, 57 (6), 382-388.
- Ring, D.G., & Novak, J.D. Effects of cognitive structure variables on achievement in college chemistry. Journal of Research in Science Teaching, 1971, 8, 325-333.
- Rollins, H.A., & Genser, L. Role of cognitive style in a cognitive task: A case favoring the impulsive approach to problem solving. Journal of Educational Psychology, 1977, 69 (3), 281-287.

- Rosenberg, H., Mintz, S., & Clark, R.E. The educational significance of field dependence research. Educational Technology, August 1977, 43-44.
- Rosenshine, B., & Furst, N.F. Research on teacher performance criteria. In B.O. Smith (Ed.), Research in teacher education: A symposium. Englewood Cliffs, N.J.: Prentice-Hall, 1971.
- Rothkopf, E.Z. The concept of mathemagenic behaviours. Review of Educational Research, 1970, 40, 325-336.
- Rothkopf, E.Z. & Kaplan, R. Exploration of the effect of density and specificity of instructional objectives on learning from text. Journal of Educational Psychology, 1972, 63, 295-302.
- Rubin, E. [Synoplevede Figurer.] In D.C. Beardslee & M. Wertheimer (Eds. and trans.), Readings in Perception Princeton: Van Nostrand, 1958.
- Ruble, D.N. & Nakamura, C.Y. Task orientation versus social orientation in young children and their attention to relevant social cues. Child Development, 1972, 43, 471-480.
- Salomon, G. Heuristic models for the generation of aptitude-treatment instruction hypotheses. Review of Educational Research, 1972, 42 (3), 327-343.
- Salomon, G. & Clark, R.E. Reexamining the methodology of research on media and technology in education. Review of Educational Research, 1977, 47, 99-120.
- Scandura, J.M., & Wells, J.N. Advance organizers in learning abstract mathematics. American Educational Research Journal, 1967, 4 (3), 303-320.
- Schimek, J.G. Cognitive style and defenses: A longitudinal study of intellectualization and yield independence. Journal of Abnormal Psychology, 1968, 73 (6), 575-580.
- Schnell, T.R. The effect of "organizers" on reading comprehension of community college freshmen. Journal of Reading Behavior, 1973, 5 (3), 169-176.

- Schulz, R.W. The role of cognitive organizers in the facilitation of concept learning in elementary school science. (Doctoral dissertation, Purdue University, 1966). Dissertation Abstracts, 1967, 27, 3784. (University Microfilms No. 67-5495).
- Schwen, T.M. The effect of cognitive styles and instructional sequences on learning a hierarchical task. (Doctoral dissertation, Indiana University, 1970). Dissertation Abstracts International, 1970, 31, 2797A-2798A. (University Microfilms No. 70-23,380).
- Shouksmith, G. Intelligence, creativity and cognitive style. New York: Wiley-Interscience, 1970.
- Snow, R.E. Research on aptitude for learning: A progress report. Review of Research in Education, 4, Shulman, L.S. (Ed.) 1976, Itasca, Ill.: Peacock Publishers, Inc. 50-105. (a)
- \_\_\_\_\_ . Research on aptitudes: A progress report. Technical Report No. 1. Aptitude Research Project School of Education, Stanford University Contract No. N000 14-75-C-0882, 1976. (b)
- \_\_\_\_\_ . Individual differences and instructional theory. Educational Researcher, 1977, 6, (10), 11-15.
- Stienfeld, S.L. Level of differentiation and age as predictors of reinforcer effectiveness. (Doctoral dissertation, Hofstra University, 1973). Dissertation Abstracts International, 1973, 34, 2912B-2913B. (University Microfilms No. 73-25,324).
- Thelen, J.N. Use of advance organizers and guide material in viewing science motion pictures in a ninth grade. (Doctoral dissertation, Syracuse University, 1970). Dissertation Abstracts International, 1971 31, 6288. (University Microfilms No. 71-10,990).
- U.S. Air Force Manual 50-9, Principles and techniques of instruction. Washington, D.C. Department of the Air Force, 1967.
- Vernon, P.E. The distinctiveness of field independence. Journal of Personality, 1972, 40, 366-39.
- Weiseberg, J.S. The use of visual advance organizers for learning earth science concepts. Journal of Research in Science Teaching, 1970, 7, 161-165.

