EFFECTS OF FIELD-DEPENDENCE/INDEPENDENCE AND SEX ON PATTERNS OF ACHIEVEMENT AND GRADING IN A FIRST-SEMESTER CALCULUS COURSE (COGNITIVE STYLE, REMEDIAL MATHEMATICS, GRADING BIAS, APPRAISAL, COLLEGE)

TIMOTHY JOHN KELLY
University of New Hampshire, Durham

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EFFECTS OF FIELD-DEPENDENCE/INDEPENDENCE AND SEX ON PATTERNS OF ACHIEVEMENT AND GRADING IN A FIRST-semester CALCULUS COURSE

BY

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B.A., University of Scranton, 1969
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A DISSERTATION

Submitted to the University of New Hampshire
in Partial Fulfillment of
the Requirements for the Degree of

Doctor of Philosophy
in
Mathematics Education

September, 1985
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ACKNOWLEDGEMENTS

I would like to thank the members of my committee for the many insights and suggestions that they provided at, what always seemed to be, just the right moment.

I wish to begin by thanking my advisor, Mr. Geeslin, for providing the right blend of directedness and freedom that made the entire experience so worthwhile. Thanks are due also to Ms. Oja whose understanding of the construct of cognitive style has inspired my own understanding to mature. I wish to acknowledge the support and encouragement that Mr. Balomenos has provided consistently throughout this project, and throughout my years of graduate study as well. I wish to express my gratitude to Ms. Ferrini-Mundy for the long hours she has spent with me discussing the many details of the project, and for the insights she has shared with me regarding the position that research on sex differences occupies in the study of cognitive style. Finally, I would like to extend special thanks to Mr. Constantine for his careful and thoughtful assistance in planning the statistical analyses for the study. His efforts are greatly appreciated.

I wish also to thank Ms. Greenleaf of the Kingsbury Hall Word Processing Center for her untiring and expert assistance in the preparation of the manuscript.

Finally, to my good friends Joan, Dick, Jenny, Bill, and Tyler, I would like to extend my heartfelt gratitude for helping me to maintain my physical, emotional, and cognitive balance over the past several months, and for doing so with such style.
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ABSTRACT

EFFECTS OF FIELD-DEPENDENCE/INDEPENDENCE AND SEX ON PATTERNS OF ACHIEVEMENT AND GRADING IN A FIRST-SEMESTER CALCULUS COURSE

by

TIMOTHY JOHN KELLY

University of New Hampshire, September, 1985

The purpose of this study was twofold: first, to investigate effects of field-dependence/independence (f-d/i), sex, and different types of audiovisual remedial instruction on mathematics achievement (Experiment I); second to investigate the effects of student and grader cognitive style (f-d/i) and sex on calculus test grades (Experiment II).

One hundred fifty first-semester calculus students, identified by an algebra/trigonometry pretest as requiring trigonometry remediation, served as subjects for Experiment I. As measures of f-d/i, the Group Embedded Figures Test (GEFT) and The Miniaturized Rod and Frame Test (MRFT) were administered to the subjects, who were apportioned into six experimental groups, representing three remedial conditions: dialog, monolog, and control. Following each of the five slide-tape sessions, subjects were posttested on the trigonometry skills presented during the session. The calculus unit test requiring trigonometry measured calculus achievement.

Analyses revealed significant correlations between GEFT and MRFT, and between these measures and mathematics achievement, with different
correlational patterns for men and women. Multivariate analyses of
covariance indicated significant main effects favoring women on the
postsession measures. Other significant main and interaction effects
are discussed. Within the female group, treatment appeared to favor
low and midrange scorers on the GEFT.

For Experiment II, 41 calculus unit exams, that had been graded
in a face-to-face student/grader arrangement, were selected for
analysis. Available for the analysis were pretest, GEFT, and MRFT
scores for the students, and GEFT and MRFT scores for the graders.
The 41 exams were cleaned of all grader markings and regraded in a
non-face-to-face situation by another group of 41 graders. Univariate
analyses of covariance revealed a significant grader GEFT x grader sex-
x student sex interaction in the face-to-face situation, and a
significant student MRFT effect in the non-face-to-face situation.
Grades given in the face-to-face situation were significantly higher
than grades in the non-face-to-face situation.

Results suggest that the GEFT and MRFT produce different patterns
of significant effects in analysis, and that GEFT and MRFT may have
different predictive value for each of the sexes.
CHAPTER I
THE RESEARCH PROBLEM IN GENERAL CONTEXT

Overview

Two of the most conspicuous tasks faced by educators are, unquestionably, the delivery of instruction and the evaluation of learning. In the present study, the information processing styles of learners and evaluators have been investigated for possible relevance to these two tasks. The dimension of information processing exploited in this investigation is commonly identified by its poles, field-dependence and field-independence, and is generally classified as a cognitive style. When referring to the field-dependence/field-independence cognitive style, we shall use the abbreviation f-d/i. The most popular, though somewhat oversimplified interpretation of f-d/i construes an individual's position on the f-d/i continuum as indicative of a tendency towards an analytic (field-independent) versus global (field-dependent) approach in processing external or internal stimuli. In other words, a relatively field-independent individual's perception of a stimulus field is characterized by a tendency to approach the field as a compound of constituents that are discrete from one another and from the field as a whole. A relatively field-dependent individual's perception of a stimulus field is marked by a tendency to accept the field as a given organized whole, requiring no further analysis of part-to-part or part-to-whole relationships.
The purpose of the present study was twofold:

i) to explore relationships among f-d/i, sex, and achievement in mathematics, following different types of audiovisual remedial instruction, and

ii) to examine main and interaction effects of students' and graders' cognitive styles and sex on calculus test grades.

**Cognitive Styles**

The study of cognitive styles has produced one rather imposing chapter in the epic of individual differences research. Over the past four decades, several cognitive style dimensions have been suggested, each alleging to identify certain stable information processing characteristics responsible for individuals' idiosyncratic patterns of response to the cognitive, and in some cases social and psychological demands of the environment. Among the more widely researched dimensions are serialism vs. holism (Pask, 1969, 1975), impulsivity vs. reflexivity (Kagan, Rosman, Day, Albert, & Phillips, 1964), leveling vs. sharpening (Gardner, Holzman, Klein, Linton, & Spence, 1959), and field-dependence vs. field-independence (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962).

There is frequent disagreement as to the precise nature of a cognitive style, and whether a given construct covers a broad enough range of individual functioning to warrant the term style. For example, in discussing the communalities of the "true" cognitive styles, Messick (1982) claims that cognitive styles are value-differentiated since
"each stylistic extreme has adaptive value but in different circum-
stances" (p. 9), and that they represent within the individual self-
consistent ways of "organizing and processing information and experi-
ence" (p. 3), which are "not...easily modifiable by tuition or train-
ing" (p. 4), which pervade "cognitive, personality, and interpersonal
domains" (p. 4), and which are "spontaneously applied without con-
scious consideration of choice in a wide variety of situations" (p. 
5). Consistent with this viewpoint is Messick's relegation of
serialism/holism to the status of a cognitive strategy (since an
individual can be trained to choose consciously between a serialist
vs. holist approach in response to specific situational requirements),
and leveling/sharpening to the status of cognitive control (since it
is value-directional and refers to a specific aspect of cognitive
function, namely memory.)

Over the past 35 years, such problems of taxonomy have apparently
failed to impede a rather headlong and, in some cases, impetuously
charted program of aptitude treatment interaction (ATI; Cronbach,
1967) or trait-treatment interaction (TTI; Di Vesta, 1973) research
employing cognitive style as an aptitude or trait variable. On the
basis of sheer number of studies published, the f-d/i construct has
been the most extensively explored of all the cognitive styles
(Witkin, Oltman, Cox, Ehrlichman, Hamm, & Ringler, 1973; Witkin, Cox,
Friedman, Hrishikesan, Siegel, 1974; Witkin, Cox, & Friedman, 1976;
Cox & Witkin, 1978; Cox, 1980; Cox & Gall, 1981.)
Field-Dependence/Independence: A Brief Introduction

The f-d/i construct has undergone several changes in scope and emphasis over the past 35 years. These changes were precipitated in part by the large body of research alluded to above, but are primarily the effects of an aggressively waged and articulately documented campaign of theory building and revision on the part of Herman Witkin and his associates.

Witkin developed two types of performance measures of f-d/i: orientation tasks, such as the Rod-and-Frame Test (RFT; Witkin, 1946a), and a visual disembedding task, called the Embedded Figures Test (EFT; Witkin, 1950a). The RFT measures an individual's ability to overcome the distracting influence of a tilted frame when asked to move a rod within the frame to a position representing true vertical. In the testing situation, the only objects visible to the subject are the rod and the frame, and hence the only cues available for positioning the rod correctly are the visual field defined by the frame, and the gravitational field defined by the subject's kinesthetic responses to the downward force of gravity.

In the EFT, the subject is required to retain a simple geometric shape in memory, and then to locate it in a complex figure in which it has been structurally assimilated, and thus perceptually "hidden."

The earliest conceptualization of the f-d/i construct was based on the observation of individuals' self-consistencies across a variety of orientation tasks such as the RFT (Witkin, Lewis, Hertzman, Machover, Meissner, & Wapner, 1954). The researchers viewed f-d/i as a continuum associated with the tendency to rely on internal gravitational referents
(field-independent) vs. external visual referents (field-dependent) in locating true upright. Later, when it appeared that performance on the orientation tasks correlated with performance on the visual disembedding task (EFT), they generalized f-d/i to be a perceptual analytic ability that accounted for differences in individuals' proficiencies in separating an object from an organized field.

Though essentially the same performance measures have been used since the early days of f-d/i research, the construct has been reconceptualized several times in response to results extending its application from the purely perceptual domain into intellectual, social, and psychological domains as well (Witkin et al., 1962; Witkin, Goodenough, & Karp, 1967; Witkin & Goodenough, 1976; Witkin, Moore, Goodenough, & Cox, 1977; Witkin, Moore, Oltman, Goodenough, & Friedman, 1977; Witkin & Goodenough, 1977; Witkin & Goodenough, 1981). When Witkin began using the term cognitive style to describe f-d/i (Witkin, 1964; Witkin et al., 1967), he ceased referring to f-d/i as an ability dimension and, in fact, began a rather serious campaign to emphasize its identity as a style. In their most recent formulation of f-d/i, Witkin and Goodenough (1976, 1981), persist in classifying f-d/i as a stylistic dimension (a cognitive style), but now conceptualize it as the relative autonomy with which an individual functions. However they suggest two lower order dimensions which they refer to as abilities: interpersonal competency and cognitive restructuring skill. Let us make the following three observations in the light of these somewhat contradictory classifications:
i) Witkin and Goodenough have termed cognitive restructuring an ability dimension. This appears to be in response to criticisms claiming that the EFT and RFT are not measures of purely stylistic individual differences. Cronbach (1960) reports that the Embedded Figures tests correlated 0.35 to 0.60 with ability tests such as Block Design, Number Series, and Thurstone's tests of the spatial factor" (p. 360). Factor analytic studies (Pemberton, 1952; Messick & French, 1975) suggest that hidden figures tasks, of the type used in the EFT, load on a flexibility of closure factor of general intelligence; this result is widely accepted. Even Witkin and his associates (1962) report similar results. In all cases field-independence is associated with greater ability.

ii) That interpersonal competencies persist in being implicated with f-d/i is consistent with the large body of research indicating that relatively field-dependent individuals display greater interest in interpersonal situations and demonstrate more highly developed social interaction skills than their field-independent counterparts (Messick & Damarin, 1964; Ruble & Nakamura, 1972; Bogo, Winget, & Gleser, 1970; Elliott, 1961; Oltman, Goodenough, Witkin, Freedman, & Friedman, 1975; Crandall & Sinkeldam, 1964; Bard, 1972; Witkin & Goodenough, 1977).
iii) That f-d/i, in the light of i and ii above, is construed by Witkin as a stylistic dimension is somewhat perplexing. Throughout this report the terms cognitive style and field-dependence/independence will be used interchangeably; this merely reflects acquiescence to common usage rather than any conviction on the part of the researcher that f-d/i is in fact a stylistic dimension. A more formal and precise development of the conceptualization of f-d/i which guided the present research will be offered in chapter II.

Three Recurrent Themes in Field-Dependence/Independence Research: Restructuring Ability, Interpersonal Competencies, and Sex Differences.

Restructuring Ability

That field-independence is related to perceptual and intellectual restructuring ability has been suggested by many studies involving, for example, speed of closure (Messick & French, 1975), perceptual constancy (Gardner, Jackson, & Messick, 1960), Piagetian conservation (Pascuale-Leone, 1969), concept attainment (Nebelkopf & Dreyer, 1973), set breaking (Guetzkow, 1951), as well as perceptual perspectivism (Okonji & Olagbáiyé, 1975), conceptual perspectivism (Futterer, 1973), and syntactic disambiguation (Goodman, 1971).

In designing studies of f-d/i that focus on its cognitive restructuring component, the assumption is usually made that relatively field-independent individuals will show a greater capacity than relatively field-dependent individuals in structuring previously
unstructured stimulus fields or restructuring fields that are already structured. Field dependent individuals are generally expected to accede to the dominant referents in the given stimulus field. Experimental designs in studies of teaching and learning generally reflect the expectation that field-dependent individuals will benefit from situations that provide compensatory structuring mechanisms (Schwen, 1970; Koran, Snow & McDonald, 1971; Witkin, Moore, Goodenough, & Cox, 1977; Scott, Smith, & Rosenberg, 1981). This expectation is sometimes substantiated (Koran et al., 1971) and sometimes not (Scott et al., 1981).

**Interpersonal Competencies**

The relatively greater social orientation of field-dependents is a well documented result. For example, studies have demonstrated the field-dependent's penchant for selectively attending to the faces of others (Crutchfield, Woodworth, & Albrecht, 1958; Messick & Damarin, 1964; Ruble & Nakamura, 1972), and to verbal messages containing incidental social information (Eagle, Fitzgibbons, & Goldberger, 1966), for repressing hostility towards others (Bogo et al., 1970; Elliott, 1961), for adjusting their rate of speaking to that of their partners in speech (Marcus, 1970), and for being more well-liked than relatively field-independent individuals and more helpful in conflict resolution situations (Oltman et al., 1975). In general, relatively field-dependent persons display behaviors indicating greater interest in interpersonal situations (Crandall & Sinkeldam, 1964; Bard, 1972) and in careers Favoring interpersonal/nonanalytical skills (Clar,
That this outer-directed (or other-directed) behavior can function as an asset or a liability to the field-dependent perceiver has been exhibited in a variety of studies investigating the field-dependent's use of external cues in situations possessing some inherent ambiguity. For example, in a concept attainment study (Ruble & Nakamura, 1972), field dependent students showed greater sensitivity to a socially mediated cue (necessary for successfully determining the concept) than did the field-independent students. However, when such a cue was no longer relevant to the task, the field-independent students proved to be more successful in discovering the concept.

A study by Linton (1952) revealed that field-dependents' estimates of autokinetic movement were far greater (and hence less accurate) in the presence of erroneous information provided by a "planted" confederate. This study is interpreted by Witkin and his associates (Witkin, Moore, Goodenough, & Cox, 1977) as demonstrative of the "responsiveness of field-dependent persons to external social referents, particularly in situations in which there is some ambiguity" (p. 11). In some situations this reliance on external cues is productive, but in other situations it can lead the field-dependent to an incorrect decision.

**Sex Differences**

Small differences are frequently observed in the performance of men vs. women on tests of f-d/i, with women sometimes reported to be more field-dependent than men (DeRussy & Futch, 1971; Bieri, Bradburn, & Galinsky, 1957; Bogo et al., 1970; Witkin et al., 1967), though not
always (Stuart, Breslow, Brechner, Ilyas, & Wolpoff, 1965; Willoughby, 1967). Vaught (1965) demonstrated a positive relationship for both men and women between masculinity (associated with mechanical and scientific interests and with a preference for the analytic and impersonal) and field independence, measured by the RFT. DeRussy and Futch (1971) reported that college-age female science majors were found to be significantly more field-dependent (measured by the EFT) than male science majors, significantly more field-independent than female liberal arts majors, and not significantly different from male liberal arts majors. Bieri et al. (1957) found significant sex differences in favor of males on the EFT, and significant correlations for both men and women between mathematics aptitude and EFT performance. They conclude that superior mathematics aptitude for the male subjects was partially responsible for differential performance on the EFT.

A review of the studies intending to demonstrate relationships between the cognitive style sex difference and sociological factors have not been convincing (Waber, 1977). The high loading of EFT on a visual-spatial factor has been suggested as the basis for sex differences in f-d/i (Sherman, 1967; Maccoby & Jacklin, 1974). However, Waber (1977) suggests that the correlation of spatial ability with field independence might indicate that the two are affected by similar biological factors, and cites existing data consonant with the theory that maturational rate may account for differences in f-d/i.

It is understandable therefore that in the methodology of f-d/i research, one frequently finds that separate analyses are conducted
for men and women. This approach is reminiscent of Sigel's rationale (1965) for separate-sex analyses of cognitive data. Such an approach can make it difficult to assess sex differences on a specific task. The approach taken in the present study allows sex to be entered as a factor in all analyses, thus permitting the detection of significant sex differences.

Measures of F-d/i (RFT;EFT): Two Tests or Two Constructs?

Despite Witkin's early claims regarding the high degree of correlation between the RFT and EFT (Witkin et al., 1962), several subsequent studies have reported substantially lower correlations, in the range of 0.3 to 0.6 (Vernon, 1972; Dubois & Cohen, 1970; Gough & Olton, 1972; Arbuthnot, 1972). The widely accepted relationship between EFT and certain measures of general intelligence has been referenced earlier in this chapter. In 1976, Witkin and Goodenough admitted the possibility of the distinctiveness of factors involving closure-flexibility (associated with the EFT) vs. perception of the upright (as measured by the RFT). Dubois and Cohen's (1970) suggestion that performance on the RFT is less contaminated by intelligence than the EFT was supported in Vernon's (1972) factor-analytic study reporting relatively low loadings of RFT scores on factors of general or spatial ability.

What then does the RFT measure? If, indeed, it is a tracer for behaviors other than the obvious ability to determine the upright, what sorts of behaviors might these be? Pascuale-Leone and his associates (Pascuale-Leone, Goodman, Ammon, & Subelman, 1978) characterize
field-dependents as being less capable of selecting strategies appropriate to the performance of a task at hand. They attribute this deficiency to the existence of a weak "interrupt" function - a function responsible for interrupting the application of schemes that are irrelevant for a task. Linn (1978) demonstrated that performance on the RFT measured one's ability to select the appropriate strategy for problem solution, when salient but irrelevant strategies were implicit in the problem. In 1981, Linn and Kyllonan reported results of a factor-analytic study supporting the notion that EFT and RFT are associated with two separate factors: EFT with a cognitive restructuring factor, and RFT with a factor associated with strategy selection in ambiguous situations, where the dominant strategy may be irrelevant. Linn and Kyllonan suggest that in future studies it would be fruitful to assess the separate contribution of the RFT and the EFT.

The Present Study

Background

The present study was designed to investigate some applications of the f-d/i construct to mathematics learning and teaching at the college level. More specifically, the intent of the study was twofold: i) to explore relationships between f-d/i, sex, and achievement in mathematics, following different types of audio-tutorial remedial instruction, and ii) to examine main and interaction effects of students' and graders' cognitive styles and sex on calculus test scores.
The environment for the present study was a highly structured first semester calculus course offered during the spring term of academic year 1978-1979 at the University of New Hampshire. Calculus lectures were given three times per week in large-lecture format with all enrollees in the course (roughly 200 students) assigned to the same lecture section. A calculus tutorial room, staffed by graduate students in the mathematics department, was open 50 hours per week. It was there that students could go for help with suggested exercises or questions related to the material presented in class. No homework was collected. A student's grade was determined solely by the student's performance on four free-response unit (hourly) tests.

It was deemed necessary to infuse the experimental environment with features to which the f-d/i construct is believed to be sensitive (cognitive structuring, social loading, decision-making in an ambiguous situation), without altering in any significant way the overall structure of the course. Two aspects of the course seemed particularly susceptible to analysis using f-d/i, namely the concurrent delivery of remedial instruction in a mathematics resource center, and the face-to-face grading of calculus unit tests by advanced undergraduate graders. The study was thus composed of two experiments: Experiment I, concerned with learning, and Experiment II, concerned with grading.

**Experiment I: Remedial Instruction**

At the beginning of the calculus course, students are pretested to determine their status regarding prerequisite algebra and trig-
onometry skills thought to be necessary for success in the course. A student found lacking in these skills must satisfy a remedial requirement while taking the calculus course. A five-session audio-visual minicourse, covering the basic concepts and skills of trigonometry had been previously developed in monolog form for this remedial purpose. For the present study an alternate presentation was designed to cover precisely the same material in precisely the same sequence, but in teacher-student dialog form. The expectation was that the interpersonal nature of the dialog presentation, together with the inclusion of questions (posed by the student in the dialog) specifically designed to structure the material for the learner, would work in tandem to provide a more profitable learning experience for the field-dependent learner. The dialog presentation was thus designed as both a conciliatory and compensatory device which might appeal to the field dependent's social proclivities and cognitive-structural deficiencies.

Experiment II: Grading

Grading of the four unit tests in the Calculus I course is done by advanced undergraduates. Each test is graded immediately after the student finishes, in a face-to-face student-grader "confrontation". Although the grader is provided with a fairly well-detailed solutions manual for the tests, there is concern that the inherent ambiguity of students' responses, and of the answer key itself, leaves a great deal to the imagination of both student and grader. Therefore, the situation seemed suited to testing for cognitive style and sex match/
mismatch effects on grading outcomes. Moreover, in the spirit of the Linton (1952) study and in the external-reliance-in-the-face-of-ambiguity (Witkin, Moore, Goodenough, & Cox, 1977) or the selection-of-salient-but-irrelevant-strategy (Linn & Kylonan, 1981) aspects of field dependence in general, one might expect relatively field-dependent graders to be more susceptible as a group to the external pressure imposed by the student who rationalizes, cajoles, and pleads during the grading session.

The Research Questions

In investigating the effects of cognitive style and sex on learning and the evaluation of learning, the present study had two major foci: the extent of learning, retention, and transfer following matched-to-style audio-visual instruction, and the extent of style-related biases in grading. Let us summarize by listing specific questions on which the foregoing line of reasoning is intended to converge.

Primary Questions

1. (Experiment I) What are the effects of remedial treatment conditions (dialog, monolog, and control), cognitive style, and sex upon three types of criterion measures: post-session quizzes, post-remedial program trigonometry achievement test, and delayed calculus achievement test drawing on knowledge of trigonometry?

2. (Experiment I) Are disembedding tasks (e.g. the EFT) and orientation tasks (e.g. the RFT) equivalent as cognitive style measures
in producing patterns of effects of cognitive style, sex, and modality of instructional delivery on criterion measures?

3. (Experiment II) How are calculus test scores affected by students' and graders' cognitive styles and sex?

4. (Experiment II) Are disembedding tasks (e.g. the EFT) and orientation tasks (e.g. the RFT) equivalent as cognitive style measures in detecting grader or student effects on calculus test scores?

**Secondary Questions**

1. Are there significant sex differences present on either cognitive style measure, the course pretest, or the unit IV calculus test?

2. Are the same patterns of cognitive style effects present in both face-to-face and non-face-to-face grading situations?

3. Are there significant treatment effects on the unit IV calculus test?

4. Are scores given in the face-to-face situation significantly higher than scores given in the non-face-to-face situation?
CHAPTER II

HISTORICAL AND THEORETICAL FRAMEWORK

Introduction

Despite the proliferation of research on f-d/i, there is apparent in the literature a lack of agreement, and often a lack of concern, over the true nature of the construct, and the cognitive processes that it intends to explain. For example, in 1963, Zigler reviewed Psychological Differentiation (Witkin et al., 1962), a book attempting to place f-d/i in the context of the broad organismic construct indicated in the title. Witkin, Goodenough, and Oltman (1979) summarize the differentiation concept as follows:

Briefly stated, differentiation is a major formal property of an organismic system. A less differentiated system is in a relatively homogeneous state; a more differentiated system is in a relatively heterogeneous state. A system that is more differentiated shows greater self-nonself segregation, signifying definite boundaries between an inner core of attributes, feelings, and needs identified as the self, and the outer world, particularly other people. In a less differentiated system, in contrast, there is greater connectedness between self and others (p. 1127).

Zigler’s review, entitled A Measure in Search of a Theory, calls into serious question the theoretical basis for and utility of the differentiation concept as explanatory of performance on Witkin’s perceptual measures, such as the Rod-and-Frame Test (RFT) and the Embedded Figures Test (EFT). Later, in 1970, Dubois and Cohen published results of a study exploring the relationship between measures of f-d/i (RFT and EFT) and measures of intellectual ability. They
concluded that, "a considerable gap still exists between empirical findings on field-independence and their adequate conceptualization" (p. 415), and that the dimension "is certainly not very clearly explained at this point" (p. 415). More recently, Linn and Kyllonan (1981), in exploring the nature of the factor-structural differences between the EFT and RFT, give motivation for their factor-analytic investigation by remarking that, "In spite of widespread interest, the construct represented by the various measures of FDI is not well understood" (p. 261).

Interestingly, even the harshest critics mollify their remarks with words that encourage further investigation of the construct. For example, despite his methodological and conceptual criticisms, Zigler (1963) concludes, "there is little doubt that there is something meaningful here" (p. 134), while Dubois and Cohen (1970) temper their concerns with the suggestion that, "the dimension may yet hold unexpected significance as a broad explanatory construct in human perception and behavior" (p. 411).

The ambiguity evident in the literature makes one thing perfectly clear: if one is about to undertake research on f-d/i, the first obligation is to identify those human processes believed to underlie the construct, and to substantiate this identification. To define f-d/i as that which is measured by the EFT and RFT serves little heuristic value in the design of experiments. To define f-d/i as a vague construct descriptive of a global vs. analytic approach to the environment serves even less. One goal of the present chapter is to trace the conceptualization of f-d/i which served as a heuristic definition in generating the hypotheses of the present study.
A Critical Consideration of the F-d/i Construct

Background

It was by virtue of their close association with early Gestalt psychologists that the initial shapers of f-d/i theory pursued a research program focused squarely on perception.

The early Gestalt theorists were guided by the conviction that it was the mind's natural tendency to structure and give meaning to experience (Hergenhahn, 1982). Perceptual phenomena offered particularly fertile ground for exploring the principles guiding these mental processes, though a frequently overlooked tenet of early Gestalt theory is that such principles were claimed relevant to all cognition. One such principle, the law of Prägnanz (Koffka, 1935), posits that a cognitive object is processed in such a way that renders it as regular, stable, and meaningful as possible. Other Gestalt principles have ready application to questions of figure-ground relationships in perception. For example, the principle of closure (which asserts that incomplete experiences tend to be processed as complete) is responsible for our seeing the square in Figure 1, while the principle of inclusiveness (which states that the most dominant feature in a cognitive field is the one with the greatest stimulus value) explains why we may have difficulty seeing the word "way" in Figure 2 or the simple shape on the left in Figure 3 once it has been integrated into an embedding field on the right.
Figure 1. An example of closure.

Figure 2. An example of inclusiveness.

Figure 3. Sample of simple and complex figures similar to those used in the EFT (Witkin, Moore, Goodenough, & Cox, 1977, p. 5).
It is perhaps appropriate to mention at this point that the early Gestaltists did not focus their attention exclusively on perception. For example, Max Wertheimer's most memorable work is not on perception, but rather on problem solving (Wertheimer, 1920). In this vein, Kanisza (1979) articulates the Gestalt attitude towards problem solving, an attitude which may be of interest to us in understanding one possible bias affecting Witkin's theory:

...the belief is still very widespread that insight is proposed as a causal agent in reaching solutions. However, gestalt theory maintains that intelligent solutions derive essentially from a restructuring or from successive restructur­tings of the problem situation, and gestalt research has attempted to establish the laws and precise causes of these restructuring processes. Insight is not one of these causes, nor is it a force that leads to restructuring; on the contrary, it is its (restructuring's) consequence: through restructuring, the situation becomes transparent. Insight accompanies, but does not produce the solution (p. 71).

It is Witkin's emphasis on cognitive restructuring that has acted to unify the process of conceptualizing and reconceptualizing f-d/i over the past 35 years. Let us now consider that process in some detail.

F-d/i from 1948 to the Present

Although the early Gestalt theorists were concerned with "set" and "past experience" in their study of perception (Wertheimer, 1923), their main interest lay not in the role of the perceiver, but in the role which field factors (characteristics of the field itself) play in the perceptual process (Witkin et al., 1954). Consequently they showed little interest in individual differences in perception. Tyler (1965) reports:
The rise of Gestalt psychology and its signal success in clarifying the nature of perceptual processes probably served also to play down the importance of individual differences. Gestalt workers focused their attention on phenomena for which striking similarities between subjects are the rule - apparent movement, figure and ground, tendencies toward closure and "pragnanz," the constancy effects. (p. 212)

Since the focus of Gestalt research was on the field rather than on the individual, studies generally involved small numbers of subjects (Gottschaldt, 1926; Dunker, 1929) whose average performance was used to derive information regarding some characteristic of the perceptual field; intrasample variance or modality of distribution were of little interest. Despite these tendencies, the Gestalt movement did "bring 'reality' into a central position in psychological theory" (Witkin et al., 1954, p. 496).

If the spirit of early f-d/i research derived from the perceptual inclinations of Gestalt theory, then its intellect was born of the New Look movement in perception. This movement sought to focus perception research on the characteristics of the perceiver, rather than on the characteristics of the perceptual field. Witkin and Goodenough (1981) identify Klein and Schlesinger's (1949) seminal paper, Where's the Perceiver in Perceptual Theory, as capturing the essence of the movement. In that paper, the authors emphasize the importance of investigating individual differences in the basic processes of perception, as well as individuals' characteristic patterns of perceptual response, referred to as their "preferred styles" (p. 40). Witkin and Goodenough summarize Klein and Schlesinger's position, as well as their response to it, as follows:
What Klein and Schlesinger called for instead was assignment of a pivotal role in conceptualizing perception-personality relationships to a central adapting, regulating personality structure, which enters into all functioning, including perceiving. In our current view of field dependence-independence as an expression of the extent of differentiation of an individual's psychological structure we take precisely this stance (p. 3).

In articulating the movement from perceptual object to person as the focus of perceptual research, Witkin and his associates (1954) acknowledged the approval of the great Gestalt psychologist Max Wertheimer in the face of this new era of research:

In view of the predominant emphasis on field factors in the Gestaltists' own work, it is interesting to note that the earliest groundwork for the study of individual differences in perception was laid when one of us was working with Wertheimer, who gave warm encouragement to the first efforts to investigate the personalities of subjects with different modes of space orientation. (p. 496)

One can't help but observe the joint effects of the Darwinian theory of selectivity of adaptive biological functioning and the Gestalt perceptual theory in the genesis of this research movement. Prior research exploiting Darwinian survivalist notions attempted to relate differences in perceptual abilities first to biological adjustment procedures of various species (Maier & Schneirla, 1935), and then later to human social adjustment constructs such as motivation (Levine, Chein, & Murphy, 1942) and coping techniques (Klein, 1951). Extending Darwinian survivalist arguments into the realm of the intraindividual conflict among competing strategies in ontogeny, one is led rather naturally to the conclusion that what survives in a specific individual are those mechanisms having the greatest adaptive value for that individual's cognitive and emotional adjustment to the environment. The research program of Herman Witkin and his associates
sought to explore individuals' different styles of adapting to the cognitive and emotional demands of the environment, by using perceptual measures as tracers of such styles. This research has spanned the last four decades and during that time has inspired the development, modification, and expansion of a broad theory of psychological functioning. (Witkin et al., 1954; Witkin et al., 1962; Witkin & Goodenough, 1976; Witkin et al., 1979; Witkin & Goodenough, 1981). It is in the framework of this theory that the present study derives its meaning.

Witkin's earliest research was initiated in an attempt to explicate observed individual differences in the manner in which people perceive the upright in space (Witkin & Ashe, 1948a; Witkin & Ashe, 1948b; Witkin, 1949a; Witkin, 1949b; Witkin, 1950b). An individual's perception of true vertical is generally mediated by distinct visual and bodily impressions which coalesce in the act of perceiving to provide a unified and accurate impression. In everyday experience these visual and bodily impressions are mutually confirmatory, that is, the impression of true vertical provided by one modality is confirmed by the impression provided by the other. To establish possible differences in modal preference among individuals faced with the task of determining true vertical, Witkin's early research exploited three experimental situations in which the two standards of verticality would fail to operate in tandem, but rather, would produce two distinct (and conflicting) estimates of true vertical. Reliance upon one of these standards of verticality would effect a relatively accurate estimation of true vertical, while reliance on the other would not.
In the first experimental situation (Witkin & Ashe, 1948a) called the Rod and Frame Test (RFT), the subject was seated in a totally darkened room where the only objects visible were a luminous square frame and a luminous rod within the frame. The midpoint of the rod was pivoted at the center of the frame, and the rod could be rotated clockwise or counterclockwise about its center by both the experimenter and the subject, while the frame could be rotated, independently of the rod, by the experimenter only. At the beginning of each experimental trial, the rod and frame were positioned in some stage of relative tilt away from true vertical; sometimes the rod was aligned with the frame and sometimes it was not. The subject was then requested to adjust the rod to a position that would be perpendicular to the floor in the room.

In the second task (Witkin, 1949b), the subject was seated in a chair which could be tilted clockwise or counterclockwise by both the experimenter and the subject. The tilting chair was pivoted at the midpoint of one wall of a small room. The room could be tilted independently of the chair, but only by the experimenter. In this task, referred to as the Body Adjustment Test (BAT), or sometimes as the Tilting-Room-Tilting-Chair Test, the room and chair were positioned by the experimenter in several different configurations and in each instance the subject was requested to adjust the chair to a position wherein the subject would be sitting up perfectly straight. In both the RFT and BAT the dominance of visual vs. gravitational impressions could be measured by the accuracy of an individual's responses in degrees deviation from true upright. Reliance upon internal kinesthetic
or vestibular sensations resulting from the body's response to the
force of gravity would yield an accurate estimate of true vertical;
reliance upon external visual stimuli such as the tilted room in the
BAT or the tilted frame in the RFT would tend to bias one's response
away from true vertical, in the direction established by the "upward"
axis of the tilted room or frame.

The third task, which Witkin (1950b) called the Rotating Room
Test (RRT), provided a situation in which the extent of reliance upon
internal (bodily) vs. external (visual) referents could be measured,
but in contrast to the other two orientation tasks, incorrect impressions
of the upright were reported by those subjects relying upon internal
standards, while those relying upon external standards were led to the
correct conclusion. In this task the subject was seated in a chair
which could be tilted clockwise or counterclockwise, and the chair was
pivoted in the center of the wall of a small, non-tilting room. The
room was driven around a circular track, thus producing a resultant
force (upon the body of the subject) which is the vector sum of the
induced "centrifugal" force and the true gravitational force. While
travelling on this track, the subject was instructed to adjust the
chair so that he or she would be sitting up perfectly straight. In
this situation the direction of the force which normally gives rise to
a (correct) internal impression of true vertical was experimentally
altered and hence the responses of those individuals relying upon this
standard were systematically biased away from the direction of true
vertical. Since the walls of the room were kept in alignment with
true vertical, this task favored those who rely upon the external
visual framework rather than their internal kinesthetic impressions.
Results of early studies involving these three orientation tasks revealed that individuals differ markedly in the extent of reliance upon external vs. internal referents as they attempt to determine the upright in space, and also that within-subject performance tends to be consistent across tasks (Witkin et al., 1954). The researchers postulated that the observed self-consistencies across tasks stemmed from an individual's characteristic degree of reliance on external visual vs. internal bodily impressions in determining the direction of true vertical. Witkin and Goodenough (1976) report that the terms "field-dependent" and "field-independent" were adopted as working labels to describe, respectively, these two contrasting modes of perception. Most of the correlations between pairs of the three orientation tasks were reported to be significant ($p < .01$), with odd-even reliability coefficients and test-retest coefficients ranging from about 0.7 to 0.9 (Witkin, et al. 1954).

At this point in the research program an attempt was made to extend the search for individual differences from perception of the upright to other types of perceptual tasks. Witkin and Goodenough (1976) explain the rationale prompting this step. (Keep in mind the importance traditionally attached to structuring by Witkin's intellectual forerunners.)

In these further studies of self-consistency the lead was followed that, while the three orientation tasks assessed reliance on field or body, they could also be conceived to involve separation of an item (body or rod) from an organized field (room or frame). This possibility was checked through the use of perceptual tasks which required the subject to disembed an item from an organized field of which it was a part, but which did not involve body-field juxtaposition or perception of the upright. (p. 5)
The test referred to at the end of the previous passage is the Embedded Figures Test (EFT), developed by Witkin (1950a). This test consists of items in which the subject must locate a known simple figure that has been integrated into a larger, more complex figure. What tends to conceal the simple figure structurally is that many of its parts also act as constituents of other (irrelevant) simple figures contained in the complex figure (see Figure 3). Witkin believed that to perform this task the subject needed to break up (analyze) the complex figure into its component parts and to restructure the appropriate parts into an organized whole (namely, the desired simple figure). Witkin and his associates (1954) reported that, in general, correlations between EFT scores and scores on each of the three orientation tasks (RFT, BAT, RRT) were significant \( p < .01 \) or \( p < .05 \) and in the expected direction for both males and females, with one exception: a non-significant correlation between RFT and EFT scores for women. The fact that individuals who aligned the rod with the tilted frame or aligned the body with the tilted room in the orientation tasks also tended to have difficulty determining the simple figure in the complex gestalt led the researchers to hypothesize that the field-dependence/field-independence construct represented a "perceptual analytical ability which manifests itself pervasively throughout an individual's perceptual functioning", (Witkin and Goodenough, 1976). At this point the construct underwent a change of identity, from a style-of-determining-verticality to a more general overcoming-embeddedness ability (to disembeod rod from frame or simple figure from complex one).
In moving from a purely perceptual to a more cognitive interpretation of f-d/i, Witkin relies heavily on the work of Glucksburg and Harris (cited in Witkin et al., 1962), whose studies of problem solving behavior suggested that relatively field-dependent subjects (e.g., those who tend to rely on the frame in the RFT, and the room in the BAT, and have trouble overcoming the influence of the complex figure in the EFT) have difficulty in solving problems that require one element of the problem be taken out its obvious context and used in a different context to effect a solution. These studies mark the entree of the f-d/i construct into research on what was traditionally classified as intellectual functioning.

In Psychological Differentiation, Witkin et al. (1962) reported a series of studies mainly using 12-year-old boys as subjects. The results reported in this book suggested that f-d/i (as measured by RFT, EFT, etc.) was a tracer for a broad psychological construct referred to as psychological differentiation, and described earlier in this chapter. It was believed that extent of psychological differentiation affected behaviors in four areas of functioning: 1) analysis and structuring in both perceptual and intellectual situations; 2) sense of separate identity in social interactions; 3) articulation of body concept (one's concept of the distinctiveness of body parts); and 4) method of impulse control and use of defenses. The studies indicated that the more highly differentiated (relatively field-independent) individual, who displays an ability to overcome imbeddedness in perceptual tasks such as the RFT and EFT also was likely: 1) to overcome embeddedness in intellectual or problem-
solving tasks; 2) to function with little guidance from external
sources and demonstrate substantial reliance on internal standards,
even in the face of contradictory evidence; 3) to be aware of the
discreteness and interrelatedness of body parts; and 4) to use
specialized defenses such as intellectualization and projection,
rather than global defenses such as repression or denial.

Witkin's attempt to follow Klein and Schlesinger's (1949) sug­
gestion that personality-perception researchers search for a broad,
organism-wide structure in terms of which personality and perception
could be integrated, is apparent in the psychological differentiation
construct. It should be noted however that it is precisely this
alleged generality that has caused the most violent reactions among
critics.

Witkin first used the term cognitive style in 1964 (Witkin,
1964), and intended that the term represent the analysis and restruc­
turing aspect of psychological differentiation. The word "cognitive"
seemed appropriate because of the applicability of the concept to
problems involving perceptual and intellectual functioning. The word
"style" seemed appropriate because it indicated a characteristic
manner in which a person approaches a wide variety of cognitive problems,
and which is stable over time (Witkin et al., 1954; Witkin et al.,
1967).

Several later studies reinforced the intellectual nature of "cog­
nitive style." In projective tests such as Rorschach series, rela­
tively field-independent individuals were found to impose structure
more readily on the ambiguously organized stimuli than their field-
dependent counterparts, who tended to leave the stimulus field very much as is (Nebelkopf & Dreyer, 1970). In the context of a social studies minicourse, Stasz, Shavelson, Cox, and Moore (1976) demonstrated that, when asked to rate course concepts in terms of their similarity to one another, field-independent teachers and students tended to group course concepts into tight mutually exclusive clusters, while field-dependent teachers and students tended to perceive the concepts as not very distinct, and thus clustered almost all of the concepts into one large structure.