- Weiss, W., & Fine, B.J. Stimulus familiarization as a factor in ideational learning. Journal of Educational Psychology, 1956, 47, 118-124.
- Weissenberg, P., & Gruenfeld, L.A. Relationships among leadership dimensions and cognitive style. Journal of Applied Psychology, 1966, 50, 392-395.
- Wertheimer, M. Untersuchungen zur Lehre von der Gestalt, II. (1923) In W.D. Ellis (Ed. and trans.). A source book of gestalt psychology. New York: Harcourt, Brace, & World, 1938.
- Witkin, H.A. & Asch, S.E. Studies in space orientation. IV. Further experiments on perception of the upright with displaced visual fields. Journal of Experimental Psychology, 1948, 38, 762-782.
- Witkin, H.A., Dyk, R.B., Fatterson, H.F., Goodenough, D.R. and Karp, S.A. Psychological Differentiation. New York: Wiley & Sons, 1962.
- Witkin, H.A., Goodenough, D.R., & Karp, S.A. Stability of cognitive style from childhood to young adulthood. Journal of Personality and Social Psychology, 1967, 7, 291-300.
- Witkin, H.A., Oltman, P.K., Raskin E., & Karp, S.A. A manual for the embedded figures tests. Palo Alto, Calif.: Consulting Psychologists Press, 1971.
- Witkin, H.A., Moore, C.A., Goodenough, D.R. and Cox, P.W. Field-dependent and field independent cognitive styles and their educational implications. Review of Educational Research, 1977, 47, 1-64. (a)
- Witkin, H.A., Moore, C.A., Oltman, P.K., Goodenough, D.R., Friedman, F., Owen, D.R., & Raskin, E. Role of the field-dependent and field-independent cognitive styles in academic evolution: A longitudinal study Journal of Educational Psychology, 1977, 69, 3, 197-211. (b)

APPENDIX A

Treatment Materials



THE PROPERTIES OF PLAIN CARBON STEEL

INTRODUCTORY PASSAGE

OVERVIEW

OBJECTIVES:

1. The student will be able to list the properties of an alloy.
2. The student will be able to describe the various internal structures of steel as they relate to its carbon content.
3. The student will be able to describe the internal changes that occur to steel as temperature increases.
4. The student will be able to state the differences between carbon steel which is rapidly cooled and that which is slowly cooled.

## INTRODUCTION

We deal with many different metals every day. Some are "pure" metals like gold or tin, and others are alloys like bronze. An alloy is obtained by combining two or more elements where at least one of them is a metal. Perhaps the most common alloy is steel.

Steel is an alloy of iron and carbon. Actually, it is a compound of iron and iron carbide (an iron carbon compound). It may also contain one or more elements to increase strength etc. However, the most interesting aspect of steel is that its internal structure is modified by temperature and the amount of carbon present.

The amount of carbon steel contains is a very impor-

tant factor in determining its internal structure. When steel contains .8% carbon, there is enough carbide available to saturate all of the iron grains. If any less carbon is present then some grains of iron are not saturated. If more than .8% carbon is present, the excess carbide forms a shell-like layer around the iron grains. This extra layer makes the steel more wear resistant.

The properties of steel also vary with its temperature. At normal temperatures, the grains of iron and iron carbide are fixed in position. As heat is applied, many internal changes take place while the steel is still in a solid state. Generally these changes take place at definite temperatures known as critical temperatures. The lower critical temperature of steel is that temperature at which the iron carbide starts going into solution. The upper critical temperature represents the point at which all carbide present is in solution.

Not only is the temperature important but the rate of cooling is also important. If steel is cooled slowly then it is relatively soft and tough. If it is cooled rapidly then it becomes very hard and brittle. Actually, it is very difficult to regulate the rate of cooling accurately. Therefore, a process called tempering is used to achieve the final degree of hardness or toughness of the steel.

Therefore, before we can accurately predict the

properties of a piece of steel, we would have to know (a) the temperature to which it was heated, (b) the amount of carbon present, and (c) the rate at which it was cooled.

THE PROPERTIES OF PLAIN CARBON STEEL

INTRODUCTORY PASSAGE

ADVANCE ORGANIZER

## METALS AND ALLOYS

Metal has certain unique advantages over other substances as a material for tools and implements. It is hard, strong, durable, and can be molded to any desired shape. When no longer required for a particular use, it can be melted and made into a new product. But even more important, perhaps, is the fact that it has a wide diversity of properties under the control of man.

Many important physical properties of metal depend upon its internal grain structure. We can, therefore, alter the properties of a given metal by changing its internal structure. Both heat and various mechanical processes modify the internal structure and hence the properties of metals. Heat, for example, changes the grain structure of metals in such a way as to soften them, and hammering at room temperature changes their grain structure in such a way as to harden them.

Nevertheless, despite the possibility of modifying the internal structure of metals by heat and mechanical means, the range of properties available among pure metals is obviously limited by the existence of only a small number of pure metals. Hence, if man restricted himself to the use of pure metals he would only have a limited variety

of grain structures and a correspondingly limited range of physical properties at his disposal.

It is true, of course, that pure metals do have certain unique functions that alloys cannot perform, especially in laboratory instruments. For most practical purposes, however, it is expedient to alloy a metal with other metals or non-metals, and thus take advantage of the much wider selection of grain structures and physical properties which thereby becomes available. Generally speaking, other elements are alloyed with metals to confer such properties as increased hardness, strength, toughness and flexibility. Almost any desired combination of physical properties can be developed to meet the specific requirements of a metal part by selecting an appropriate metal, by choosing suitable kinds and percentages of alloying elements, and by subjecting the resulting alloy to appropriate mechanical and/or other procedures.

It is clear from the foregoing, therefore, that the properties of a given alloy, like those of a pure metal, are (within certain limits) determined by its distinctive grain structure. This structure in turn depends upon the particular metal and the specific type and amount of alloying substance used. Alloys also resemble pure metals in the fact that their internal structure also varies with temperature. Unlike pure metals, however, the grain structure (and hence the properties) of some alloys are

modified by the rate at which they are cooled.

Hence, before we could predict the grain structure and properties of an alloy belonging to the latter category of alloys, we would not only have to know (a) its temperature and (b) its principal metal component, and the type and amount of alloying substance used, but also (c) the rate at which it was cooled.



THE PROPERTIES OF PLAIN CARBON STEEL

HISTORICAL PASSAGE

## IRON AND IRON ALLOYS

Iron and iron alloys have a long and interesting history. The wide range of iron derivatives available today occupies an intermediate position in both time and complexity between the ancient art of the metalsmiths and our modern science of metallurgy. Although modern methods of mass-producing iron and iron alloys are only about one hundred years old, iron products have been used for about 4,000 years, and many of the basic processes employed today are several hundred years old.

Meteroic iron was probably the first iron alloy used by man in most parts of the world. This type of iron accounts for the existence of many iron tools in areas where iron smelting was unknown. It has a high nickel content peculiar to meteoric iron; no known iron ore shares this characteristic. Although this alloy could not be melted with charcoal fires, it could be softened and formed into tools far superior to those of bronze or copper.

Wrought iron was in use before the first written records and was the primary iron products made by man until about 100 years ago. It is almost pure iron that contains strips and pieces of slag throughout, and is

fairly strong and easy to work.

Wrought iron was produced in a crude charcoal-burning furnace similar to that used in the refining of copper and tin. Wood charcoal and ore were placed in the tube-like furnace, and the charcoal was ignited from the bottom. The natural draft of air in such a furnace, however, was insufficient for the charcoal to burn fast enough to produce the necessary heat and temperature. To overcome this difficulty, the furnace was made higher and hand-operated bellows were used to increase the available air flow.

Although this type of furnace was hot enough to melt tin and copper ores, it was not hot enough to reduce iron ore to molten (liquid) state. Almost any desired combination of physical properties can be developed to meet the specific requirements of a metal part by selecting an appropriate metal, by choosing suitable kinds and percentages of alloying elements, and by subjecting the resulting alloy to appropriate mechanical and/or other procedures.

It is clear from the foregoing, therefore, that the properties of a given alloy, like those of a pure metal, are (within certain limits) determined by its distinctive grain structure. This structure in turn depends upon the particular metal and the specific type and amount of alloying substance used. Alloys also resemble pure metals in the fact that their internal structure also varies with

temperature. Unlike pure metals, however, the grain structure (and hence the properties) of some alloys are modified by the rate at which they are cooled.