Based on the voluminous body of research on f-d/i reported between 1962 and 1975, Witkin and Goodenough (1976, 1981) have more recently modified the theory of psychological differentiation, to reflect new thinking regarding the influence of cognitive style on the extent of personal autonomy in interpersonal behavior and on the role of restructuring ability in cognitive functioning. In this reformulation of the theory, differentiation remains the highest level construct (and maintains its identity as a style), and from it emanate three lower level constructs: segregation of psychological functions, segregation of neurophysiological functions, and self-nonself segregation. In this scheme, f-d/i and cognitive style become synonymous with self-nonself segregation; autonomy in interpersonal relations and restructuring ability are then conceived as two separate substructures of f-d/i.
Witkin and Goodenough (1976) explain the relationship among the parts of the conceptual triad as follows:

Greater or less self-nonself segregation is... responsible for a tendency to rely on the self as the primary referent in psychological functioning or a tendency to rely on the external field as the primary referent (p. 21).

Whether a person tends to rely primarily on internal or external referents has two particularly important consequences for behavior. First, it is likely to influence the extent to which he functions autonomously of others in interpersonal relations. Second it is likely to affect his manner of processing information from the field -- specifically whether he will restructure the field on his own through using internal referents as mediators, or accede to its dominant properties as given (p. 21).

Throughout the present report the labels cognitive style and field-dependence/independence will be used interchangeably. When the term field-dependent (or field-independent) is used, it is meant only to identify a relatively field-dependent (or field-independent) individual with respect to the sample under investigation. An individual's classification relative to the f-d/i construct is thus determined by the distribution of the sample of which the individual is a part.
The Dual Nature of the F-d/i Construct

In Witkin's final statement explicating the nature of f-d/i (Witkin & Goodenough, 1981), one does discern a more conscious acknowledgement of certain ability overtones in the description of f-d/i than present in earlier accounts (Witkin et al., 1962). As stated previously, many critics had voiced concerns regarding Witkin's strict adherence to a definition of f-d/i as a purely stylistic dimension, "value neutral" (Witkin & Goodenough, 1976, p. 47) in character, and "pervasive" (Witkin, Moore, Goodenough, & Cox, 1977, p. 15) in scope. It seems quite plausible that it was this rigorous contention of value-neutrality that made the construct a popular alternative to standard aptitude measures. It has frequently been proposed (Witkin, 1974; Witkin, Moore, Goodenough, & Cox, 1977) that since one's position on the f-d/i continuum is a less threatening piece of information than one's IQ or SAT score, f-d/i has a decided advantage over aptitude measures. It may well be that the proliferation of research on f-d/i during the 70's was more reflective of sociological trends supporting an anti-aptitude movement in education rather than a belief in or understanding of the construct as a tracer of cognitive process. In any event, the arguments intended to support the stylistic nature of f-d/i were weak, and Witkin's final statement (Witkin & Goodenough, 1981) tempered his earlier remarks.

One area of research casting substantial doubt on the notion that f-d/i is a style implicates general intelligence and specific aptitudes with the construct. As reported earlier, many investigators (Bieri et al., 1958; Podell & Phillips, 1959; Elliott, 1961; Spotts & Mackler,
1967; Crandall & Sinkeldam, 1964; Widiger, Knudson, & Rorer, 1980) have reported significant correlations between measures of f-d/i and various measures of intellectual ability. Dubois and Cohen (1970), in replicating such studies, demonstrated significant correlations between measures of f-d/i (EFT and RFT) and aptitude and achievement scores on New York State College Entrance Exams, with the EFT exhibiting a somewhat stronger relationship to ability than the RFT. Of great interest was the significant relationship detected between EFT performance and measures of pure verbal achievement—a result which calls into serious question Witkin's firmly held position that measures of field-independence are not related to verbal measures (Witkin et al., 1962). Factor analytic studies (Pemberton, 1952; Witkin et al., 1962; Messick & French, 1975) suggest that hidden figures tasks, of the type used in the EFT load on a flexibility of closure factor of general intelligence, and this result is widely accepted. In addition, as Vernon (1972) points out, the substantial correlation between tests of f-d/i and spatial tests is "almost embarrassing" (p. 368).

In questioning Witkin's tenacity in maintaining that f-d/i represents a style, Kurtz (1968) remarks that,

The important thing about style is that it is a term to designate individual differences in the carrying out of competencies... the inability to demonstrate or execute a competence is not a style (p. 526).

Kurtz adds that there may be different styles in detecting the simple figures in the EFT (a point explicated by Pascuale-Leone (1974)) but the act of detection or non-detection (the criterion in the EFT) is not a style.
Elliott (1961) makes the following suggestion in a similar vein:

The ineffective performance of frame dependent subjects in situations described as lacking structure, predictability, instructiveness, and so forth, and the extreme frame dependence of children and brain damaged patients, suggest that we might with more profit and economy change the focus of investigation from personality to intellectual function. This approach would see frame dependence primarily as a kind of intellectual deficit, and secondarily as a correlate of personality attributes (p. 35).

Wachtel (1972) concurs:

Both the EFT and RFT have clear demands for S to respond to some aspects of the stimulus field in isolation from the content in which they are embedded. The individual who does not disembed is demonstrating that he cannot, and not that he chooses not to, especially in light of the evidence that individuals who do poorly on EFT and RFT tend also to be people particularly eager to do what they are supposed to do (p. 181).

If the EFT, and perhaps the RFT, measure some intellectual ability factor, the question still remains regarding the extent to which these two measures actually converge. As early as 1972, Wachtel pointed out that the studies reported in the literature up to that point "do not compellingly require a single-process interpretation" (p. 185). Some researchers were led to explore the nature of the difference between the two measures, EFT and RFT. Based on one of the few factor analytic studies involving both EFT and RFT, Vernon (1972) concluded that while the EFT loaded on a spatial factor of general intelligence (associated with other flexibility-of-closure measures), the relatively low S and g loadings of the RFT suggested it belonged to a separate factor. In citing results of a similar study, Dubois and Cohen (1970) had suggested that the RFT might be less contaminated by intelligence than the EFT.
A very early clue suggesting the nature of the distinction between the processes underlying EFT vs. RFT performance comes in Elliott's (1961) report of a study involving the performance of college students on maze and block puzzle tasks. Elliott concluded that although EFT was related to ability, RFT was not. Rather, RFT performance was significantly related to "measures of uncertainty in unstructured situations" (p. 35). In the Linton (1952) study of autokinetic suggestibility and f-d/i (described earlier), there was a post-experimental interview in which subjects were rated for negativism, defined as the extent to which a subject made a conscious decision to ignore the influence of the planted confederate. Elliott (1961) reports that when this variable is partialled out, the relationship between performance on the EFT and the autokinetic task becomes non-significant. This suggests that perhaps it is an "overcoming irrelevant influence" aspect of EFT which accounted for the significant results reported in the original study. If this were the case, it may be that this aspect of EFT performance represents the region of overlap of EFT and RFT as constructs.

Results such as these suggest that the RFT might align with that information processing capacity governing the selection or rejection of possible strategies in coping with a given stimulus field. Following this lead, a search was made for evidence in the literature that might suggest specific cognitive processing skills believed to be related to EFT performance but which would contrast with the RFT-related skills mentioned above.
Busse (1967), Dinius (1975), and Guetzkow (1951) used the EFT in studies of set-breaking ability in problem-solving. All three studies reported that the ability to break set was positively related to EFT performance, thus suggesting that EFT measures the capacity to generate new and ultimately productive problem-solving templates. In a study by Goodman (1971) subjects' performances on challenging tasks of sentence disambiguation were shown to be related to EFT performance. However, when subjects were actually given the various options for interpreting each of the task sentences, no relationship was found between EFT performance and task competence. The ingredient in the original task apparently measured by the EFT was more related to the generation of possible solutions than to their selection once the possibilities were available. Supportive of this conceptualization is the evidence supplied in a concept learning study (Nahinsky, Morgan, & Oeschger, 1979) in which the choice of a strategy (between global and hypothesis testing) was found not to be correlated with performance on the EFT.

It seems quite plausible then that the EFT's relationship to structuring ability implicates the capacity for strategy generation or invention. On the other hand the results cited above suggest that the RFT measures something quite different. It is perhaps appropriate to mention at this point that Witkin and Goodenough (1976) anticipated this dichotomy and suggested that any study of f-d/i should use both RFT and EFT. The common practice of using only one of these measures in f-d/i research has been criticized severely by several writers (Arbuthnot, 1972; Wachtel, 1972; Vernon, 1972) as producing results
that defy integration into a larger framework. This situation is further complicated by the fact that most researchers view f-d/i as a single construct measured equally well by either the EFT or RFT.

We have presented a case for associating EFT performance with some type of strategy/structure invention ability. We have suggested that RFT performance appears to be related to a certain manner of strategy selection ability. To suggest a theoretical basis for this selection-of-strategy nature of the RFT, we consider Pascuale-Leone's (1974) process structural model for f-d/i based on the theory of constructive operators. Pascuale-Leone views the structuring deficiencies and outwardly directed searching behavior of the field-dependent person as interlocked. When outwardly directed behavior must be stifled to respond correctly to a given situation, the field-dependent can do so only with great difficulty. Pascuale-Leone views the RFT as eliciting from the subject visual and postural procedures which are already in the subject's repertoire: generating the procedures is not the issue in RFT performance; applying the appropriate procedure is. Pascuale-Leone maintains that the "interrupt" function (responsible for interrupting the application of schemas that are task-irrelevant) is particularly weak in field-dependent individuals. It was Linn (1978) who demonstrated that performance on the RFT correlated with the ability to select the appropriate strategy for problem solution when salient but irrelevant strategies were implicit in the problem. When only relevant strategies were suggested, RFT had no explanatory power.
Based on the evidence presented here, the emerging picture of f-d/i, as measured by the EFT and RFT, suggests two related though contrasting abilities.

i) the ability to generate potentially productive templates by analyzing or structuring components of the stimulus field;

ii) the ability to select from among those possible templates the one or ones that are most appropriate to the situation at hand.

The conceptualization of f-d/i which guided the design of the present study maintains as the construct's most prominent characteristics the two processes of strategy (or template) generation and strategy selection, with the former process more strongly related to EFT performance, and the latter process to RFT performance.

This conception of f-d/i has since been corroborated by the factor analytic study of Linn and Kyllonan (1981), whose results suggest that tests of cognitive restructuring, such as Raven Advanced Progressive Matrices, Hidden Figures, and Surface Development, load on an ability factor resembling that associated with the EFT (Cronbach, 1960), while the RFT "measures selection of an appropriate strategy among salient competing strategies..." (p. 272).

**F-d/i and Interpersonal Competencies**

Perhaps it is best at this point to consider the frequently reported relationship between f-d/i and interpersonal competencies, and the manner in which such a relationship can be assimilated into the conceptualization of f-d/i presented above.
As has been mentioned earlier, Witkin consistently included interpersonal competencies in the profile of the field-dependent individual - a position consistent with his belief that f-d/i was a construct explanatory of an individual's level of autonomous functioning. What must not be overlooked, however, is Witkin's caution as to the nature of this externally directed social orientation. That this behavior is understood as cognitively motivated is crucial if "autonomy in interpersonal relations" is to remain a valid sub-construct within the framework of f-d/i. Witkin and Goodenough (1976) cite the work of Dolson (1973), Farley (1974), and Throckmorton (1974) in emphasizing that when manifestations of social dependency were devoid any information-gathering or information-processing motives, correlations with f-d/i failed to achieve significance. Witkin and Goodenough (1976) conclude

The conception to which we have been led by the evidence on interpersonal behavior specifically identifies the information-seeking aspect of reliance on others as salient in the social behavior of more differentiated and less differentiated people (p. 27).

The evidence now available clearly does not support the position we considered earlier that a limited sense of separate identity is likely to foster emotional dependence ("dependent attitudes" we called it) and that emotional dependence is therefore a feature of separate identity. The autonomy construct, by giving a central role to the drawing of information primarily from others or from internal sources in structuring ambiguous situations, is in fact proposing a cognitive basis for differences in social behavior between more differentiated and less differentiated people (pp. 27-28).

To what extent then can the development of interpersonal competencies be integrated into our conceptualization of f-d/i? The key to such a synthesis may lie in viewing an individual's tendency to
depend on external referents in processing information as a manifestation of some general processing deficiency. The field-dependent, who in some measure is more deficient in general reasoning ability than his or her field-independent counterpart, may learn to invest in certain other-directed behaviors in order to facilitate access to information, strategies, or structuring devices needed for resolving cognitive dilemmas. In light of the relationship between the EFT and tests of general intelligence, support for this position is found in Wachtel's (1972) description of the assumption of WISC scatter analysis (as outlined by Rapaport, Gill, and Schafer (1945)):

In the course of development, as the individual begins to emphasize particular adaptive strategies and particular defense preferences, he begins to invest in particular skills and perhaps to actively underplay others, as in the hysteric for whom memory is impaired as a function of defensive needs (p. 186).

It is in this spirit that the field-dependents' social proclivities may be interpreted as manifestations of an outwardly-directed search mechanism, cultivated for its adaptive value in situations making heavy cognitive demands. Earlier in this chapter an allusion was made to the applicability of survivalist arguments to the competition among strategies within the individual. It is precisely the strategy of other-directedness which, if adequately developed, can serve the field-dependent individual well in cognitively demanding situations. Intrapersonal competencies are a by-product of the recurrent need for external cognitive support.
Research Relevant to the Present Study

The Search for ATI's

The logic behind Cronbach's (1957, 1967) proposal that educators should seek out instructional strategies consonant with specific learning characteristics commands the search for significant aptitude-treatment interactions (ATI), or trait-treatment interactions (TTI), as a sensible approach in conducting educational research. Unfortunately the enthusiasm generated by the call for this new methodology was somewhat dampened by reviews of early ATI research indicating that results lacked conclusiveness and generalizability (Bracht, 1970; Glass, 1970; Cronbach & Snow, 1975). This shortcoming was also observed in reviews of ATI research in mathematics education (Holtan, 1975).

Some researchers claimed that the difficulties in ATI research may be due to the lack of suitable aptitude variables (Behr & Eastman, 1975), while others (Salomon, 1972b; Glaser, 1972; Di Vesta, 1973) pointed to a far more fundamental problem that must be faced in designing meaningful ATI experiments: the need to articulate the cognitive processes underlying the specific aptitude or trait under study. As early as 1967, both Glanzer and Melton emphasized the need for acknowledging the "process or mechanisms that intervene between stimuli and responses" (p. 240) in the conduct of individual differences research.

The search for ATI's using f-d/i as an aptitude variable has by no means been immune from the problems of interpretability and reliability that marked ATI research in general. For example, in 1971,
Koran, Snow, and McDonald applied Melton's (1967) process model of associative learning to an investigation focusing on interactions of f-d/i and written vs. video modeling presentations of a teaching skill. According to Melton's (1967) model, the first component in associative learning (and perhaps all learning) involves a coding response to the external stimulus. Koran and her associates hypothesized that the perceptual demands of a multiple channel video-modeled presentation, requiring the derivation of task-relevant information in the presence of a substantial amount of perceptual noise, would favor those individuals possessing greater perceptual analytic ability (i.e., field independents). Results of the study indicated just the opposite. Scores on the Hidden Figures Test (similar to and frequently used as an alternative to the EFT) correlated significantly and negatively with criterion performance following the video-modeling treatment. (The RFT was not used in this study.) The investigators interpret these results as suggestive of the compensatory value of the video-modeling approach for field-dependents: the video treatment "may provide a behavioral representation for the learner that he could not generate for himself if given the written modeling treatment, and thereby it facilitates his performance" (p. 226). Carrying this "compensatory" argument one step further, the investigators suggest that for the field-independents, such a lock-step and fully visualized presentation may not only "fail to be facilitative, but may interfere with encoding processes or attenuate performance through boredom or fatigue" (p. 226). From a cognitive processing point of view this position seems reasonable.
since the field independents in the video treatment are simply not
given the opportunity to do what they do best: generate their own
representation of the concept to be learned, in this case a teaching
skill "template." It is important to note two things: the
significant interaction with f-d/i was based on an EFT-like measure of
f-d/i with no RFT scores available, and the task involved the genera-
tion of an appropriate internal model of the teaching skill and not
the rejection of salient, irrelevant models. That the field-
dependents benefited from the concrete representation offered by the
video modeling technique supports the position stated earlier in this
chapter that perceptual tests of closure are tracers of that aspect of
f-d/i involving template generation.

The above interpretation of the Koran et al. (1971) study is
reminiscent of Salomon's (1972a) explication of a "supplantation"
function, whereby a process is generated through some medium, thus
supplanting the need for the learner to generate the process
internally on his own. Salomon investigated performance differences
on a task requiring the subjects to unfold three-dimensional objects
into planar form and then to reconstruct the objects into solid form.
Treatments involving representations by motion-pictorial techniques
proved beneficial to the low verbal ability group but deleterious to
the performance of the high-ability group, thus supporting the
"supplantation" hypothesis that the low-ability groups benefited by
experiencing a continuous transformation of the object from one state
to another, a process which might only be achieved internally with
great difficulty, if at all. The natural processing style of the
high-ability groups was apparently inhibited, suggesting that the
denial of an active closure operator can work to the disadvantage of
certain high-ability groups.

**Media Research**

Since Experiment I in the present study involved two different
types of audio-slide presentations, we now consider some of the
relevant literature in the field of media research. It is well
accepted that inserting questions into written instructional materials
facilitates the learning of those materials (Rothkopf, 1970; Frase,
1970). Lumsdaine's (1963) review of the literature regarding tech­
niques in instructional film indicates similar results. Gagné and
Rohwer (1969) found that techniques designed to direct attention to
the learning task are generally conducive to learning. However,
Allen, Cooney, and Weintraub (1968) concluded that when the narrator
of video and slide presentations explicitly directed attention to
important points in the slides, students of lesser ability benefited
while students of higher ability did not. Berliner and Cahen's (1973)
research supports the notion of an ATI between question-posing and
mental ability, favoring the lower ability learner. It seems reason­
able that question-posing might prove to be an appropriate technique
for maintaining the attention of the field-dependent learner on the
instructional task. In addition to the facilitative value of the
technique described above, the field-dependent learner might stand to
be even more positively affected if the narration in an audio-slide
presentation were to center around a question-answer dialog between a
teacher and student. The interpersonal nature of the interaction might serve to heighten the arousal value of the narrative since it simulates the field-dependent's preferred style of information gathering. Moreover, to make the presentation even more valuable to the field-dependent learner, it also could be constructed in such a way as to "supplant" one of the field dependent's information processing deficiencies: structuring ability.

The use of structuring techniques in the form of outlines (Anderson, 1967; Gagné, 1973) and content sequencing (Brown, 1970) has been found to enhance criterion performance across a wide variety of tasks. Allen (1975) suggests that, although little evidence is available to suggest such a hypothesis, methods intended to structure the material to be learned may facilitate learning in those students deficient in organizational ability, while being of neutral or negative value for those students possessing well-developed structuring skills. It seems reasonable then that the field-dependent student, whose outwardly directed information-processing style develops in response to an internal structuring deficiency, would stand to benefit if the questions alluded to above also served to structure the material by calling attention to logical milestones in the development, in much the same way that an effective system of titles and subtitles serves to provide a formative structuring device in printed materials.

While the present study was being conducted, a similar study was in process at the Wayne State University Medical School. That study (Scott et al., 1981) involved the use of highly structured vs. self-
directed instructional sequences dealing with colorectal cancer. The hypothesis under scrutiny in that study was similar to our own, with the self-directed sequence believed to favor the field-independent students, and the highly structured sequence believed to favor the field-dependents. In addition, an attempt was made to infuse the structured sequence with social value by using some motion pictorial segments showing the doctor interacting with the colorectal cancer patient. The sole measure of f-d/i in that study was the Group Embedded Figures Test. No significant interactions were found. The researchers suggest that the highly charged competitive atmosphere of a medical school may not be the appropriate site for the detection of such interaction effects.

**ATI's in Mathematics Education Research**

Owing to the superior analytic abilities of field-independents, research results indicating that relatively field-independent individuals are likely to show educational or vocational interest in areas requiring analytic skills, such as mathematics or the sciences, should come as no surprise (Chung, 1967; Clar, 1971; Keen, 1974). These results are consistent with the large body of research supporting the hypothesis that field-independence is significantly related to achievement and aptitude in mathematics (Elliott, 1961; Greenfield, 1971; Hunt & Randhawa, 1973; Abelew, 1974). Witkin and his associates (Witkin, Moore, Goodenough, & Cox, 1977) reviewed 27 studies relating performance on the Mathematics Scholastic Aptitude Test to f-d/i. Eleven of the studies used women as subjects and in all 11 studies the
relationship was statistically significant, with an average correlation of 0.44. The remaining 16 studies used men as subjects and in 11 out of 16 the relationship was statistically significant, with the mean of the correlations equal to 0.29.