Hence, before we could predict the grain structure and properties of an alloy belonging to the latter category of alloys, we would not only have to know (a) its temperature and (b) its principal metal component, and the type and amount of alloying substance used, but also (c) the rate at which it was cooled.

THE PROPERTIES OF PLAIN CARBON STEEL

THE LEARNING PASSAGE

### THE PROPERTIES OF PLAIN CARBON STEEL

When you mix two or more substances together and at least one of them is a metal, you get a new metallic substance called an alloy. Depending on how hot the alloy is, it will either be a solution or a mixture. When the solution cools it becomes a mixture. If you examine either under a microscope you can see that the elements which make up the alloy are mixed in the same pattern from one part to another. That is to say, an alloy has a uniform internal structure.

If the ingredients in a metal are not mixed evenly throughout, it is not considered an alloy. For example there may be pockets of impurities scattered from place to place throughout the metal. These impurities are not mixed evenly (homogeneously) with the metal. Therefore, the mixture is not an alloy. Of course you do find impurities in alloys too. Most metal ore is not refined to the point where all impurities are removed. Such refining would be very expensive. Besides, a small amount of impurities in an alloy does not damage its quality.

The grain structure in an alloy may be simple or complex. The grain structure will be simple and predictable, if the elements which are combined to make the alloy

do not chemically interact. Take bronze, an alloy of copper and tin. It is an example of a simple grain structure. Here all the grains are alike: each grain is a grain of bronze. When the two metals are heated and then cooled, the copper and tin unite in each grain. These grains are like grains of pure metal except that they are made of two elements instead of one. The copper and tin are not chemically united, but you can no longer tell them apart as two metals.

When the elements which make up an alloy combine chemically, the grain structure is not predictable. Steel, which is an alloy of iron and carbon, is an example of this. Here the carbon interacts chemically with some of the iron. It makes a chemical compound called iron carbide. Tiny fragments of iron carbide are mixed evenly with the grains of iron. This is not like bronze where each particle is exactly the same as the next. Instead, there are two distinct components; iron and iron carbide. The mixture, or solution, has grains of metal (iron) with the chemical compound (iron carbide) mixed evenly within and around them. The actual arrangement of these particles differs depending on how it is treated by heat and cold. Simple grain alloys, like bronze, and pure metals do not have this ability to change their grain structure. Because the grain structure can be varied by "heat treatment" varying hardnesses of the alloy can be achieved.

Only the few alloys which have complex grain structures can be heat treated. Iron alloys which contain some amounts of carbon and some alloys of magnesium and aluminum can be hardened by heat treatment.

The principle substances combined to make steel are iron and carbon. The amount of carbon is small. It usually varies between 1.1% and 1.5% and never goes higher than 2%. Most steel made and in use today combines only carbon and iron. One or more additional elements are added sometimes. This is done to change some of the alloy's properties. These properties include hardness, strength, toughness, flexibility and resistance to corrosion.

Temperature affects the properties of steel. The most obvious change related to temperature is the change from a solid to a liquid. This happens when steel is heated above its melting point. When it is cooled down the reverse occurs. As the temperature is lowered below the melting point the molten (liquid) steel hardens into grains much as water freezes into ice.

The internal structure of steel changes several times before it reaches a liquid state. At normal atmospheric temperatures the iron and iron carbide grains are in a fixed arrangement. As it is heated, and while it is still a solid, that arrangement begins to change. These changes occur at definite temperatures. These temperatures are known as "critical temperatures." When steel



is heated above its upper critical temperature it is actually a solid solution.

You may think it strange to call a solid material a solution. A material which has a uniform internal structure which varies within wide limits is a solution. The best known example of this is glass. Steel, heated above its upper critical temperature and below its melting point is another. Its internal structure is uniform, yet it varies within wide limits.

The characteristic of steel as both a liquid solution and a solid solution is the variability of its internal structure. The iron carbide breaks up into tiny, hard, and brittle particles. These particles more or less float throughout the grains of iron. They form and reform. They assume the size, shape and relationship most normal for each given temperature. When the steel is cooled below its lower critical temperature this freedom is lost. The internal structure becomes fixed and invariable.