There is some cause to believe that ATI's involving mathematics learning and f-d/i do exist, though the evidence is far from compelling. Carpenter, McLeod, and Skvarcius (1976) found weak support for the position that f-d/i interacts with level of guidance in mathematics instruction, but no support for the belief that f-d/i may interact with level of abstraction in an instructional unit.

In Holtan's (1982) updated review of ATI research in mathematics, including research involving f-d/i, he concludes that since 1975 there have been more significant interactions than reported prior to that date, although he concludes that there is still insufficient evidence to form a basis for a general theory.

The increment in reported "significance" observed by Holtan may be due, in part, to a heightened consciousness of the need to understand the cognitive processes underlying the aptitude in ATI research. Di Vesta (1975) summarizes the conclusions of Glaser (1972), Koran (1972), and Hunt (1973) regarding such research by suggesting that "the theory underlying TTI research must consider the cognitive processes assumed to be correlated with traits and/or the processes induced by treatments if such research is to be fruitful" (p. 186).

In light of the structuring deficiencies and interpersonal proclivities of the field-dependent as learner, it seemed reasonable that narration centering around a question/answer dialog between a teacher
and a student, with questions designed to structure the material, would prove more beneficial to the field dependent learner than a monolog presentation devoid of explicit interpersonal or structuring mechanisms. This logic led to the design of Experiment I in the present study.

**Match/Mismatch Research**

The research bearing on Experiment I of the present study might be termed "person-thing" research since its basis is the extent to which some structural aspect of the external stimulus field affects the cognitive performance of an individual classified as field dependent or field independent. In designing Experiment II of the present study (the grading experiment), it was necessary to review a strand of f-d/i literature which reports what might be called "person-person" or match/mismatch research. It should be noted that research on teacher/student match-mismatch effects has been very limited. Moreover, reports of such research in the context of actual high school or college courses are almost nonexistent.

One study of students and teachers in a regular classroom setting (DiStefano, 1970) reported that students and teachers of the same cognitive style tended to view each other more positively on both personological and cognitive grounds than students and teachers of different styles. In a study of teachers and students in a small minicourse (one teacher per six students with three of the students field-independent and three field-dependent), James (1973) found that the most extremely field-independent teacher assigned the three highest
grades in the class to the three field-independent students, and the most extremely field-dependent teacher assigned the three highest grades in that class to the three field-dependent students. In may be that the cognitive style match yields a better interpersonal experience, or that the match is in fact accountable for more learning in the student because the mind of the teacher is "in phase" with the mind of the student, or, as Shows (1968) has suggested, it may be that characteristic verbal communication patterns of field-dependents (or field-independents) may facilitate understanding in matched-for-style dyads. Mahlios (1981) suggests that cognitive style alone is not highly associated with interaction patterns. In the DiStefano and James studies, a sex match/mismatch effect was not allowed to occur. (DiStefano used male teachers and students only; James used male teachers and female students only.) However, Witkin, Moore, Goodenough, and Cox (1977) reported that in a match/mismatch study conducted in collaboration with another group of researchers, they observed a sex match/mismatch effect, as measured by teachers' and adolescent students' evaluations on post-course interpersonal attraction questionnaires, but failed to detect any cognitive style match/mismatch effect. In this last study, the most positive evaluations were found in the same-sex dyads. Unfortunately, none of the early studies of the effects of teacher/student cognitive style match/mismatch dealt with mathematics learning.

One well designed match/mismatch study which did involve mathematics, was done by Packer and Bain (1978). These investigators reported positive teacher/student matching effects on objective test
performance, following a 30-40 minute lesson on network tracing. In this study the lesson was taught by college students to college students.

The studies mentioned above raise a number of questions. For example, are matching effects responsible for more efficient cognitive processing on the part of the student and hence conducive to greater learning? Are matching effects responsible for greater interpersonal attraction which in turn motivates the student to invest more time and energy in the learning process? Or, are matching effects responsible for greater interpersonal attraction, which influences, not necessarily the extent of learning, but rather the outcome of evaluations in favor of a student matched to the evaluator's style?

It is this last question upon which Experiment II focuses. The notion that extraneous aspects of a performance are often brought to bear on the evaluations of that performance has been demonstrated in a study by Markam (1976) who found that essays submitted in better handwriting received higher grades than poorly handwritten essays, regardless of the quality of the content. Clifford and Walster (1973) found that physical attractiveness was significantly related to teacher expectations regarding a number of student characteristics, including intelligence. That the interpersonal attraction observed in matched-to-style rater/ratee dyads might mediate a more magnanimous rating response is consistent with the match/mismatch studies cited above.

In addition to certain expectations for match/mismatch effects in grading, there is some evidence supporting an expectation of certain main effects of grader cognitive style on grading outcomes.
In chapter I we built a case, on theoretical grounds, supporting the expectation that the field-dependent grader might accede more readily than the field-independent grader, to the interpersonal pressures of the grading situations. This acquiescence might then manifest itself in different grading patterns for the two sets of graders.

Results in the field of appraisal research suggest that field independents are more accurate and more discriminating in their ratings of others. Results of a study conducted by Gruenfeld and Arbuthnot (1969) support the hypothesis that variability in the ratings of individuals is significantly related to f-d/i as measured by the RFT but not the EFT, with field dependents showing greater variability in rating patterns than field independents. More recently, Cardy and Kehoe (1984) demonstrated that field-independents provided significantly more accurate ratings of others than did field-dependent raters, when those ratings were based on written vignettes describing the "other." The natural question arises then as to whether or not, in addition to possible cognitive style match/mismatch effects in a grading situation, there might also exist main effects favoring the students graded by the field-dependent graders.

Since grading in the calculus course under investigation occurs in a face-to-face student-grader arrangement, the hypothesis that field-dependents are more liberal in their grading behavior becomes quite reasonable when the field-dependent is viewed as an individual unlikely to "interrupt" (Pascuale-Leone, 1974) the irrelevant though commanding influence of the student, whose interpersonal pressure has one purpose: to produce the most favorable grading outcome. Based on
the discussion contrasting the predictive powers of the EFT and RFT, is reasonably to assume that the RFT would act as a better tracer for such rating differences than the EFT. Moreover, the possibility for sex interaction effects to wash out the influence of cognitive style effects should be considered in any analysis of the grading scenario.

**Sex Effects vs. Cognitive Style Effects**

In discussing cognitive style match/mismatch research, we noted that it is sometimes the case that sex match/mismatch effects "wash out" the cognitive style effects. The "washing out" of cognitive style effects by sex effects may not be restricted to person-person situations. There is some support for the position that certain curricular procedures may be differentially effective for males and females, particularly in the area of mathematics instruction. That such sex effects may overshadow expected cognitive style effects should be considered a real possibility.

One argument that certain types of instruction might be more effective for female than male learners stems from a consideration of contrasting characteristics of males and females, not unlike the differences between field-independent and field-dependent learners already discussed. Chodorow (1974) suggests that women possess a "stronger basis for experiencing another's needs or feelings as one's own" (p. 167), and "experience themselves as less differentiated than boys, as more continuous with and related to the external object-worlds, and as differently oriented to their inner object-world as well" (p. 167). It was precisely this lack of differentiation that
Witkin et al. (1962) perceived as responsible for the poorly developed analytic skills and the highly developed social interaction skills of the field-dependent. On this basis, instruction that compensates for analytic deficiencies and involves a social component is expected to be facilitative for the field-dependent learner. However, in the light of Chodorow's comments, it seems not unreasonable that such instruction might be facilitative for the female learner.

A few clarifications are in order. From the cognitive style point of view, the social interaction skills are the result of a pattern of other-directed information-gathering behaviors intended to compensate for certain analytic deficiencies in the field-dependent individual. From the sex-difference perspective, the existence of such social skills may be little more than a developmental artifact. For Witkin, analytic deficiencies are pervasive and irreversible characteristics of field-dependence. However, in women the manifestation of such deficiencies may be the result of constantly repressing the exercise of analytic skills, in conformance to what David McClelland calls "standards of psychological expectation" (1975, p. 81). This suggests that women may benefit from programs designed to awaken these latent abilities, and the research on such intervention programs in mathematics has borne this out (Brody & Fox, 1980; MacDonald, 1980), with the importance of a social component in such programs duly noted (Brady & Fox, 1980). In a study of spatial abilities in male and female calculus students, Mundy (1980) observed that spatial training was more effective for women that men in enhancing spatial visualization abilities. It may be the latency of
such skills in women that accounts for their greater responsiveness to intervention.

**Summary**

An individual's position on the field-dependence/independence continuum has been presented here as an indicator of a cluster of information processing traits. The contrasting profiles of field-dependent vs. field-independent individuals suggest that field-dependents are more likely than field-independents to rely on and be influenced by external sources of information. These profiles suggest several hypotheses regarding

i) the relative effectiveness of various types of instructional treatments for students of the two types (Experiment I), and

ii) patterns of grading related to the cognitive style of the grader, as well as interaction effects of student's and grader's cognitive styles (Experiment II).

The field-dependent as a learner appears to be an individual for whom instructional materials may be more valuable if they incorporate specific structuring mechanisms and involve a socially mediated information gathering component. The field-dependent as a grader appears likely to be influenced by the interpersonal pressure exerted by the student.

In the next chapter we turn our attention to the specific hypotheses of the study and the experimental designs employed to test them.
CHAPTER III

EXPERIMENTAL DESIGN AND METHODOLOGY

Introduction

One strand of research on cognitive styles has been motivated by the desire to identify those characteristics of instruction which appear to be differentially facilitative for individuals of contrasting styles. Prerequisite to the success of such Aptitude Treatment Interaction (ATI) research is the need for delineating behaviors and processes characteristic of individuals of different styles. The theoretical basis for the cognitive profiles of field-dependent vs. field-independent individuals, as applied in the present study, has been explicated in chapter II. Stated briefly, the field-independent is likely to be more adept than the field-dependent at autonomously generating productive templates in situations requiring cognitive restructuring, and in ignoring the influences of salient but non-productive templates. Reflecting a more "other-reliant" approach in gathering and processing information, the field-dependent usually exhibits a well developed set of social interaction skills and an affinity for interpersonally loaded situations. Such characteristics are not so commonly found in field-independents.

The present study will contribute to the existing body of educationally oriented research on field-dependence/independence (f-d/i) by exploring
i) effects of f-d/i, sex, and contrasting types of audiovisual tutorial presentations on achievement in mathematics (Experiment I), and

ii) effects of students' and graders' cognitive styles on calculus test scores (Experiment II).

The effects of sex on cognitive style and mathematics achievement measures also are assessed, as are student/grader sex match/mismatch effects on the calculus test scores.

Environment

The setting for the present study was the first course in a two-semester calculus sequence, Math 425-Math 426, offered at the University of New Hampshire (UNH) during the spring term of academic year 1978-1979. UNH is a state university whose student population is composed of roughly 1000 graduate students and 9300 undergraduates, with approximately 60% of the undergraduates reporting New Hampshire as their state of permanent residence. During the 1978-1979 academic year, UNH granted 196 Associate's, 2006 Bachelor's, 341 Master's, and 31 Doctoral degrees.

Usually, freshmen intending to take the two-semester calculus sequence, Math 425-Math 426, complete Math 425 in the fall semester and Math 426 in the spring semester. Reflecting this practice, Math 425 enrollment in the fall semester normally runs between 1100 and 1200 students, while the spring offering of Math 425 usually has an enrollment of 200 to 300 students.
Math 425 is configured so as to incorporate many of the characteristics of Keller's system of personalized instruction (Keller & Sherman, 1974). Formal presentation of course material is accomplished through large lectures delivered in one-hour classes three times per week. In addition, each student is assigned to a two-hour testing period each week. At the time when the present study was being conducted, the course content was subdivided into four units, and a student's grade for the course was based solely on four unit test scores.

Consistent with the mastery learning approach, students may take up to three "trys" on each unit test, with the score on the final try (whether it be the first, second, or third try) standing as the score for the unit. However, each student is required to report to the testing center for a "first-try" on each unit's material at his or her assigned time during the week designated as "first-try week" for the unit. The student can then elect to return at his/her assigned time on either or both of the two subsequent weeks for repeat testings on parallel forms of the same unit test. Obviously, only two repeat testings are available for each unit in the course. For the semester under investigation, "first-tries" occurred on weeks 4, 7, 10, and 13 of the semester for units I, II, III, and IV respectively. Weeks 1 and 2 of the semester were reserved for pretesting.

The text for the course was Calculus with Analytic Geometry (Swokowski, 1975), and content for the course was organized as follows:
Unit 1  Computing limits; computing derivatives of polynomial and rational functions and functions involving radicals; using the product, quotient, and chain rules; implicit differentiation; higher derivatives; equations of tangent lines.

Unit 2  Graphing conic sections; first and second derivative tests; asymptotic behavior; max-min problems; related rates problems.

Unit 3  Antiderivatives; definite and indefinite integrals of polynomial functions and functions involving radicals; computing areas of regions bounded by polynomial functions; computing volumes of solids of revolution using polynomial functions; arc length; applied work and fluid pressure problems.

Unit 4  Exponential, logarithmic, and trigonometric functions: differentiation, integration, curve sketching, max-min problems, related rates problems, areas by integration, solids of revolution.

Informal calculus help sessions are conducted by mathematics graduate students in a tutorial room which is open 30 hours per week. Students generally come to this room to have their calculus questions answered by the graduate students, and frequently find that their discussions involve other students.

No calculus homework is collected as part of the course requirements, though problems are assigned as preparation for the unit tests.

At the beginning of the course, a test of algebra and trigonometry knowledge is administered to all students. This test will be referred to hereafter as the pretest. For each student the pretest score is used to determine whether or not a formal review of certain precalculus skills is to be included as one of the calculus course requirements. Should such a review be deemed necessary, the student is directed to the Mathematics Center (MaC), where an appropriate program of review is outlined for the student. Such remedial programs utilize individualized audio and audio-visual tutorial materials developed in modular form, and usually require that the student visit MaC for several
one-hour sessions and work on homework problems between sessions. At the time when the present study was conducted, students were required to complete any required remedial work prior to their first attempt of the unit IV test (week 13 of a 15-week semester).

As mentioned earlier, all testing for the calculus course is conducted in a testing center. Moreover, each calculus test is graded immediately after the student finishes, in a grading room next door to the testing center. The graders are advanced undergraduates, mostly students in the College of Engineering and Physical Sciences, the college in which the Mathematics Department is housed. After finishing a unit test, the student is assigned to the next available grader, who then proceeds to grade the exam in the presence of the student. Each unit test contains five problems, and there are 26 parallel versions of each problem. The tests are assembled in a random fashion to produce a sufficient number of variations to accommodate a large number of students in the mastery testing environment. A grading manual provides the graders with guidelines for the allocation of points. (Each problem requires a free-response solution, thus grading invariably involves some grader judgment.)

**Experiment I: Remedial Instruction**

The first experiment in the present study was designed to explore possible main and interaction effects of cognitive style, sex, and type of remedial presentation on measures of trigonometry achievement and calculus achievement following intervention. Based on the prevailing theoretical framework, explicated in chapter II, the
expectation was that the posttreatment performance of field-dependent learners would be enhanced by the interpersonally rich and (subtly) structured environment created by the Dialogs. On the other hand, the field-independent learner might be expected to perform optimally under the more direct Monolog condition. Moreover, the analyses employed in investigating these hypotheses should allow for the possibility of sex differences, and also for the possibility that a disembedding measure of f-d/i (such as the EFT) might produce a different pattern of effects from that produced by an orientation measure of f-d/i (such as the RFT).

**Subjects**

Subjects involved in Experiment I were those students in the first semester calculus course offered at UNH in spring 1979, who failed to receive a score of 7 or better on the 16-item trigonometry subtest of the pretest. (The pretest will be described in greater detail in the discussion of instrumentation for Experiment I.)

Prior to random assignment of subjects to treatment groups, some steps were taken to determine precisely who was and who was not intending to take the course. Of the 230 students listed on the initial course roster, 36 students either failed to take the pretest (administered during the first and second weeks of classes) or failed to take the required first attempt of the calculus unit I test (administered during the fourth week of classes). When an attempt was made to contact these students individually in the hope of ascertaining their status in this course, either they replied that they were
dropping the course, or it was determined that they had failed to return to campus after the previous semester. Scores on the trigonometry subtest of the pretest were then used to determine who, of the remaining 194 "active" students, would require remediation. (Remediation was aimed solely at trigonometry deficiencies for the purposes of the present study.) Forty-five students received a score of 7 or better on the trigonometry portion of the pretest, and were subsequently informed that no remediation would be required. The remaining 149 students were informed that they would be required to participate in a remedial program offered in MaC, as part of their calculus course requirements. These 149 students were randomly assigned to six experimental groups, designed to accommodate pretested and unpretested levels of three experimental conditions. Shortly after assignment, four students were excused from the MaC remedial sessions (one for medical reasons, one due to involvement in a child custody suit, one due to family commitments, and one for employment reasons). The data for these four students have been eliminated from all analyses. In addition, five students who added the course late were pretested and all five required remediation. These five students were then randomly assigned to the existing treatment groups. Therefore there was a total of 195 students actively enrolled in the course and fulfilling all its requirements, with 150 of these students required to take remediation, and thus serving as subjects for Experiment I. Age data were available for 122 of these 150 subjects. Ages as of January 1979 are given in Figure 5.
Figure 5. Age data for subjects in Experiment I.

Class and college data were available for all 150 subjects. These data are shown in Figures 6 and 7 respectively.

Figure 6. Class data for subjects in Experiment I.
As was mentioned earlier, the calculus course providing the environment for the present study was offered during the spring semester, and had a total enrollment of roughly 200 students. During the fall semester the same course has a total enrollment of roughly 1100-1200 students. In addition to the obvious difference in enrollment figures between the fall and spring offerings of Math 425, there appear to be differences in the characteristics of the enrollees as well.

A comparison of student characteristics in the present study with student characteristics in a study focusing on the Math 425 course offered in the fall semester of academic year 1979-1980 (Mundy, 1980), reveals several differences. Forty-five percent of the spring enrollees were 17 or 18 years old, while 88% of the fall enrollees fall in that age bracket; 28% of the spring enrollees were between 20 and 30 years of age, while only 6% of the fall enrollees were in that
bracket. Agewise, the spring enrollees are far less homogeneous than the fall enrollees.

As far as class data are concerned, 75% of the spring enrollees were Freshmen vs. 90% of the fall enrollees, while 14% of the spring enrollees were Sophomores vs. 6% of the fall enrollees. Again, the tendency is for the spring students to represent a somewhat more heterogeneous mix when compared with the fall students who are overwhelmingly Freshmen.

College-wise, notable differences between the two Math 425 groups were as follows: for the spring group, 19% came from the College of Engineering and Physical Sciences (CEPS), 30% from the College of Liberal Arts (LA), and 29% from the College of Life Science and Agriculture (LSA); for the fall group 43% came from CEPS, 26% from LA, and 16% from LSA. It is clear that the fall group contains a much higher concentration of students from Engineering and Physical Sciences than the spring group.

Design: Experiment I

The three experimental conditions were as follows: (1) a remedial program in trigonometry consisting of five one-hour sessions employing audio-visual (slide/tape) presentations in teacher-student dialog form; (2) a remedial program in trigonometry consisting of five one-hour sessions employing audio-visual (slide/tape) presentations in teacher-only monolog form; (3) a control condition consisting of five one-hour sessions in which no trigonometry remediation was offered, but in which topics in analytic geometry and algebra were reviewed in audio-tutorial (monolog) form.
The topics covered in each of the five sessions of the dialog and monolog treatment conditions were as follows:

Session 1  Right triangles; unit circle; the definition of degree and radian measurement.

Session 2  Conversion between degree and radian measurement; trigonometric function values of 0, π/6, π/4, π/3, π/2, and angles having those as reference angles.

Session 3  Simple identities; domains, ranges, and periodicity of the trigonometric functions; algebra of trigonometric expressions; graphs of the trigonometric functions and their transformations.

Session 4  Sum and difference formulas; half- and double angle identities; proving identities; trigonometric equations.

Session 5  Inverse functions; evaluating and graphing the inverse trigonometric functions.