At the lower critical temperature of steel, carbide starts going into solution. At the upper critical temperature all the carbon is in solution. Between these two temperatures more and more carbide in the steel goes solution.

All carbon steels have the same lower critical temperature, namely 1350°F. The upper critical temperature varies, depending on the carbon content. If the carbon

AD-A058 412

AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OHIO  
THE INTERACTIVE EFFECTS OF COGNITIVE STYLE AND LEARNER PREPARAT--ETC(U)  
JUN 78 J A GUERRIERI  
AFIT-CI-78-73

F/G 5/10

UNCLASSIFIED

NL

2 OF 2

AD  
A068412



END  
DATE  
FILMED  
10-78  
DDC

content is very low the upper critical temperature will be very high. As the carbon content gets higher, (up to .8%,) the upper critical temperature gets lower. It goes down from 1600°F. for .1% carbon to 1350°F. for .8% carbon. For .8% carbon steel the lower and upper critical temperatures are the same, that is 1350°F. If there is more than .8% carbon in steel, the upper critical temperature does not go below 1350°F. That means that all of the carbide goes into solution at 1350°F. When there is less than .8% carbon present only part of the carbide goes into solution at the lower critical temperature, 1350°F. The carbide is fully in solution when it reaches its upper critical temperature.

After heat, the amount of carbon content, in the form of carbide, determines the internal structure of steel. At .8% carbon and below, all of the carbide is found within the grains of iron. If there is more than .8% carbon, the excess carbide forms a shell-like layer around the iron grains. The iron grains themselves are saturated with iron carbide grains. If the steel has less than .8% carbon, there is not enough carbide to saturate all the iron grains. For example, in .4% carbon steel, one half of the iron grains are saturated with iron carbide. In .2% carbon steel, there are iron carbide particles within only one quarter of the grains. Three quarters of the grains are pure iron. The proportion of iron

carbide to pure iron keeps this ratio up to .8%. Above .8% carbon the extra carbide forms a shell around the iron grains.

Iron carbide grains are very, very hard. Therefore, the more carbon in steel, the harder it is. At least that is completely true up to .8% carbon steel. Above that, hardness depends on two things, the carbon content of the steel and how quickly it is cooled.

We have seen that the internal structure of steel is related to heat and carbon content. Now we will look at another factor; the rate steel is cooled. By rate of cooling we mean the speed at which steel is passed through its upper and lower critical temperatures. Rate of cooling determines the type of fixed internal structure that steel assumes.

When steel is in a solid solution, the carbide particles in it move around. As if they were floating, they change places depending on their normal position for that particular temperature. The positions and size of the carbide grains become fixed as the metal is cooled through its upper and lower critical temperatures. If the solid solution is cooled slowly, the carbide particles have time to assume the position natural for lower temperatures. If the solution is cooled quickly, there is not enough time for the particles to rearrange in a natural way. The fixed structure which results is strained and unnatural.

When a piece of steel is cooled very slowly through its critical temperatures, the arrangement of its carbide particles is natural. Its internal structure is unstrained. The natural internal structure of slowly cooled steel makes it soft and tough. It is also easy to form, to bend or stretch it without breaking it.

Slow cooling does not eliminate the effects of high carbon content. Depending on the percentage of carbon in the steel, the carbide particles collect into spheres within all or some of the grains of iron into layers around them. Higher carbon steels are slightly harder than low carbon steels that had the same slow cooling process. Beyond .8% carbon content, the carbon spheres continue to influence the hardness of slowly cooled steel. For example 1.2% slowly cooled carbon steel is harder than .9% carbon steel that is slowly cooled.

Rapid cooling also affects the internal structure of steel. This results in steel that is very hard. When the steel is cooled quickly from a solid solution the iron carbide particles do not have time to reform. They remain very small. The iron carbide remains finer and more completely scattered within the grains of iron the faster the cooling takes place. They become fixed before they can rearrange within and around the particles of iron. This is considered an unnatural structure. It results in greater hardness and brittleness. These properties also increase

with the amount of carbon in the steel up to .8%. Maximum hardness is achieved at .8% carbon content. Rapidly cooled 1% carbon steel is not any harder than .8% carbon steel that is cooled as quickly.

A piece of steel can be cooled through its critical temperatures in less than a second. When cooled at that speed, the carbide particles are trapped in a completely dispersed structure. This structure looks like a network of tiny, spiny, pine needles. The iron grains are locked between these spines like concrete is reinforced by interlocking rods. This arrangement is very hard and rigid. There are more spines in steel that has more carbon (up to .8%). This results in greater hardness. It also results in greater brittleness. High carbon steel that is cooled very rapidly is very hard and more brittle than glass. It will break before it will bend.

This rapid cooling of steel to make it harder is called heat treatment. It takes advantage of the unnatural internal structure which is trapped by the cooling through the critical temperatures. The carbide must be in solution to start with. That only starts to happen at 1350°F. Rapid cooling from a temperature less than that will not increase hardness. As we said before, steel is one of the few alloys that can be hardened by heat treatment.

Carbon content above .8% does not affect the hardness of steel. It does affect its wear resistance, however.

To wear down such a piece of steel you would have to wear away the very hard shell around each iron grain as well as the very hard grain itself. This iron carbide shell also increases the brittleness of the steel. This is a big disadvantage of high carbon steels. They are more likely to break on impact or bending than tougher low carbon steels.

Some precautions must be taken during heat treatment. Steel is chemically more active at high temperatures. This means that oxygen in the air burns out carbon from the surface of the steel while it is being heated. This reduces the carbon content of the steel. Oxygen in the air also rusts (oxidizes) iron very rapidly while it is hot. You can heat it in gases other than ordinary air. If you use an atmosphere of carbon gas, the steel will absorb carbon into its surface. Sometimes this is done to give a piece of low carbon steel a hard outer shell. Generally though, care must be taken to prevent rusting, loss of carbon from the surface or absorption of carbon while finished parts are being heat treated.

Hardness alone in a piece of steel is usually not enough. The use of the particular piece of steel indicates what properties it should have. Perhaps it needs to be soft and tough, or flexible, etc. In theory you would think that it would be possible to control these properties. For example, we should be able to produce hard, strong steel by cooling it rapidly. It would also seem that we should

be able to produce soft, tough steel. This should be possible by cooling the steel more slowly. So much for theory. Actually it is very hard to control cooling in such a precise way as to get a specific degree of hardness.

In practice, steel is cooled as rapidly as possible during heat treatment. Afterwards, any degree of hardness which is not desired is removed. This is done by a process called tempering. Tempering is the process of reheating hardened steel to a temperature below the lower critical temperature. The hardness of steel is closely related to its other properties. If we get the right amount of hardness it will probably have the other properties we want. The right degree of hardness results from heat treatment and tempering.

Carbide particles in hardened steel are trapped in unnatural needle-like formations. These formations generate structural stresses. As a result there is an internal tendency toward reforming into a more natural arrangement. At ordinary temperatures this tendency cannot function. However, if the hardened steel is reheated, the structure can modify itself. This reforming starts as low as 212°F. At this temperature the trapped carbide spines can reform into spheres. As the temperature is raised, more and more spines break down and become spheres. This makes the steel softer and tougher, or less hard and brittle. The amount of softness and toughness, or hardness and brittleness



that is desired is the reason for tempering; and dictates the highest temperature (below the critical temperature) to which the tempered steel is raised.

In tempering a file, it is reheated to 212°F. This modifies some needles, removing some brittleness. However, most of the hardness is retained. Cutting tools and wearing parts are tempered at about 400°F. This removes some brittleness. It also takes away a little hardness. Battering tools are reheated to about 500°F. A little hardness and brittleness is removed. However, the tools are tougher and less apt to break. Springs are tempered at about 750°F. This achieves the best balance between toughness, hardness and flexibility.

Parts reheated to 900°- 1000°F. lose additional hardness. They gain toughness and the ability to bend without breaking. Higher tempering temperatures modify more of the spiny structure. If a part is overheated it becomes too soft. It must be rehardened, and then tempered at the proper temperature. This means that it must be heated above its upper critical temperature and then rapidly cooled before it is tempered.