For each of the five sessions there were pre- and postsession quizzes covering the topic in trigonometry treated in that session.

To accommodate the two treatment conditions and a control condition, a modified Solomon four-group design (Campbell & Stanley, 1966, p. 24) was used. Experimental groups II, IV, and VI did not receive the presession quizzes, but received the same experimental treatments, respectively, as pretested groups I, III, and V. The intent of this design is to allow control for possible practice effects and presession quiz x treatment interaction effects on the postsession quizzes.

The number of subjects in each of the six experimental groups is shown in Table 1, with breakdowns by sex.
Table 1

Numbers of Subjects by Experimental Group and by Sex

<table>
<thead>
<tr>
<th>Experimental Group</th>
<th>n</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (dialog; pretested)</td>
<td>25</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>II (dialog; unpretested)</td>
<td>25</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>III (monolog; pretested)</td>
<td>26</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>IV (monolog; unpretested)</td>
<td>26</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>V (control; pretested)</td>
<td>23</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>VI (control; unpretested)</td>
<td>25</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>150</td>
<td>100</td>
<td>50</td>
</tr>
</tbody>
</table>

As mentioned earlier, all students received the algebra/trigonometry pretest by the end of the second week of classes. In addition, two measures of f-d/i, the Group Embedded Figures Test (GEFT; Witkin, Oltman, Raskin, & Karp, 1971) and the Miniaturized Rod and Frame Test (MRFT; Mansueto & Adevai, 1967), were administered to all students enrolled in the calculus course. A parallel version of the trigonometry subtest of the pretest was used as a measure of trigonometry achievement after the five-session program in the Mathematics Center was completed. Scores on the unit IV calculus test, a test requiring the knowledge and application of trigonometry, were used to measure the transfer of knowledge to the calculus setting. (All measures will be considered at length in the discussion of instrumentation for Experiment I.)

The experimental design for Experiment I is summarized in Table 2.
### Table 2

#### Experimental Design: Experiment I

<table>
<thead>
<tr>
<th>Treatment Groups</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra/Trigonometry Pretest</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Group Embedded Figures Test (GEFT)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Miniaturized Rod and Frame Test (MRFT)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Treatment&lt;sup&gt;a&lt;/sup&gt;</td>
<td>DIA</td>
<td>DIA</td>
<td>MONO</td>
<td>MONO</td>
<td>CTRL</td>
<td>CTRL</td>
</tr>
<tr>
<td>Presession Quizzes</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Postsession Quizzes</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Remedial Program Trigonometry Posttest</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Unit IV Calculus Test</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**Note.** "+" indicates that the measure was administered; "-" indicates that it was not.

<sup>a</sup>"DIA" indicates that remedial treatments were in dialog form; "MONO" indicates that remedial treatments were in monolog form; "CTRL" indicates the control condition.

#### Procedure: Experiment I

All students enrolled in the calculus I course were given the Algebra/Trigonometry pretest by the second week of the course. Based on performance on the trigonometry subtest of this pretest, 150 of the 195 students actively enrolled in the course were informed that remediation would be required, and that this requirement would necessitate five visits to MaC. Moreover, they were warned that failure to complete the remedial program would prohibit their taking the unit IV calculus test. These 150 remedial students acted as subjects in Experiment I.
At the same time the test of precalculus knowledge was administered, the Group Embedded Figures Test was also administered to all students in the course.

Subjects were randomly assigned to the six treatment groups, and given appointment schedules for visiting MaC at the pace of one visit per week. During a given session, subjects in the two dialog and two monolog treatment groups were given the appropriate treatment together with pre- and/or postquizzes, and were then given a sheet of suggested homework problems as they left MaC. Subjects in the two control groups received no trigonometry remediation in MaC, but as they left each session they were given written trigonometry review pamphlets paralleling the in-lab remediation, and also were given the sheet of homework problems. Neither control nor non-control subjects were assessed a penalty for failure to submit homework. In cases where homework was submitted at a given session, it was graded and returned to the student at the end of the session.

Pre- and posttesting the topic of an individual remedial session was accomplished according to the schedule indicated in Table 2. Posttesting the entire remedial program was accomplished after each student's fifth visit. Students were informed that there was no "penalty" associated with performance on the program posttest. The unit IV calculus test, as a measure of transfer, was administered, as all calculus tests, in the Testing Center, during the 13th-15th weeks of the semester.

The Miniaturized Rod and Frame Test was administered individually to all students in the calculus course during the first three weeks of
treatment. Since each administration took roughly 20 minutes, and since the investigator was the sole administrator of the test, a more curtailed schedule for MRFT administration was impossible.

Instrumentation: Experiment I

Algebra/Trigonometry Pretest

Since the Fall semester of academic year 1978-1979, all students taking calculus I at UNH have been required to take the same pretest that was used in the study being reported here. The test consists of 41 multiple choice items, gleaned from two separate measures published by the Mathematical Association of America (1977). The test used at UNH is a composite of the MAA's 25-item Mathematics Test AA/1 (Advanced Algebra), and the 16 trigonometry items from the 32-item Mathematics Test T/2 (Trigonometry and Elementary Functions). Table 3 presents descriptive statistics by college for the entire 41-item pretest, the 25-item algebra subtest, and the 16-item trigonometry subtest for the entire Spring 1979 calculus I class. A reliability coefficient of .64 was estimated for the entire test, based on the entire class, using the Kuder-Richardson technique (Popham, 1975), with reliability for the algebra subtest and trigonometry subtest estimated to be .62 and .54 respectively by the same technique. Descriptive statistics for the entire pretest and the two subtests are given by college for all remedial students in Table 4, and for all nonremedial students in Table 5. Finally, descriptive statistics for the pretest and the two subtests are given by remedial status and by sex in Table 6. All descriptive statistics reported in this chapter were determined via
statistical programs in SPSS (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975).
### Table 3

Descriptive Statistics for Pretest by College, Entire Calculus I Class, Semester II, 1978-1979

<table>
<thead>
<tr>
<th>College</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering and Physical Sciences</td>
<td>37</td>
<td>19.432</td>
<td>4.805</td>
<td>14.405</td>
<td>3.869</td>
<td>5.027</td>
<td>2.609</td>
</tr>
<tr>
<td>Liberal Arts</td>
<td>60</td>
<td>19.083</td>
<td>4.670</td>
<td>14.783</td>
<td>3.420</td>
<td>4.300</td>
<td>2.657</td>
</tr>
</tbody>
</table>
| Thompson School                       | 1  | 13.000|-     | 10.000|-     | 3.000 |-
| Division of Continuing Education      | 11 | 17.182| 5.845| 13.455| 3.698| 3.727 | 3.797|
| **Entire Class**                      | 195| 19.118| 5.241| 14.585| 3.893| 4.533 | 2.569|
Table 4

Descriptive Statistics for Pretest, by College, for Remedial Students in the Calculus I Class, Semester II, 1978-1979

<table>
<thead>
<tr>
<th>College</th>
<th>n</th>
<th>Entire Test</th>
<th>Algebra Subtest</th>
<th>Trigonometry Subtest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Engineering and Physical Sciences</td>
<td>25</td>
<td>18.800</td>
<td>5.385</td>
<td>15.120</td>
</tr>
<tr>
<td>Health Studies</td>
<td>7</td>
<td>18.857</td>
<td>3.671</td>
<td>15.000</td>
</tr>
<tr>
<td>Whittemore School of Business and Economics</td>
<td>20</td>
<td>17.950</td>
<td>4.696</td>
<td>13.950</td>
</tr>
<tr>
<td>Thompson School</td>
<td>1</td>
<td>13.000</td>
<td>-</td>
<td>10.000</td>
</tr>
<tr>
<td>Division of Continuing Education</td>
<td>10</td>
<td>16.100</td>
<td>4.864</td>
<td>12.900</td>
</tr>
<tr>
<td>All Remedial Students</td>
<td>150</td>
<td>17.593</td>
<td>4.483</td>
<td>14.087</td>
</tr>
<tr>
<td>College</td>
<td>n</td>
<td>Entire Test M</td>
<td>SD</td>
<td>Algebra Subtest M</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>----</td>
<td>---------------</td>
<td>----</td>
<td>-------------------</td>
</tr>
<tr>
<td>Engineering and Physical Sciences</td>
<td>12</td>
<td>20.750</td>
<td>3.079</td>
<td>12.917</td>
</tr>
<tr>
<td>Life Sciences &amp; Agriculture</td>
<td>15</td>
<td>25.733</td>
<td>3.770</td>
<td>17.933</td>
</tr>
<tr>
<td>Health Studies</td>
<td>2</td>
<td>27.500</td>
<td>2.121</td>
<td>20.000</td>
</tr>
<tr>
<td>Whittemore School of Business and Economics</td>
<td>1</td>
<td>29.000</td>
<td>-</td>
<td>19.000</td>
</tr>
<tr>
<td>Thompson School</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Division of Continuing Education</td>
<td>1</td>
<td>28.000</td>
<td>-</td>
<td>19.000</td>
</tr>
<tr>
<td>All Nonremedial Students</td>
<td>45</td>
<td>24.200</td>
<td>4.326</td>
<td>16.244</td>
</tr>
</tbody>
</table>
Table 6

Descriptive Statistics for Pretest by Remedial Status and by Sex, Calculus I Class, Semester II, 1978-79

<table>
<thead>
<tr>
<th></th>
<th>Entire Test</th>
<th>Algebra Subtest</th>
<th>Trigonometry Subtest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Entire Class</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>73</td>
<td>20.123</td>
<td>5.525</td>
</tr>
<tr>
<td>Remedial Students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>100</td>
<td>17.480</td>
<td>4.613</td>
</tr>
<tr>
<td>Nonremedial Students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>23</td>
<td>25.130</td>
<td>4.635</td>
</tr>
<tr>
<td>Men</td>
<td>22</td>
<td>23.227</td>
<td>3.841</td>
</tr>
</tbody>
</table>

Measures of Field-dependence/independence

(1) Group Embedded Figures Test (GEFT)

The Group Embedded Figures Test (Oltman et al., 1971) was designed as a group-administrable alternative to the individually administered Embedded Figures Test (EFT; Witkin, 1950b). In this test, the subject is given a test booklet containing 18 embedded figure tasks. For each task, the subject views a complex figure wherein a simple figure lies embedded. The object of the task is to locate the simple figure and then outline it. The simple figures are displayed on the last page of the test booklet and hence cannot be
viewed simultaneously with the complex figure. An item similar to those used in the GEFT has been given in Figure 3 (chapter I).

The GEFT is composed of three sections. The first section contains seven very simple items and is used exclusively for practice purposes. The Second and Third Sections each contain nine items of greater difficulty, and form the basis on which a score is determined for each subject. Of the 18 complex figures that are used in the Second and Third Sections, 17 were taken directly from the individually administered EFT. Witkin, Oltman, Raskin, & Karp (1971) report product-moment correlation coefficients of -.82 and -.63 for performance on EFT vs. GEFT for male and female undergraduates respectively. (Correlations are negative since the measures are scored in the opposite directions.) They also report a reliability estimate of .82 for both males and females on the GEFT. The KR21 reliability coefficient for the GEFT based on the present sample was also .82.

(2) Miniaturized Rod and Frame Test (MRFT)

The Miniaturized Rod and Frame Test was developed by Mansueto and Adevai (1967) as an alternative to the costly Portable Rod and Frame Test (PRFT; Oltman, 1968). Moreover, the developers of the MRFT report that the PRFT is "not directly comparable to the standard Rod and Frame Test (RFT) since the PRFT limits rod and frame adjustments to a maximum of 20° from the vertical, while the standard rod and frame apparatus (and the MRFT as well) utilizes 28° tilts" (Mansueto & Adevai, 1967, p. 207).
The MRFT is a box-like structure 2 ft. long, 14 in by 14 in at the subject end and 18 in by 18 in at the experimenter end, as shown in Figure 8. The MRFT apparatus used in this experiment was built by the investigator according to the specifications provided by Mansueto and Adevai (1967).

![Figure 8. Three views of the MRFT. (Mansueto & Adevai, 1967, p. 208)](image)

In the MRFT, the subject is permitted to view the inside of the box, wherein the only objects visible are a luminescent frame (12 in by 12 in) and within it a thin luminescent rod (10.75 in), placed at the opposite (experimenter) end of the box. Before each of eight trials, rod and frame are set by the experimenter: two sets of all combinations of frame 28° to right or left of vertical and rod 28° to the right or left of vertical. The task for the subject is to reorient the rod so that it represents true vertical, thus overcoming the confounding influence of the surrounding frame. The sum of the deviations (in degrees) of "subjective vertical" from "true vertical" over the eight trials is taken as the subject's score on this measure.
Mansueto and Adevai (1967) report a rank correlation of scores on the standard rod and frame test (RFT) and the MRFT equal to .97 (p < .01).

Descriptive statistics for the GEFT and MRFT are given by remedial status and by sex in Table 7.

Table 7
Descriptive Statistics for the GEFT and MRFT by Remedial Status and by Sex, Calculus I Class, Semester II, 1978-79

<table>
<thead>
<tr>
<th></th>
<th>GEFT</th>
<th>MRFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>Entire Class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>73</td>
<td>13.411</td>
</tr>
<tr>
<td>Men</td>
<td>122</td>
<td>13.689</td>
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<tr>
<td>All Students</td>
<td>195</td>
<td>13.585</td>
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<tr>
<td>Remedial Students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>50</td>
<td>12.520</td>
</tr>
<tr>
<td>Men</td>
<td>100</td>
<td>13.560</td>
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<tr>
<td>All Remedial Students</td>
<td>150</td>
<td>13.213</td>
</tr>
<tr>
<td>Nonremedial Students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>23</td>
<td>15.348</td>
</tr>
<tr>
<td>All Nonremedial Students</td>
<td>45</td>
<td>14.822</td>
</tr>
</tbody>
</table>
Session Pre- and Postquizzes

For the purpose of measuring specific knowledge gains in the course of the five treatment sessions, five pairs of pre- and post-session quizzes were developed by the experimenter. Each of the ten quizzes contained ten free-response items, and all quizzes were graded by the same individual. No partial credit was allowed for any of the 100 items used on the quizzes. Students were given a maximum of ten minutes to complete each quiz. Questions used on each presession/postsession quiz closely followed the material presented in the associated remedial session. (Content for the various remedial sessions was outlined earlier in this chapter.)

For the analyses to be carried out in the present study, the five presession quiz scores were added together and the five postsession quiz scores were added together, thus yielding two summary measures, which will be referred to as PREQ and POSTQ. Kuder-Richardson 21 (KR21) reliability estimates (Popham, 1975) for PREQ and POSTQ were .79 and .92 respectively, based on the present sample. Copies of the session pre- and postquizzes are given in appendix B.

Trigonometry Posttest

As a post-program test of trigonometry knowledge, the 16 trigonometry items from the 41-item multiple choice Mathematics Test T/2b (Trigonometry and Elementary Functions), developed by the Mathematical Association of America (1977) were used. The test T/2b is published as alternate form of test T/2 which was used as a source for the trigonometry items on the Algebra/Trigonometry pretest described
earlier. A KR<sub>21</sub> reliability coefficient of .16 was estimated for this posttest measure, using the present sample. Because of the poor reliability of this measure, it has been dropped from all analyses.

Calculus Unit IV Test

Each student's score on the calculus unit IV test was used as measure of transfer of trigonometry knowledge to the calculus setting. The test contained five free-response problems covering the topics presented in unit IV, described earlier in this chapter.

Descriptive statistics for the calculus unit IV test are given by remedial status and by sex in Table 8.
Table 8

Descriptive Statistics for the Calculus Unit IV Test by Remedial Status and by Sex, Calculus I Class, Semester II 1978-1979

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Entire Class</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>69</td>
<td>69.623</td>
<td>19.746</td>
</tr>
<tr>
<td>Men</td>
<td>113</td>
<td>66.363</td>
<td>22.533</td>
</tr>
<tr>
<td>All Students</td>
<td>182</td>
<td>67.599</td>
<td>21.521</td>
</tr>
<tr>
<td><strong>Remedial Students</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>46</td>
<td>66.043</td>
<td>20.602</td>
</tr>
<tr>
<td>Men</td>
<td>93</td>
<td>65.183</td>
<td>21.572</td>
</tr>
<tr>
<td>All Remedial Students</td>
<td>139</td>
<td>65.468</td>
<td>21.185</td>
</tr>
<tr>
<td><strong>Nonremedial Students</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>23</td>
<td>76.783</td>
<td>16.020</td>
</tr>
<tr>
<td>Men</td>
<td>20</td>
<td>71.850</td>
<td>26.478</td>
</tr>
<tr>
<td>All Nonremedial Students</td>
<td>43</td>
<td>74.488</td>
<td>21.396</td>
</tr>
</tbody>
</table>

aThirteen students dropped from the course before week 13 of the semester.

Treatment Materials: Experiment 1

Overview

Subjects in treatment groups I and II experienced five audiovisual (slide/tape) presentations, developed by the experimenter, and designed in such a manner so as to incorporate interpersonal and subtle knowledge-structural components believed to be appealing and
facilitative to the field-dependent learner. These presentations took the form of a conversation between a teacher and student during an office visit. They will be referred to hereafter as the Dialogs.

Subjects in treatment groups III and IV experienced five audiovisual (slide/tape) presentations, some of which had been developed for a previous study. These presentations involved a single voice in the audio component and employ a traditional didactic approach in their manner of presentation. These presentations will be referred to throughout the discussion as the Monologs. Both the Dialogs and Monologs made use of the same visuals.

Subjects in treatment groups V and VI served as controls. They experienced five sessions reviewing various aspects of Analytic Geometry and Algebra in a format incorporating audio tapes and written materials. They received written versions of the trigonometry remedial materials following each session, and were encouraged to work on these at home.

Development

During the spring term of academic year 1977-1978, the year prior to the year in which the study was done, the investigator administered the GEFST to students enrolled in his Elementary Functions (primarily trigonometry) course, and identified each student as field-dependent or field-independent. Students were frequently encouraged to visit the instructor's office for individual help with the course material and problem sets. By means of these personal interviews with the students, coupled with the knowledge of their cognitive styles, the
investigator gained some useful insights into the types of probes, initiated by both student and instructor, which seemed most congenial to the field-dependent's learning style. These informal conversations revealed that field-dependent students tend to initiate clarification probes more often than field-independent students - very often in a form such as, "What do these symbols mean in plain English?" Also popular with field-dependent students were student-initiated relational probes, requesting the instructor to relate one concept to another, and, what the investigator calls, "oversimplification" probes, in which the student would "test out" on the instructor some hypothesis embodying an oversimplified version of a concept. These observations were quite useful in designing the Dialogs used in the present study. For instance, attempts to incorporate clarification probes can be seen in EXAMPLES 1, 5, 6, 7, and 8 below, a relational probe is evident in EXAMPLE 3, as is an oversimplification probe in EXAMPLE 4.

In summary, the Dialogs were developed in such a way as to maintain the same sequencing and depth of topic coverage which characterized the Monologs. What differentiated the presentations in the Dialogs from those in the Monologs were

1) a teacher-student interaction model in the Dialogs vs. a teacher-only lecture model in the Monologs, and

2) the use of probes in the Dialogs as means of calling attention to structure in the material vs. the non-use of such mechanisms in the Monologs.
Examples

The following eight EXAMPLES present transcriptions from the Dialogs and Monologs in support of the validity of the claims made in the previous section.

EXAMPLE 1 (Introduction to the first session)

Dialog

Teacher  Hi Joan. What seems to be the problem?
Student  Well, I'm in this calculus course and I've forgotten all the trig I ever knew - and that wasn't very much to start with!

Teacher  OK. Have a seat. Probably the best way to start reviewing trig is to take a quick look at the Pythagorean Theorem.
(Slide shows a bust of Pythagoras.) Oh, that's Pythagoras - that's not the theorem. He was quite a guy. He lived in the 6th century B.C. He was a scientist, statesman, and people thought of him as, well, sort of a mystic. (Slide advances to show the Pythagorean theorem.) At any rate, here's the Pythagorean Theorem. (Slide shows \( a^2 + b^2 = c^2 \), and a triangle.)

Student  OK, tell me in words what it means.

Teacher  It says that in a right triangle, the square of the hypotenuse is equal to the sum of the squares of the other two sides.

Student  OK. Can you tell me if I've got it? The square of the hypotenuse equals... the sum... of the square of the other two sides. Does this work only in right triangles?

Teacher  Yes, and recall that we use the word hypotenuse to mean the side opposite a 90° angle in a triangle. So no 90° angle, no hypotenuse,...

Student  ... and no Pythagorean Theorem!