APPENDIX B

Posttest

THE PROPERTIES OF PLAIN CARBON STEEL

QUESTION BOOKLET

1. The primary purpose of tempering steel is to reduce:
  - (a) hardness
  - (b) brittleness
  - (c) wear-resistance
  - (d) toughness
  - (e) softness
  
2. An alloy is a substance composed of two or more elements:
  - (a) which has metallic properties
  - (b) which has at least one metal constituent
  - (c) which do not interact chemically
  - (d) "a" and "b"
  - (e) "b" and "c"
  
3. The most reliable method of making the first of two identical pieces of steel harder than the second is to:
  - (a) cool the first piece more slowly during heat treatment
  - (b) cool the first piece more rapidly during heat treatment
  - (c) heat the first piece at a higher temperature during heat treatment
  - (d) temper the first piece at a higher temperature
  - (e) temper the first piece at a lower temperature
  
4. In .6% steel:
  - (a) all of the iron grains are saturated with carbide
  - (b) one-quarter of the iron grains are saturated with carbide
  - (c) one-half of the iron grains are saturated with carbide
  - (d) three-quarters of the iron grains are saturated with carbide
  - (e) carbide forms in a shell-like layer around the grains of iron
  
5. A kitchen knife made of which of the following would remain sharp the longest?
  - (a) .2% carbon steel
  - (b) .4% carbon steel
  - (c) .8% carbon steel
  - (d) .95% carbon steel
  - (e) 1.5% carbon steel

6. To be able to get maximum hardness in steel, it must contain:
- (a) at least .1% carbon
  - (b) at least .4% carbon
  - (c) at least .8% carbon
  - (d) not over 1.5% carbon
  - (e) not over 2% carbon
7. Which of the following events do not occur as steel is transformed from a mixture to a solution?
- (a) the carbide particles become more highly dispersed
  - (b) the metal becomes a liquid
  - (c) the carbide particles become smaller
  - (d) the grain structure varies with changes in temperature
  - (e) the carbide particles acquire greater freedom to reform
8. By knowing the hardness of a piece of steel we do not know:
- (a) its toughness
  - (b) its tensile strength
  - (c) its corrosion resistance
  - (d) its ability to withstand impact
  - (e) its ability to withstand bending without breaking
9. When an alloy is examined under a powerful microscope, it can be demonstrated that:
- (a) it has a uniform internal structure throughout the piece
  - (b) all grains have the same general appearance
  - (c) all grains have the same size and general appearance
  - (d) its internal components are not distinguishable from each other
  - (e) "b" and "d"
10. Cooling a piece of steel rapidly from the tempering temperature will:
- (a) completely reharden the piece
  - (b) partially reharden the piece depending on the tempering temperature

- (c) partially reharden the piece depending on the carbon content
- (d) partially reharden the piece depending on both tempering temperature and carbon content
- (e) have no effect whatsoever

11. A steel part with a tough center and a hard, wear-resistant surface (such as an axle) could be produced by:

- (a) hardening a high carbon steel part and then reheating only the surface
- (b) hardening a low carbon steel part and then reheating only the surface
- (c) hardening and tempering a low carbon steel in a carbon atmosphere
- (d) hardening and tempering a high carbon steel in an ordinary air atmosphere
- (e) hardening and tempering a low carbon steel in an ordinary air atmosphere

12. Which of the following statements is not true?

- (a) the carbide in .6% carbon steel starts to go into solution at the same temperature as the carbide in .4% carbon steel
- (b) the carbide in .6% carbon steel is all in solution at a lower temperature than the carbide in .4% carbon steel
- (c) the carbide in 1.5% carbon steel is all in solution at a lower temperature than the carbide in .8% carbon steel
- (d) the carbide in 1.5% carbon steel begins to go into solution at the same temperature as the carbide in .8% carbon steel
- (e) the carbide in .6% carbon steel begins to go into solution at the same temperature as the carbide in .8% carbon steel