Teacher  Right! So what do you think we use the theorem for?
Student Well, I guess if you know the two shorter sides of a right triangle... what do you call them?...

Teacher Legs.

Student ... yea, if you know the lengths of the legs, then you can find the hypotenuse.

Teacher OK. Actually, with just a little algebra we can use this formula to find the length of any side of a right triangle, provided we know the other two sides. Can you try a problem? (Slide shows a triangle.) See if you can find the length of side b in this triangle.

Monolog

Certain geometric ideas are vital in the study of trigonometry, so we begin there. There is a fact about right triangles which is named for the Greek mystic, scientist, and aristocratic statesman, Pythagoras, who lived from about 580 to 500 B.C. It is called the Pythagorean Theorem and it asserts that the sum of the squares of the legs of a right triangle equals the square of the hypotenuse. Remember that the hypotenuse of a right triangle is the side opposite the 90° angle, in other words, the longest side.

In symbols, the Pythagorean theorem can be written in the following ways. If we denote the hypotenuse of the right triangle by the letter c, and call the two legs a and b, then \(a^2 + b^2\) must be equal to \(c^2\).

Knowing this theorem enables us to find the length of the third side of any right triangle if we know the lengths of the other two sides. You may wish to make a note of this fact.

Let's use the Pythagorean Theorem to solve a problem. Find the length of side b in the triangle pictured.

EXAMPLE 2 (Later in the first session)

Dialog

Teacher You know, since we're on the subject of right triangles, we should take a look at some special triangles and the relations that exist among the sides and the hypotenuse in these triangles.

For instance, in a right triangle where the 2 acute angles measure...
Student  Whoa! What's an acute angle?

Teacher  Oh sorry. An acute angle is one that measures less than 90°. So in a right triangle we have 2 acute angles and one right angle, OK?

Student  Yep!

Teacher  Well, in a right triangle in which the 2 acute angles measure 30 degrees and 60 degrees, the side opposite the 30-degree angles will always measure one-half the length of the hypotenuse.

Monolog

Another fact to be remembered concerns a right triangle in which the two acute angle measure 60 degrees and 30 degrees. In such a triangle, the side opposite the 30 degree angle measure half the hypotenuse.

EXAMPLE 3  (Connecting the notions of special triangles and unit circles)

Dialog

Teacher  Any questions?

Student  Just one. What does this stuff about right triangles have to do with trig?

Teacher  I guess to answer your question honestly I should first tell you a little about the unit circle.

(Dialog of unit circle takes place.)

Teacher  OK. I think you've got yourself a method to handle those kinds of problems (arcs in unit circles). Now we'll look at a problem where you've got to use the stuff about special triangles.

Monolog

Now let us investigate some properties of circles and then combine that information with the facts we've learned about triangles. (Discussion of unit circle takes place.)

Now it is time to combine some of the geometric concepts introduced at the beginning of this unit with measurements on the unit circle.
EXAMPLE 4 (Discussing angle measurement in the second session)

Dialog

Teacher ... and finally 780° takes us around twice in the counterclockwise direction and then 60° more counterclockwise into the first quadrant.

Student So 780° and 60° are the same angle?

Teacher No, not the same angle, but they have the same terminal side, and sometimes that's all we're interested in.

Student Oh, OK. You know, my calculator has two functions on it, and it also have two different ways of describing an angle; one of them is in degrees, what's the other one called?

Teacher Radians.

Student Right. What's "radians" all about?

Teacher Although we didn't say so, actually we were using radian measure when we were talking about angles subtending or cutting arcs.

Monolog

The 780 degree angle is shown here. Its terminal side is the first quadrant. Now we turn to the subject of radian measure. Although it was not emphasized at the time, you were actually using radian measure in the preceding unit.

EXAMPLE 5 (Recapitulating a method - just practiced - for determining the trig function values of an angle)

Dialog

Teacher OK. Let's pretend I meet you on a bus, and I sit down next to you and ask you how I can find the trig functions of a certain angle t. What would you tell me?

Student I'd tell you to buzz off.

Teacher OK, let's suppose on a test you were asked the same question. What would you reply?

Student First draw the angle t in standard position on the unit circle, then find the coordinates of P, and finally apply the definitions using the coordinates of P?
Teacher And what's P?

Student The point where the terminal side of the angle hits the unit circle.

Monolog

Now we'll review the procedure once more: first, draw the angle in standard position in the unit circle; second, find the coordinates of point P; third, apply the definitions using the coordinates of P.

EXAMPLE 6 (Solving simple trigonometric identities)

Dialog

Teacher Try to simplify the trig expression (tan t) (cos t)...
What do you get?

Student Nothing yet. I guess I don't understand what you mean by "simplify."

Teacher Well, if we work it out, maybe you'll understand. Do you know of another way of writing tan t?

Student Yeah, tan t is the same as sin t/cos t, isn't it?

Teacher: Right. So if we replace tan t with sin t/cos t we have sin t/cos t times cos t.

Student Oh, I see. So the cos t's cancel out, and we're left with sin t.

Monolog

Simplify the trigonometric expression: (tan t) (cos t). You can replace tan t with sin t divided by cos t, and then the cos t's cancel to yield sin t.

EXAMPLE 7 (Working with sum and difference formulas)

Dialog

Teacher Let's look at the problem: sin(θ+2π). See if you can use one of the sine identities to simplify it.

Student I think I can just use the formula for the sine of a sum, right?
\[
\sin(\theta + 2\pi) = \sin\theta \cos 2\pi + \cos\theta \sin 2\pi \\
= \sin\theta \cdot 1 + \cos\theta \cdot 0 \\
= \sin\theta
\]

Teacher  Now what does this say: \(\sin(\theta+2\pi)\) equals \(\sin\theta\)?

Student  What do you mean? It says what you just said.

Teacher  No, I mean \textit{in words}, what does this tell you about the \(\sin\) function?

Student  OH - PERIOD! The period is \(2\pi\) since the \(\sin\) of an angle \(\theta\) is equal to the \(\sin\) of the same angle plus \(2\pi\).

Teacher  Right. Well, almost right but we won't split hairs yet.

\textbf{Monolog}

As an example of the use of the \(\sin\) identity, we calculate \(\sin(\theta+2\pi)\). By the formula, we find that \(\sin(\theta+2\pi)\) equals \(\sin\theta\). This result of course verifies that the functional values for the \(\sin\) function repeat themselves at intervals of \(2\pi\).

\textbf{EXAMPLE 8} (Writing the inverse of a one-to-one function)

\textbf{Dialog}

Teacher  Let's take a look at one... function, and show a method for finding its inverse. Consider the function described by the formula \(y = 3x+1\).

Student  That would graph as a straight line, wouldn't it?

Teacher  Yes. Now to get a formula for the inverse of the function, we first replace \(x\) with \(y\) and \(y\) with \(x\). Remember, this is exactly what we did earlier: we interchanged the \(x\) and \(y\) values in each ordered pair in the function. Here, interchanging the variables \(x\) and \(y\) in the formula for the function has exactly the same effect.

Next we solve for \(y\) to get a description of the new inverse function in terms of \(x\), since this is the way we like to describe functions. Got it?

Student  Let's see if I've got it. I start with the given rules, then I interchange \(x\) and \(y\) in the rule, and then I solve for \(y\) in terms of \(x\).
Monolog

Here is an example of a function $y = 3x+1$. If a function $f$ has no two ordered pairs with the same second element, then the inverse of $f$ will also be a function. The rule for obtaining the inverse of a function is to replace $x$ with $y$ and $y$ with $x$ everywhere they occur in the function. Generally, after the replacement has taken place, the statement is solved for $y$.

Experiment II: Grading

The second experiment of the present study involved the investigation of possible main and interaction effects of student and grader cognitive style and sex on the student's calculus test grade. In the light of our theoretically-based expectations, outlined in chapter II, the nature of the face-to-face grading process employed in the calculus course suggested that grading outcomes might be influenced by the interaction of the cognitive styles of the student and grader in each grading dyad, or, perhaps more directly, by the simple effect of grader's cognitive style. In addition, the effects of student/grader sex match/mismatches were also explored. Finally, the question regarding possible student/grader cognitive style effects on calculus grades was investigated in situations wherein the grading is done without the student present, and without any knowledge regarding the student.

Procedure: Experiment II

The Group Embedded Figures Test (GEFT) and the Miniaturized Rod and Frame Test (MRFT) were administered to all students enrolled in the calculus course described earlier in this chapter. In addition, the same two measures of cognitive style were administered to all 61
students hired by the testing center for the semester during which the calculus course was offered.

Ideally there would have been equal numbers of male graders, female graders, male students, and female students so as to permit equal cells in a 2 x 2 (grader sex x student sex) design, with measures of students' and graders' cognitive styles as covariates. Unfortunately there simply were not as many graders as there were students, nor were both sexes equally represented in both graders and students. Moreover, without doing serious violence to the long-standing (random) procedure established for guiding the flow of students through the grading room, blocking was impossible. Thus, upon completion of his or her test, each student was assigned to the next available grader, as per the status quo. As a result, neither students nor graders had any knowledge or suspicions that aspects of the grading process were under any extraordinary scrutiny or analysis, and the naturalistic environment was maintained.

In the interest of avoiding the contaminating effects of having the same grader in several student-grader dyads (the 195 students could be graded by at most 61 available graders), one test was randomly selected as a representative grading for each of the graders who had graded during the first-try week for unit I. First-try on Unit I was selected since it takes place during the first official week of testing, a time when familiarity of students and graders with one another is minimized. Of the 61 graders hired for the semester under study, 41 of them actually graded unit I tests during first-try week, with each of the 41 graders having graded from 1 to 13 tests. Thus one test was
randomly selected from each of the corresponding 41 sets of unit I first-tries. All analyses of the effects of cognitive style on grading outcomes in the face-to-face situation are based on these 41 tests.

Students

Of the 41 students whose tests were selected for the random sample, 18 were women and 23 were men. Age data were available for 30 of them: as of February 1979, 15 students were 18 years old, 10 students were 19 years old, 4 students were 20 years old, and 1 subject was 23 years old. Among these 41 students, 31 were freshman, 8 were sophomores, and 2 were special students; 5 were enrolled in the College of Engineering and Physical Sciences, 13 in the School of Life Sciences, 15 in the College of Liberal Arts, 4 in the Whittemore School (Business), 3 in the Division of Continuing Education, and 1 in the Thompson School of Applied Science. When compared with the data for the larger experimental group in Experiment I (Figures 5 through 7), these data indicate that the sample of 41 is quite representative with respect to age, and class and college status.

Graders

Graders who took part in the 41 face-to-face dyads (that produced the 41 tests under analysis) will be referred to as face-to-face graders.

In an effort to determine whether the grading patterns observed in the face-to-face arrangements would be different if the grading
were done without the student present, and, in fact, with no knowledge of the student, a second stage of the experiment involved the following procedure: copies of the 41 tests alluded to above were cleaned of all grader markings, photocopied, and regraded by a new group of 41 graders employed by the testing center in a later semester. This group of graders will be referred to as non-face-to-face graders. The rationale for this second stage of grading was to remove from the test scores that portion of variance attributable to sex match/mismatch effects or to interpersonally mediated cognitive style match/mismatch effects.

As the third and final stage in this experiment, each of the non-face-to-face graders was asked to grade a common measure. The 15 items used in constructing this test were composed of problems selected from the archives of previously graded tests from units I, II, and VII, transcribed without grader markings and duplicated. The rationale for this third stage of grading was to remove, from stage two conditions, those sources of grading outcome variance attributable to differences in student aptitude, sex, and cognitive style. With these data, grading differences attributable to grader cognitive style alone can be assessed more accurately.

As a measure of calculus aptitude, the calculus I grades for both grader groups were used. For each group 40 of the 41 grades were available. For the face-to-face graders, there were 34 A's, 5 A-'s, and 2 B+'. For the non-face-to-face graders, there were 35 A's, 2 A-'s, 3 B+'s and one B.
Age, college, and major data for the two groups of graders are shown in Figures 9 through 11.

**Figure 9. Frequency data for graders' ages.**

- Age in years of face-to-face graders.

- Age in years of non-face-to-face graders, (one missing datum)
Figure 10. Frequency data for graders' colleges.

College affiliations of face-to-face graders.

College affiliations of non-face-to-face graders.
Figure 11. Frequency data for graders' majors.
Summary

The two experiments that have been described here represent an attempt to answer questions regarding the importance of cognitive style and sex in assessing the effects of different modes of audio-visual instruction on various achievement measures (Experiment I), and in assessing the possibility of biases operative in various grading configurations (Experiment II). The analyses performed to test the specific hypotheses inherent in these questions are reported in chapter IV.
CHAPTER IV

ANALYSES AND RESULTS

The analyses which are reported in this chapter were performed in order to address the questions posed in chapter I. The two facets of the present study, Experiment I, Remedial Instruction, and Experiment II, Grading, are treated separately, and in each case the analyses are preceded by a listing of the variables employed, and relevant descriptive measures.

Experiment I: Remedial Instruction

In an effort to simplify the present discussion, the following codes have been used when referring to the variables employed in the experiment.

Pretreatment measures

TOTPRE: The score on the Algebra/Trigonometry pretest, consisting of 25 algebra questions and 16 trigonometry questions.

PREQ: The total of five trigonometry quizzes administered to treatment groups I, III, and V prior to the five treatment sessions.

GEFT: Group Embedded Figures Test score.

MRFT: Miniaturized Rod and Frame Test score.

Posttreatment measures

POSTQ: The total of five trigonometry quizzes administered to all treatment groups following the five treatment sessions.
CALCIV: The score on the final-try of the calculus unit 4 test.

Descriptive Statistics

Means and standard deviations for all measures are shown in Table 9. All descriptive statistics and analyses reported in this chapter were determined via statistical programs reported in SPSS (Nie et al., 1975) and SPSS Update 7-9 (Hull & Nie, 1981).

Table 9

<table>
<thead>
<tr>
<th>Measure</th>
<th>n</th>
<th>M</th>
<th>SD</th>
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</thead>
<tbody>
<tr>
<td>TOTPRE (5;27;41)</td>
<td>150</td>
<td>17.593</td>
<td>4.483</td>
</tr>
<tr>
<td>PREQ (1,29;50)</td>
<td>71</td>
<td>13.577</td>
<td>6.563</td>
</tr>
<tr>
<td>GEFT (3,18;18)</td>
<td>150</td>
<td>13.213</td>
<td>3.981</td>
</tr>
<tr>
<td>MRFT (4,49;0)</td>
<td>148</td>
<td>15.730</td>
<td>8.840</td>
</tr>
<tr>
<td>POSTQ (3,46;50)</td>
<td>147</td>
<td>26.299</td>
<td>11.458</td>
</tr>
<tr>
<td>CALCIV (0,98;100)</td>
<td>139</td>
<td>65.468</td>
<td>21.185</td>
</tr>
</tbody>
</table>

Numbers in parentheses are, respectively, the minimum score achieved by any subject, the maximum score achieved by any subject, and the maximum possible score.

For the MRFT the optimal score is 0, indicating a 0° total deviation of the rod (from true vertical).

Breakdowns by sex for all measures are given in Table 10.
### Table 10

**Means and Standard Deviations for All Subjects and All Measures, by Sex**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>TOTPRE</td>
<td>100</td>
<td>17.4800</td>
</tr>
<tr>
<td>PREQ</td>
<td>45</td>
<td>14.3556</td>
</tr>
<tr>
<td>GEFT</td>
<td>100</td>
<td>13.5600</td>
</tr>
<tr>
<td>MRFT</td>
<td>100</td>
<td>15.5700</td>
</tr>
<tr>
<td>CALCIV</td>
<td>93</td>
<td>65.1828</td>
</tr>
</tbody>
</table>

Breakdowns by experimental condition for all measures are given in Table 11.
<table>
<thead>
<tr>
<th>Measure</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>SD</td>
<td>n</td>
<td>M</td>
<td>SD</td>
</tr>
</tbody>
</table>
All groups that experienced either one of the two remedial programs in trigonometry in MaC (Groups I, II, III, and IV) can be considered "treated", whereas the control groups (V and VI) were essentially "untreated" in MaC. Means and standard deviations for all measures are shown for the treated vs. untreated groups in Table 12.

Table 12
Means and Standard Deviations for All Subjects and All Measures, by Treatment Status

<table>
<thead>
<tr>
<th>Measure</th>
<th>Treated Groups (I,II,III,IV)</th>
<th>Untreated Groups (V,VI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>TOTPRE</td>
<td>102</td>
<td>17.8529</td>
</tr>
<tr>
<td>PREQ&lt;sup&gt;a&lt;/sup&gt;</td>
<td>50</td>
<td>13.7400</td>
</tr>
<tr>
<td>MRFT</td>
<td>102</td>
<td>15.8922</td>
</tr>
<tr>
<td>POSTQ</td>
<td>101</td>
<td>32.5743</td>
</tr>
<tr>
<td>CALCN</td>
<td>96</td>
<td>66.8125</td>
</tr>
</tbody>
</table>

<sup>a</sup>Only treated groups I and III and untreated group V took the PREQ.

Table 13 shows descriptive statistics for the Dialog groups (I and II) and the Monolog groups (III and IV).
Table 13

Means and Standard Deviations for All Treated Subjects and All Measures, by Treatment Type

<table>
<thead>
<tr>
<th>Measure</th>
<th>Dialog (Groups I and II)</th>
<th>Monolog (Groups III and IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>TOTPRE</td>
<td>50</td>
<td>17.6600</td>
</tr>
<tr>
<td>PREQ(^a)</td>
<td>24</td>
<td>13.1667</td>
</tr>
<tr>
<td>GEF'T</td>
<td>50</td>
<td>13.6200</td>
</tr>
<tr>
<td>MRFT</td>
<td>50</td>
<td>16.0200</td>
</tr>
<tr>
<td>POSTQ</td>
<td>50</td>
<td>32.3800</td>
</tr>
<tr>
<td>CALCIV</td>
<td>49</td>
<td>67.6122</td>
</tr>
</tbody>
</table>

\(^a\)Only dialog group I and monolog group III took the PREQ.

Means and standard deviations for the measures POSTQ and CALCIV by Sex by Experimental condition are given in Tables 14 and 15 respectively. (POSTQ and CALCIV are of special interest since they will act as dependent measures for the main analyses to follow.)
Table 14
Means and Standard Deviations on POSTQ for All Subjects with Breakdowns by Treatment Condition by Sex

<table>
<thead>
<tr>
<th>Experimental Condition</th>
<th>Dialog (Groups I,II)</th>
<th>Monolog (Groups III,IV)</th>
<th>Control (Groups V,VI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>n</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Female</td>
<td>17</td>
<td>33.294</td>
<td>10.030</td>
</tr>
<tr>
<td>Male</td>
<td>33</td>
<td>31.909</td>
<td>7.747</td>
</tr>
</tbody>
</table>

Table 15
Means and Standard Deviations on CALCIV for All Subjects with Breakdowns by Treatment Condition by Sex

<table>
<thead>
<tr>
<th>Experimental Condition</th>
<th>Dialog (Groups I,II)</th>
<th>Monolog (Groups III,IV)</th>
<th>Control (Groups V,VI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>n</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Female</td>
<td>16</td>
<td>69.937</td>
<td>19.213</td>
</tr>
<tr>
<td>Male</td>
<td>33</td>
<td>66.485</td>
<td>18.740</td>
</tr>
</tbody>
</table>

The Solomon four-group design offers control over the effects of practice (by virtue of some subjects' experience with certain pre-treatment tests) on posttreatment measures, and on pretest-by-treatment interactions. Tables 16 and 17 present means and standard deviations on POSTQ and CALCIV, respectively, by pretesting status and by treatment status.
Table 16
Means and Standard Deviations on POSTQ for All Subjects with Breakdowns by Treatment Status by Pretesting Status on PREQ

<table>
<thead>
<tr>
<th>Treatment Status</th>
<th>Treated (Groups I,II,III,IV)</th>
<th>Untreated (Groups V,VI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest Status</td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>Pretested</td>
<td>50</td>
<td>33.1600</td>
</tr>
<tr>
<td>Unpretested</td>
<td>51</td>
<td>32.0000</td>
</tr>
</tbody>
</table>

Table 17
Means and Standard Deviations on CALCIV for All Subjects with Breakdowns by Treatment Status by Pretesting Status on PREQ

<table>
<thead>
<tr>
<th>Treatment Status</th>
<th>Treated (Groups I,II,III,IV)</th>
<th>Untreated (Groups V,VI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest Status</td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>Unpretested</td>
<td>47</td>
<td>66.3404</td>
</tr>
</tbody>
</table>

Zero-order (Pearson product-moment) correlation coefficients were computed for each pair of measures for the entire sample (Table 18), for the entire sample by sex (Table 19), and finally for each experimental group (Table 20). Certain of the significant correlations are consoling, for example, the very strong correlations among TOTPRe, PREQ, and POSTQ for the entire group; others are intriguing, for example the moderately strong correlation between GEFT and MRFT for
the entire group (Table 18), sustained in significance for men but not for women (Table 19); and some are downright perplexing, for example, the lack of significant correlation between the pretest (TOTPRE) and the calculus unit IV test (CALCIV). Scattergrams for selected pairs of variables are given in appendix A for the entire remedial group, for remedial women, and for remedial men.

Table 18

Correlations Among All Pairs of Variables, All Subjects

<table>
<thead>
<tr>
<th>Measure</th>
<th>TOTPRE</th>
<th>PREQ</th>
<th>GEFT</th>
<th>MRFT</th>
<th>POSTQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.5276***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(71)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEFT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.1388*</td>
<td>.1494</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(150)</td>
<td>(71)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRFT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-.0341</td>
<td>-.1149</td>
<td>-.2344***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(148)</td>
<td>(71)</td>
<td>(148)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POSTQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.3048***</td>
<td>.4835***</td>
<td>.1537*</td>
<td>-.0145</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(147)</td>
<td>(70)</td>
<td>(147)</td>
<td>(147)</td>
<td></td>
</tr>
<tr>
<td>CALCIV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.0927</td>
<td>.0512</td>
<td>-.0366</td>
<td>.1888*</td>
<td>.1440*</td>
</tr>
<tr>
<td></td>
<td>(139)</td>
<td>(68)</td>
<td>(139)</td>
<td>(139)</td>
<td>(138)</td>
</tr>
</tbody>
</table>

Note. The number of pairs used in computing each correlation coefficient is given in parentheses.

**** \( p < .001 \)

*** \( p < .005 \)

** \( p < .01 \)

* \( p < .05 \)
### Table 19
Correlations Among All Pairs of Variables, All Subjects, by Sex

<table>
<thead>
<tr>
<th>Measure</th>
<th>TOTPRE</th>
<th>PREQ</th>
<th>GEFT</th>
<th>MRFT</th>
<th>POSTQ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PREQ</td>
<td>0.5925****</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(26)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEFT</td>
<td>0.1341</td>
<td>-0.0346</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(50)</td>
<td>(26)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRFT</td>
<td>0.0091</td>
<td>-0.4155*</td>
<td>-0.1700</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(48)</td>
<td>(26)</td>
<td>(48)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POSTQ</td>
<td>0.3668***</td>
<td>0.4316*</td>
<td>0.1112</td>
<td>-0.0477</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(48)</td>
<td>(26)</td>
<td>(48)</td>
<td>(48)</td>
<td></td>
</tr>
<tr>
<td>CALCIV</td>
<td>0.1375</td>
<td>0.4012*</td>
<td>-0.1764</td>
<td>0.2687*</td>
<td>0.2464*</td>
</tr>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PREQ</td>
<td>0.5412****</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(45)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEFT</td>
<td>0.1517</td>
<td>0.2875*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(100)</td>
<td>(45)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRFT</td>
<td>-0.0534</td>
<td>-0.0189</td>
<td>-0.2690***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(100)</td>
<td>(45)</td>
<td>(100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POSTQ</td>
<td>0.2788***</td>
<td>0.5489****</td>
<td>0.1780*</td>
<td>0.0024</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(99)</td>
<td>(44)</td>
<td>(99)</td>
<td>(99)</td>
<td></td>
</tr>
<tr>
<td>CALCIV</td>
<td>0.0716</td>
<td>-0.0831</td>
<td>0.0496</td>
<td>0.1541</td>
<td>0.0925</td>
</tr>
<tr>
<td></td>
<td>(93)</td>
<td>(43)</td>
<td>(93)</td>
<td>(93)</td>
<td>(92)</td>
</tr>
</tbody>
</table>

**Note.** The number of pairs used in computing each correlation coefficient is given in parentheses.

* **** p < .001
* *** p < .005
* ** p < .01
* * p < .05
Table 20

Correlations Among All Pairs of Variables, All Subjects, by Experimental Group

<table>
<thead>
<tr>
<th>Measure</th>
<th>TOTPRES</th>
<th>PREQR</th>
<th>GEFT</th>
<th>MRFT</th>
<th>POSTQR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREQ</td>
<td>.6055****</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(24)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEFT</td>
<td>.0203</td>
<td>.4101*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(25)</td>
<td>(24)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRFT</td>
<td>-.1195</td>
<td>-.2704</td>
<td>-.1634</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(25)</td>
<td>(24)</td>
<td>(25)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POSTQ</td>
<td>.4679**</td>
<td>.8052****</td>
<td>.3488*</td>
<td>-.3430*</td>
<td></td>
</tr>
<tr>
<td>CALCIV</td>
<td>-.0111</td>
<td>-.0141</td>
<td>.0353</td>
<td>.1946</td>
<td>.1894</td>
</tr>
<tr>
<td></td>
<td>(24)</td>
<td>(23)</td>
<td>(24)</td>
<td>(24)</td>
<td>(24)</td>
</tr>
</tbody>
</table>

Group I (Dialog; pretested)

| PREQ    | .2621   |       |      |      |        |
|         | (25)    |       |      |      |        |
| GEFT    |        | .2621 |      |      |        |
|         | (25)    | (25)  |      |      |        |
| MRFT    | -.0165  |       | -.1997|      |        |
|         | (25)    |       | (25) |      |        |
| POSTQ   | .5330***| .2843 | -.0803|      |        |
|         | (25)    | (25)  | (25) |      |        |
| CALCIV  | .2778   | .0523 | .0916 | .1889|        |

Group II (Dialog; unpretested)
<table>
<thead>
<tr>
<th>Measure</th>
<th>TOTPRE</th>
<th>PREQ</th>
<th>GEFT</th>
<th>MRFT</th>
<th>POSTQ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preq</strong></td>
<td>.4785** (26)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Geft</strong></td>
<td>.0128 (26)</td>
<td>.1148 (26)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mrft</strong></td>
<td>-.1659 (26)</td>
<td>-.2036 (26)</td>
<td>-.3564* (26)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Postq</strong></td>
<td>.3497* (25)</td>
<td>.6069**** (25)</td>
<td>.4529** (25)</td>
<td>-.1824 (25)</td>
<td></td>
</tr>
<tr>
<td><strong>Calciv</strong></td>
<td>-.0410 (25)</td>
<td>.0294 (25)</td>
<td>-.1402 (25)</td>
<td>.1378 (25)</td>
<td>-.2046 (25)</td>
</tr>
</tbody>
</table>

**Group III (Monolog; pretested)**

| **Preq** | -.0946 (26) |
| **Geft** | -.0498 (26) | .0437 (26) |
| **Mrft** | .1699 (26) | .1989 (26) | .1447 (26) |
| **Postq** | .2981 (22) | .1548 (22) | .1775 (22) | .3084 (22) |

**Group IV (Monolog; unpretested)**
<table>
<thead>
<tr>
<th>Measure</th>
<th>TOTPRE</th>
<th>PREQ</th>
<th>GEFT</th>
<th>MRFT</th>
<th>POSTQ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group V (Control; pretested)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PREQ</td>
<td>.5421**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(21)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEFT</td>
<td>.4034*</td>
<td>-.0234</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(23)</td>
<td>(21)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRFT</td>
<td>-.2227</td>
<td>.2104</td>
<td>-.6553****</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(21)</td>
<td>(21)</td>
<td>(21)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POSTQ</td>
<td>.5341**</td>
<td>.9287****</td>
<td>.0802</td>
<td>.0559</td>
<td></td>
</tr>
<tr>
<td>(21)</td>
<td>(21)</td>
<td>(21)</td>
<td>(21)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CALCIV</td>
<td>-.1739</td>
<td>.1532</td>
<td>-.1203</td>
<td>.0227</td>
<td>.1312</td>
</tr>
<tr>
<td>(20)</td>
<td>(20)</td>
<td>(20)</td>
<td>(20)</td>
<td>(20)</td>
<td></td>
</tr>
<tr>
<td><strong>Group VI (Control; unpretested)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PREQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEFT</td>
<td>.1655</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(25)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRFT</td>
<td>.3331</td>
<td>-.2267</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(25)</td>
<td>(25)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POSTQ</td>
<td>.4897**</td>
<td>.1971</td>
<td>.2699</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(25)</td>
<td>(25)</td>
<td>(25)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CALCIV</td>
<td>.2733</td>
<td>-1216</td>
<td>.3597*</td>
<td>.1587</td>
<td></td>
</tr>
<tr>
<td>(23)</td>
<td>(23)</td>
<td>(23)</td>
<td>(23)</td>
<td>(23)</td>
<td></td>
</tr>
</tbody>
</table>

**Note.** The number of pairs used in computing each correlation coefficient is given in parentheses.

****  $p < .001$

***  $p < .005$

**  $p < .01$

*  $p < .05$
Experiment I: Analyses

The primary research question motivating the analyses in Experiment I, Remedial Instruction, focuses on the effects of experimental condition (DIALOG, MONOLOG, or CONTROL), sex, and cognitive style upon postsession measures of trigonometry knowledge (POSTQ) and the calculus unit IV test (CALCIV). Furthermore, the theoretical framework developed in chapter II suggests that the analysis of this question be sensitive to the possibility that the Group Embedded Figures Test (GEFT) and the Miniaturized Rod and Frame Test (MRFT) measure different aspects of cognitive functioning, and hence may produce different patterns of significant effects.

Testing the significance of specific effects implicit in these conjectures was accomplished by means of two separate analyses, one which entered GEFT as a covariate and one which entered MRFT as a covariate. Prior to the analyses, histograms and normal plots of all variables (as well as scattergrams of appropriate pairs thereof) were inspected, and no serious deviations from normality were observed. In addition, the significance of presession quizzes (PREQ) x treatment interaction was tested to aid in the interpretation of any treatment effects that may achieve significance in the main analyses. We now consider this preliminary analysis in detail.

Practice Effects

Prior to each of the five remedial sessions, subjects in experimental groups I, III, and V were pretested with a 10-item quiz. These five pretests were consolidated into the single measure PREQ for purposes of the main analyses. Five parallel quizzes also were
developed as post-session measures, and were consolidated into the single measure POSTQ. The post-session quizzes were administered to all six experimental groups. For the purpose of assessing the effects of pretesting and pretest-by-treatment interaction effects on POSTQ performance, a 2 x 3 (pretesting status by experimental condition) analysis of variance was performed with POSTQ as the criterion variable. Each of the six cells in the model corresponds to one of the experimental groups, as shown below.

<table>
<thead>
<tr>
<th></th>
<th>Dialog</th>
<th>Monolog</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretested</td>
<td>I</td>
<td>III</td>
<td>V</td>
</tr>
<tr>
<td>Unpretested</td>
<td>II</td>
<td>IV</td>
<td>VI</td>
</tr>
</tbody>
</table>

Means and standard deviations for each cell in the model are given in Table 21.

Table 21

Cell Means and Standard Deviations of POSTQ, by Pretesting Status and Experimental Condition.

<table>
<thead>
<tr>
<th></th>
<th>DIALOG</th>
<th>MONOLOG</th>
<th>CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Pretested</td>
<td>25</td>
<td>32.840</td>
<td>8.300</td>
</tr>
</tbody>
</table>

The results of the analysis are given in Table 22.
Table 22

2 x 3 Analysis of Variance of POSTQ, by Pretesting Status and Experimental Condition.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretesting Status</td>
<td>96.334</td>
<td>1</td>
<td>96.334</td>
<td>2.142</td>
</tr>
<tr>
<td>Treatment</td>
<td>12617.657</td>
<td>2</td>
<td>6308.829</td>
<td>140.270*</td>
</tr>
<tr>
<td>Pretest x Treatment</td>
<td>18.422</td>
<td>2</td>
<td>9.211</td>
<td>.205</td>
</tr>
<tr>
<td>Error</td>
<td>6341.678</td>
<td>141</td>
<td>44.976</td>
<td></td>
</tr>
</tbody>
</table>

*p < .001.

The significant effect of treatment condition will be explored in the main analyses. Neither pretesting nor pretesting-by-treatment effects were significant, thus allowing any subsequent statements regarding the significance of treatment to be free from the implication that pretesting in some way enhanced the effects of that treatment.

Multivariate Analysis of Covariance of POSTQ and CALCIV, by Sex and Treatment Condition, with Covariates TOTPRES, PREQ, and GEFT

The analysis employed a 3 x 2 fixed effects model. The levels of the first factor, treatment condition (symbolized as GROUP), were DIALOG, MONOLOG, and CONTROL, and the levels of the second factor, sex (SEX), were FEMALE and MALE. The design was completely randomized, though unbalanced, and the principal statistical procedure was a multivariate analysis of covariance with POSTQ and CALCIV as dependent variables, and PREQ, TOTPRES (two pretreatment measures of mathematics ability), and GEFT as covariates. For the analyses in Experiment I, the mathematical aptitude/achievement covariates were combined into a
single joint effect, and will be referred to as PREQ + TOTPREF. Pre-
tested groups I (DIA), III (MONO), and V (CTRL) were used in this
analysis. The SPSS MANOVA procedure (Hull & Nie, 1981) employs a
sequential sum of squares model, wherein sums of squares for each
effect specified in the design are adjusted for those effects pre-
ceding it. Thus the order in which terms are entered into the model
is important. The design employed in the present analysis is given in
Table 23.

Table 23

Order of Effects Tested in the Multivariate Analysis of Covariance of
POSTQ and CALCIV by Sex and Treatment Condition, with Covariates TOTPREF,
PREQ, and GEFT.

<table>
<thead>
<tr>
<th>Order</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SEX</td>
</tr>
<tr>
<td>2</td>
<td>GEFT</td>
</tr>
<tr>
<td>3</td>
<td>GEFT x SEX</td>
</tr>
<tr>
<td>4</td>
<td>GROUP</td>
</tr>
<tr>
<td>5</td>
<td>SEX x GROUP</td>
</tr>
<tr>
<td>6</td>
<td>GEFT x GROUP</td>
</tr>
<tr>
<td>7</td>
<td>GEFT x SEX x GROUP</td>
</tr>
</tbody>
</table>

A multivariate test of the assumption of homogeneous within-cells
dispersion matrices, using Box's M test, was nonsignificant ($F(75,3131)$
= 1.02659, $p > .40$). A multivariate test of the parallelism hypothesis,
using Wilk's $\Lambda$, was nonsignificant also ($F(20,84) = .93310$, $p > .54$
and thus supported the hypothesis of parallel regression surfaces.
Thus the assumptions for the multivariate analysis of covariance were
Wilk's Λ was used to test the significance of each effect in the model. The following effects achieved significance: SEX x GROUP, GEFT x SEX, GROUP, and SEX. Because the two interaction effects confound the interpretation of main effects for GROUP and SEX, only the interaction effects will be discussed.

**SEX x GROUP Effect**

In the multivariate test of significance, the SEX x GROUP effect emerged as significant via Wilk's Λ ($F(4,84) = 2.39771, p < .06$). Two univariate analyses of covariance (one with POSTQ as dependent variable, and one with CALCIV dependent) were then performed in order to examine further the nature of the multivariate result. These tests indicated a significant SEX x GROUP effect on POSTQ ($F(2,43) = 4.33672, p < .02$), but no significant effect on CALCIV ($F(2,43) = .53883, p > .50$).

In order to shed some light on the nature of the SEX x GROUP effect on POSTQ scores, the interaction is presented graphically in Figure 12, following Tables 24 and 25, which present, respectively, cell means and standard deviations for the covariates, and cell means for POSTQ (observed and adjusted for the covariates).
### Table 24

**Cells Means and Standard Deviations, TOTPRE, PREQ and GEFT.**

<table>
<thead>
<tr>
<th>Treatment Condition</th>
<th>TOTPRE</th>
<th>PREQ</th>
<th>GEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIALOG</td>
<td>7</td>
<td>18.43</td>
<td>3.55</td>
</tr>
<tr>
<td>MONOLOG</td>
<td>11</td>
<td>18.56</td>
<td>3.75</td>
</tr>
<tr>
<td>CONTROL</td>
<td>7</td>
<td>19.14</td>
<td>3.29</td>
</tr>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIALOG</td>
<td>16</td>
<td>17.06</td>
<td>5.87</td>
</tr>
<tr>
<td>MONOLOG</td>
<td>13</td>
<td>18.15</td>
<td>3.93</td>
</tr>
<tr>
<td>CONTROL</td>
<td>13</td>
<td>18.46</td>
<td>5.53</td>
</tr>
</tbody>
</table>
Table 25

Observed and Adjusted Cell Means for POSTQ, Adjusted for TOTPRE, PREQ, and GEFT.

<table>
<thead>
<tr>
<th>Treatment Condition</th>
<th>n</th>
<th>Observed Mean</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Women</td>
<td></td>
</tr>
<tr>
<td>DIALOG</td>
<td>7</td>
<td>37.29</td>
<td>37.76</td>
</tr>
<tr>
<td>MONOLOG</td>
<td>11</td>
<td>33.27</td>
<td>34.67</td>
</tr>
<tr>
<td>CONTROL</td>
<td>7</td>
<td>12.86</td>
<td>12.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Men</td>
<td></td>
</tr>
<tr>
<td>DIALOG</td>
<td>16</td>
<td>31.69</td>
<td>31.54</td>
</tr>
<tr>
<td>MONOLOG</td>
<td>13</td>
<td>33.54</td>
<td>32.33</td>
</tr>
<tr>
<td>CONTROL</td>
<td>13</td>
<td>14.70</td>
<td>14.29</td>
</tr>
</tbody>
</table>
Figure 12. POST as a function of treatment condition and sex, adjusted by TOTPRE, PREQ, and GEFT.
Inspection of Figure 12 suggests that the women outperformed the men following treatment of either DIALOG or MONOLOG type, while the pattern is reversed under the CONTROL condition. This result is consistent with Mundy's (1980) result, cited earlier, supporting the position that women may be more responsive to the influence of treatment.

The expected cognitive style x GROUP effect (that field-dependents perform better following DIALOG treatment and field-independents perform better following MONOLOG) was not supported. In the light of our earlier discussion of the analogy between the field-dependent vs. field-independent and the female vs. male dichotomies in approach to information processing, it would be tempting to speculate that the women perform better following the DIALOG treatment and the men perform better following the MONOLOG treatment. If this were so, we might conclude that sex had the effect of washing out the expected GEFT effect. Although the nature of the interaction depicted in Figure 12 hints at this, the evidence is far from conclusive.

**GEFT x SEX Effect**

In the multivariate test of significance, the GEFT x SEX effect emerged as significant via Wilk's $\Lambda (F(2,42) = 3.77, p < .04)$. Two univariate analyses of covariance (one with POSTQ dependent and the other with CALCIV dependent) were then performed in order to explore the nature of the multivariate result. These tests indicated that the effect was significant on POSTQ scores ($F(1,43) = 7.628, p < .009$), but not on CALCIV scores ($F(1,43) = .004, p > .95$). In an attempt to visualize the nature of the significant interaction, a graphical
representation of the interaction is presented in Figure 13. Covariate means and standard deviations, and means for POSTQ (observed and adjusted) are presented in Tables 26 and 27.

Table 26
Means and Standard Deviations for TOTPRe and PREQ.

<table>
<thead>
<tr>
<th>Sex</th>
<th>TOTPRe</th>
<th>PREQ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Low GEF (Field-dependent)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>18.909</td>
</tr>
<tr>
<td></td>
<td>Mid range GEF</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>17.143</td>
</tr>
<tr>
<td>Male</td>
<td>20</td>
<td>18.650</td>
</tr>
<tr>
<td></td>
<td>High range GEF (Field-independent)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>10</td>
<td>18.800</td>
</tr>
<tr>
<td>Male</td>
<td>11</td>
<td>19.546</td>
</tr>
</tbody>
</table>
### Table 27

**Observed and Adjusted Means for POSTQ, Adjusted by TOTPRE and PREQ**

<table>
<thead>
<tr>
<th>Sex</th>
<th>n</th>
<th>Observed Mean</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low range GEFT (Field-dependent)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>30.70</td>
<td>29.53</td>
</tr>
<tr>
<td>Male</td>
<td>15</td>
<td>26.64</td>
<td>24.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mid range GEFT</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>30.50</td>
<td>32.68</td>
</tr>
<tr>
<td>Male</td>
<td>20</td>
<td>28.00</td>
<td>25.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High range GEFT (Field-independent)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>10</td>
<td>25.22</td>
<td>27.31</td>
</tr>
<tr>
<td>Male</td>
<td>11</td>
<td>29.73</td>
<td>27.64</td>
</tr>
</tbody>
</table>
Inspection of Figure 13 suggests that the effect of GEFT achievement on the criterion measure POSTQ is different for men and women, with an apparent negative relationship between GEFT performance and adjusted POSTQ performance in the high-GEFT women. The results depicted here support the position that special treatment of any type may be more facilitative to field-dependent women than to field-independent women. In an attempt to explore further the POSTQ vs. GEFT relationship for women, a second multivariate analysis of covariance was performed, similar to that reported in Table 23, but
with the quadratic factor GEFT^2 introduced in parallel to the linear GEFT factor. The order of effects tested were: SEX, GEFT, GEFT^2, GEFT x SEX, GEFT^2 x SEX, GROUP, SEX x GROUP, GEFT x GROUP, GEFT^2 x GROUP, GEFT x SEX x GROUP, and GEFT^2 x SEX x GROUP. Precisely the same pattern of significant effects emerged here as before, with no effect involving the quadratic term achieving significance.