13. Which tempering temperature is best for battering tools?

- (a) 300° F
- (b) 400° F
- (c) 500° F
- (d) 750° F
- (e) 950° F

19. Steel with a carbon content over .8% is used where it is important to have:
- (a) extra hardness
  - (b) increased flexibility
  - (c) high corrosion resistance
  - (d) great toughness
  - (e) high wear resistance
20. The upper critical temperature of steel:
- (a) is the temperature above which steel melts
  - (b) is the temperature at which all of the carbide in steel is in solution
  - (c) is the temperature at which all of the carbide in steel begins to go into solution
  - (d) is the temperature above which steel must be heated for tempering to take place
  - (e) is the temperature below which steel solidifies
21. When a piece of high carbon steel is cooled rapidly from a solid solution, the piece will be:
- (a) soft
  - (b) hard
  - (c) soft and tough
  - (d) hard and brittle
  - (e) brittle
22. The most important consideration in choosing the tempering temperature of a finished steel part is:
- (a) its desired mechanical properties
  - (b) the rate at which it was cooled
  - (c) the maximum temperature during heat treatment
  - (d) the carbon content of the part
  - (e) the internal grain structure of the part
23. Which of the following alloys may be heat treated?
- (a) iron-chromium
  - (b) iron-carbon-tungsten
  - (c) copper-zinc
  - (d) iron-nickel-chromium
  - (e) copper-tin
24. Which of the following statements is not true?
- (a) slowly cooled 1.5% carbon steel is harder than slowly cooled 1% carbon steel

- (b) slowly cooled .75% carbon steel is harder than slowly cooled .6% carbon steel
  - (c) rapidly cooled .7% carbon steel is harder than rapidly cooled .5% carbon steel
  - (d) rapidly cooled .8% carbon steel is harder than slowly cooled .8% carbon steel
  - (e) rapidly cooled 1.5% carbon steel is harder than rapidly cooled 1% carbon steel
25. When tempering a cutting tool that is to be driven with a hammer (e.g., a chisel), the following tempering temperature should be used:
- (a) 212° F
  - (b) 400° F
  - (c) 550° F
  - (d) 700° F
  - (e) 900° F
26. The affect of tempering steel first becomes noticeable at:
- (a) its upper critical temperature
  - (b) its lower critical temperature
  - (c) 212° F
  - (d) 900° F
  - (e) 1200° F
27. As the tempering temperature increases, steel becomes
- (a) tougher
  - (b) harder
  - (c) softer
  - (d) tougher and harder
  - (e) tougher and softer
28. The higher the carbon content of steel:
- (a) the lower the temperature at which all of the carbide is in solution
  - (b) the higher the temperature at which all of the carbide is in solution
  - (c) the higher the temperature at which the carbide starts going into the solution
  - (d) the lower the temperature at which the carbide starts going into solution
  - (e) the higher its melting point



29. Which of the following statements about .8% carbon steel is not true?
- (a) its lower and upper critical temperatures are the same
  - (b) it is more brittle than .4% carbon steel
  - (c) its carbide starts going into solution at a lower temperature than the carbide of .4% carbon steel
  - (d) it may be hardened at a lower temperature than .4% carbon steel
  - (e) it is harder than .6% carbon steel
30. Steel is:
- (a) a compound of iron and carbon
  - (b) a solution of iron and iron carbide
  - (c) a solution or mixture of iron and iron carbide
  - (d) a solution or mixture of iron and carbon
  - (e) a solution of iron and carbon
31. Tempering should follow the hardening operation to increase:
- (a) hardness
  - (b) toughness
  - (c) brittleness
  - (d) wear-resistance
  - (e) corrosion resistance
32. A piece of metal may not be considered an alloy:
- (a) if its constituents form a compound
  - (b) if it contains impurities
  - (c) if its alloying constituent is found only in scattered pockets
  - (d) if it contains inclusions of a metal or non-metal
  - (e) if it contains impurities in the form of inclusions
33. In terms of its distinctive chemical-physical condition an alloy is defined as:
- (a) a solid solution
  - (b) a solid solution or a liquid solution
  - (c) a mixture
  - (d) a solution or a mixture
  - (e) a compound in solution

34. Maximally rapid cooling of steel from a solid solution results in:
- (a) fixing of carbide particles in a dispersed structure
  - (b) fixing of carbide particles in a needle-like structure
  - (c) fixing of carbide particles in the form of spheres within the iron grains
  - (d) fixing of carbide particles in the form of layers within the iron grains
  - (e) fixing of carbide particles in the form of layers around the iron grains
35. During heat treatment the amount of carbon in a piece of steel may decrease:
- (a) if it is heated in an atmosphere of air
  - (b) if its carbon content is originally more than .8%
  - (c) if it is cooled too rapidly
  - (d) if its carbon content is originally less than .8%
  - (e) if the maximum temperature during heat treatment is excessive