We now turn our attention to the second set of analyses for Experiment I, in which effects of MRFT performance were tested.

**Multivariate Analysis of Covariance of POSTQ and CALCIV, by Sex and Treatment Condition, with Covariates TOTP, PRED, and MRFT.**

This analysis was identical to the one just reported, except for the use of the MRFT instead of the GEFT as an indicator of cognitive style. The intent was to determine whether the same pattern of significant effects would be observed here as in the analyses involving GEFT. Once again a 3 x 2 (treatment condition by sex) fixed-effects model was tested via multivariate analysis of covariance. As before, pre-tested groups I (DIALOG), III (MONOLOG), and V (CONTROL) were used in the analysis. The design specified for the analysis is given in Table 28.
Table 28
Order of Effects Tested in the Multivariate Analysis of Covariance of POSTQ and CALCIV by Sex and Treatment Condition, with Covariates TOTPRE, PREQ, and MRFT.

<table>
<thead>
<tr>
<th>Order</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SEX</td>
</tr>
<tr>
<td>2</td>
<td>MRFT</td>
</tr>
<tr>
<td>3</td>
<td>MRFT x SEX</td>
</tr>
<tr>
<td>4</td>
<td>GROUP</td>
</tr>
<tr>
<td>5</td>
<td>SEX x GROUP</td>
</tr>
<tr>
<td>6</td>
<td>MRFT x GROUP</td>
</tr>
<tr>
<td>7</td>
<td>MRFT x SEX x GROUP</td>
</tr>
</tbody>
</table>

A multivariate test of the hypothesis of homogeneous within-cells dispersion matrices (Box's M) supported that hypothesis ($F(75,3131) = 1.07615, p > .30$). A multivariate test of the parallelism hypothesis (Wilk's $\Lambda$) supported the hypothesis of parallel regression surfaces ($F(20,84) = 1.11287, p > .35$). Thus the multivariate analysis of covariance was performed. Significant main effects were detected for SEX and GROUP with no significant effects for MRFT and no interaction effects.

**SEX Effect**

In the multivariate test of significance, the SEX effect emerged as significant via Wilk's $\Lambda$ ($F(2,42) = 5.43391, p < .01$). (The position of SEX as an effect in the sequential sum of squares model has been given in Table 28.) Two univariate analyses of covariance (one with POSTQ as dependent variable, and the other with CALCIV as the
dependent variable) were then performed. These tests revealed a significant SEX effect on POSTQ (F(1,43) = 9.82709, p < .005), but no significant effect on CALCIV (F(1,43) = .97926, p > .32). Table 29 contains the relevant descriptive data for the covariates TOTPRE and PREQ, which had entered the model prior to the SEX effect. Observed cell means and cell means adjusted for the two covariates are given in Table 30, indicating that significance was attributable to superior performance of the females.

Table 29
Means and Standard Deviations for TOTPRE and PREQ

<table>
<thead>
<tr>
<th></th>
<th>TOTPRE</th>
<th></th>
<th>PREQ</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Female</td>
<td>18.6800</td>
<td>3.4366</td>
<td>12.6800</td>
<td>6.5493</td>
</tr>
<tr>
<td>Male</td>
<td>17.8333</td>
<td>5.1462</td>
<td>14.4286</td>
<td>6.4587</td>
</tr>
</tbody>
</table>

Table 30
Observed and Adjusted Cell Means for POSTQ, Adjusted by TOTPRE and PREQ

<table>
<thead>
<tr>
<th>Sex</th>
<th>n</th>
<th>Observed Mean</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>25</td>
<td>28.6800</td>
<td>29.5649</td>
</tr>
<tr>
<td>Male</td>
<td>42</td>
<td>27.0000</td>
<td>26.7754</td>
</tr>
</tbody>
</table>

GROUP Effect

In the multivariate test of significance, the GROUP effect emerged as significant via Wilk's \(Λ (F(4,84) = 36.64250, p < .001)\). (The position of GROUP as an effect in the sequential sum of squares
model has been given in Table 28. Note that GROUP entered the model after SEX and MRFT.) Two univariate analyses of covariance (one with POSTQ dependent, and one with CALCIV dependent) were performed, revealing a significant GROUP effect on POSTQ \( (F(2,43) = 135.86534, p < .001) \) but not on CALCIV \( (F(2,43) = .62540, p > .54) \). Table 31 presents cell means and standard deviations for the covariates TOTPRE, PREQ, and MRFT. Table 32 presents observed and adjusted cell means for POSTQ by GROUP. The significance of this effect is due to differences between each treated group and the control group, with treated groups performing better than untreated groups.

Table 31
Cell Means and Standard Deviations, TOTPRE, PREQ and MRFT.

<table>
<thead>
<tr>
<th>Treatment Condition</th>
<th>TOTPRE</th>
<th>PREQ</th>
<th>MRFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>DIALOG</td>
<td>23</td>
<td>17.4783</td>
<td>5.1600</td>
</tr>
<tr>
<td>MONOLOG</td>
<td>24</td>
<td>18.3333</td>
<td>3.8491</td>
</tr>
<tr>
<td>CONTROL</td>
<td>20</td>
<td>18.7000</td>
<td>4.7465</td>
</tr>
</tbody>
</table>
Table 32

Observed and Adjusted Cell Means for POSTQ, Adjusted by TOTPRE, PREQ, and MRFT.

<table>
<thead>
<tr>
<th>Treatment Condition</th>
<th>n</th>
<th>Observed Mean</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIALOG</td>
<td>23</td>
<td>33.3913</td>
<td>33.5104</td>
</tr>
<tr>
<td>MONOLOG</td>
<td>24</td>
<td>33.4166</td>
<td>32.9977</td>
</tr>
<tr>
<td>CONTROL</td>
<td>20</td>
<td>14.0500</td>
<td>14.0975</td>
</tr>
</tbody>
</table>

**Experiment II: Grading**

The grading experiment represents the convergence of two types of speculations: those raised informally over the years, regarding the dynamics of face-to-face grading; and those of a more theoretical nature (outlined in chapter II) which suggest a possible role that cognitive style might play in situations requiring interpersonal or cognitive evaluations. Speculations of the former type have been largely based on anecdotal information and most commonly suggest the possibility of a student/grader sex match/mismatch effect on grading outcomes. Speculations of the latter type include, among others, the suggestion that graders who score high on the MRFT (field-dependents) might accede more readily than low scorers (field-independents) to the pressure exerted by the student, and might therefore, as a group, grade more liberally.

The primary research question motivating the analyses in Experiment II, the Grading Experiment, is concerned with the effects that grader and student cognitive styles may have on grading outcomes in (1) face-to-face grading situations, and (2) in solitary situations
where no knowledge of the individual being graded is available to the grader. Moreover, the theoretical framework outlined in chapter II suggests that analyses pursuant to this question should be sensitive to the possibility of effects due to the sex of the grader, or the sex of the student, or both, in the face-to-face situation. As described in chapter III, the Grading Experiment involved three stages. Each stage focused on a variation of essentially one question and so will be treated separately.

**Stage 1: Face-to-Face Grading**

**Descriptive Statistics**

The first stage of the analyses reported here focuses on the possible effects of students' and graders' cognitive styles and sex on calculus test scores. These first analyses utilized forty-one randomly selected first-tries on the unit I calculus test, representing 41 distinct student/grader dyads. The graders involved in these dyads will be referred to as "face-to-face graders". The following codes have been used in referencing the variables relevant to these analyses.

- **G1GRADE**: The student's score on the first-try unit I test, determined by the first (face-to-face) grading.
- **G1EFT**: The face-to-face grader's score on the GEFT.
- **G1RFT**: The face-to-face grader's score on the MRFT.
- **STUEFT**: The student's score on the GEFT.
- **STURFT**: The student's score on the MRFT.
- **TOTPRE**: The student's score on the pretest.
Means and standard deviations for the preceding variables are shown in Table 33.

Table 33

Means and Standard Deviations for All Variables Pertinent to the Analysis of the 41 Exams, Face-to-Face Grading Arrangement

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIRGRADE (15,100;100)</td>
<td>41</td>
<td>80.561</td>
<td>17.530</td>
</tr>
<tr>
<td>GLEFT (6,18;18)</td>
<td>41</td>
<td>14.878</td>
<td>2.750</td>
</tr>
<tr>
<td>GIRFT (3,62;0b)</td>
<td>41</td>
<td>18.634</td>
<td>11.813</td>
</tr>
<tr>
<td>STUEFT (3,18;18)</td>
<td>41</td>
<td>12.707</td>
<td>4.931</td>
</tr>
<tr>
<td>STURFT (4,43;0b)</td>
<td>41</td>
<td>17.317</td>
<td>9.493</td>
</tr>
<tr>
<td>TOTPRE (11,33;41)</td>
<td>41</td>
<td>19.268</td>
<td>5.167</td>
</tr>
</tbody>
</table>

*Numbers in parentheses are, respectively, the minimum score achieved in the sample, the maximum score achieved in the sample, and the maximum possible score.

For the MRFT the optimal score is 0, indicating a 0° total deviation of the rod (from true vertical).

Table 34 presents grand, marginal, and cell means for all variables, in a grader sex by student sex factorial arrangement.
Table 34

Cell, Marginal, and Grand Means for All Variables Pertinent to the Analysis of the 41 Exams, Face-to-Face Grading Arrangement, Grader Sex by Student Sex

<table>
<thead>
<tr>
<th>Grader Sex</th>
<th>Student Sex</th>
<th>Male (n=23)</th>
<th>Female (n=18)</th>
<th>Grand (n=39)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G1GRADE</td>
<td>76.944</td>
<td>88.728</td>
<td>81.414</td>
</tr>
<tr>
<td></td>
<td>STUEFT</td>
<td>12.444</td>
<td>13.636</td>
<td>12.896</td>
</tr>
<tr>
<td></td>
<td>STURFT</td>
<td>16.389</td>
<td>14.091</td>
<td>15.517</td>
</tr>
<tr>
<td>Male (n=29)</td>
<td>TOTPRE</td>
<td>17.722</td>
<td>20.727</td>
<td>18.861</td>
</tr>
<tr>
<td></td>
<td>G1EFT</td>
<td>15.500</td>
<td>13.636</td>
<td>14.793</td>
</tr>
<tr>
<td></td>
<td>G1RFT</td>
<td>17.444</td>
<td>22.818</td>
<td>19.483</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G1GRADE</td>
<td>79.000</td>
<td>78.143</td>
<td>78.500</td>
</tr>
<tr>
<td></td>
<td>STUEFT</td>
<td>13.600</td>
<td>11.286</td>
<td>12.250</td>
</tr>
<tr>
<td></td>
<td>STURFT</td>
<td>22.600</td>
<td>21.000</td>
<td>21.667</td>
</tr>
<tr>
<td>Female (n=12)</td>
<td>TOTPRE</td>
<td>22.200</td>
<td>18.857</td>
<td>20.250</td>
</tr>
<tr>
<td></td>
<td>G1EFT</td>
<td>15.600</td>
<td>14.714</td>
<td>15.083</td>
</tr>
<tr>
<td></td>
<td>G1RFT</td>
<td>14.000</td>
<td>18.429</td>
<td>16.583</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G1GRADE</td>
<td>77.391</td>
<td>84.611</td>
<td>80.561</td>
</tr>
<tr>
<td></td>
<td>STUEFT</td>
<td>12.696</td>
<td>12.722</td>
<td>12.707</td>
</tr>
<tr>
<td></td>
<td>STURFT</td>
<td>17.739</td>
<td>16.778</td>
<td>17.317</td>
</tr>
<tr>
<td></td>
<td>TOTPRE</td>
<td>18.696</td>
<td>20.000</td>
<td>19.268</td>
</tr>
<tr>
<td></td>
<td>G1EFT</td>
<td>15.522</td>
<td>14.056</td>
<td>14.878</td>
</tr>
<tr>
<td></td>
<td>G1RFT</td>
<td>16.696</td>
<td>21.111</td>
<td>18.634</td>
</tr>
</tbody>
</table>

Zero-order (Pearson product-moment) correlation coefficients were computed for each pair of measures relevant to the analyses in Stage 1. These coefficients are presented in Table 35.
Table 35  
Correlations for All Pairs of Variables Pertinent to the Analysis of  
Face-to-Face Grading Outcomes  

<table>
<thead>
<tr>
<th>Variable</th>
<th>G1GRADE</th>
<th>G1EFT</th>
<th>G1RFT</th>
<th>STUEFT</th>
<th>STURFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1EFT</td>
<td>-0.0727</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(41)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G1RFT</td>
<td>0.2077</td>
<td>0.2511*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(41)</td>
<td>(41)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STUEFT</td>
<td>-0.1632</td>
<td>-0.0746</td>
<td>-0.1152</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STURFT</td>
<td>0.2743*</td>
<td>-0.1163</td>
<td>0.1123</td>
<td>-0.1320</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
<td></td>
</tr>
<tr>
<td>TOTPRE</td>
<td>0.0276</td>
<td>-0.1789</td>
<td>-0.1188</td>
<td>0.4398***</td>
<td>-0.0135</td>
</tr>
<tr>
<td></td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
</tr>
</tbody>
</table>

Note. The number of pairs used in computing each correlation coefficient is given in parentheses.

*** p < .005  
* p < .05  

Stage 1 (Face-to-Face Grading): Analyses  

In Stage 1, effects of students’ and graders’ sex (STUSEX and G1SEX) and cognitive styles on unit I calculus exam scores (G1GRADE) were considered. Two separate analyses were conducted: one in order to test the effects of student and grader GEFT performance (STUEFT and G1EFT respectively), and the other to test the effects of student and grader MRFT performance (STURFT and G1RFT respectively) on G1GRADE. Prior to any analyses, histograms of all variables (and scatterplots of appropriate pairs thereof) were inspected, and no serious deviations from normality were observed.
Univariate Analysis of Covariance of G1GRADE, Face-to Face Arrangement, by Sex of Student and Sex of Grader, with Covariates TOTPRE, STUEFT, and G1EFT.

The analysis employed a 2 x 2 (STUSEX x G1SEX) model, and the principle technique was a univariate analysis of covariance on G1GRADE (the grade assigned by the grader in the face-to-face situation), with TOTPRE (the test of precalculus knowledge), STUEFT and G1EFT as covariates. Order of effects tested in the sequential procedure is given in Table 36.
Table 36
Order of Effects Tested in the Univariate Analysis of Covariance of G1GRADE, Face-to-Face Arrangement, by Sex of Student and Sex of Grader, with Covariates TOTPRE, STUEFT, and G1EFT

<table>
<thead>
<tr>
<th>Order</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TOTPRE</td>
</tr>
<tr>
<td>2</td>
<td>STUEFT</td>
</tr>
<tr>
<td>3</td>
<td>TOTPRE x STUEFT</td>
</tr>
<tr>
<td>4</td>
<td>STUSEX</td>
</tr>
<tr>
<td>5</td>
<td>TOTPRE BY STUSEX</td>
</tr>
<tr>
<td>6</td>
<td>STUEFT BY STUSEX</td>
</tr>
<tr>
<td>7</td>
<td>TOTPRE x STUEFT x STUSEX</td>
</tr>
<tr>
<td>8</td>
<td>G1SEX</td>
</tr>
<tr>
<td>9</td>
<td>STUEFT x G1SEX</td>
</tr>
<tr>
<td>10</td>
<td>G1SEX x STUSEX</td>
</tr>
<tr>
<td>11</td>
<td>STUEFT x G1SEX x STUSEX</td>
</tr>
<tr>
<td>12</td>
<td>G1EFT</td>
</tr>
<tr>
<td>13</td>
<td>G1EFT x G1SEX</td>
</tr>
<tr>
<td>14</td>
<td>G1EFT x STUSEX</td>
</tr>
<tr>
<td>15</td>
<td>G1EFT x G1SEX x STUSEX</td>
</tr>
<tr>
<td>16</td>
<td>STUEFT x G1EFT</td>
</tr>
<tr>
<td>17</td>
<td>STUEFT x G1EFT x STUSEX</td>
</tr>
<tr>
<td>18</td>
<td>STUEFT x G1EFT x G1SEX</td>
</tr>
<tr>
<td>19</td>
<td>STUEFT x G1EFT x STUSEX x G1SEX</td>
</tr>
</tbody>
</table>
It should be noted that the order of effects suggests a conservative approach to the detection of cognitive style differences in the following sense: aptitudinal and sex effects were allowed to enter the model before the cognitive style interaction effect (effect #16). This is in keeping with one of Witkin's results (and admonitions), namely, that a sex match/mismatch effect, if allowed to occur, may overpower any cognitive style match/mismatch effects (Witkin, Moore, Goodenough, & Cox, 1977).

A test of the assumption of homogeneity of variance supported the assumption at the .01 level (Bartlett; $F(3,1346) = 3.12236$). Moreover, a univariate test of the parallelism hypothesis was also nonsignificant ($F(9,26) = .7596, p > .65$). The significance of each effect listed in Table 36 was then tested by a univariate analysis of covariance. None of the effects tested achieved significance at the .05 level. However, the $G\text{LEFT} \times G\text{SEX} \times S\text{TUREX}$ effect was significant at the .075 level ($F(1,21) = 3.53$) and warrants some consideration. Cell means and standard deviations for the covariates TOTPREG and STUEFT are given in Table 37.
### Table 37

**Cell Means and Standard Deviations for TOTPRE and STUEFT for Students Assigned to High GEFT or Low GEFT Graders**

<table>
<thead>
<tr>
<th>Grader Sex</th>
<th>Low GEFT Graders</th>
<th>TOTPRE</th>
<th>STUEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>n</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Female</td>
<td>4</td>
<td>20.25</td>
<td>7.27</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>22.00</td>
<td>6.16</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>18.43</td>
<td>5.98</td>
</tr>
<tr>
<td>Male</td>
<td>2</td>
<td>25.00</td>
<td>1.41</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>11.43</td>
<td>5.98</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High GEFT Graders</th>
<th>Female Students</th>
<th>TOTPRE</th>
<th>STUEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>3</td>
<td>17.00</td>
<td>4.36</td>
</tr>
<tr>
<td>Male</td>
<td>4</td>
<td>18.50</td>
<td>3.32</td>
</tr>
<tr>
<td>Male</td>
<td>11</td>
<td>17.45</td>
<td>3.80</td>
</tr>
</tbody>
</table>

Table 38 presents observed and adjusted cell means for G1GRADE, adjusted for TOTPRE and STUEFT, broken down by high GEFT and low GEFT graders.
Table 38

Observed and Adjusted Cell Means for G1GRADE, Adjusted by TOTPRE and STUEFT, for High GEF T and Low GEF T Graders

<table>
<thead>
<tr>
<th>Grader Sex</th>
<th>n</th>
<th>Observed Mean</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low GEF T Graders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>4</td>
<td>80.2500</td>
<td>80.05</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>91.1429</td>
<td>92.26</td>
</tr>
<tr>
<td></td>
<td>Male Students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>2</td>
<td>64.5000</td>
<td>62.60</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>78.2857</td>
<td>77.32</td>
</tr>
<tr>
<td></td>
<td>High GEF T Graders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>75.3333</td>
<td>74.16</td>
</tr>
<tr>
<td>Male</td>
<td>4</td>
<td>84.5000</td>
<td>85.09</td>
</tr>
<tr>
<td></td>
<td>Male Students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>88.6666</td>
<td>88.80</td>
</tr>
<tr>
<td>Male</td>
<td>11</td>
<td>77.3636</td>
<td>77.82</td>
</tr>
</tbody>
</table>

To help shed some light on the nature of the G1EFT x G1SEX x STUSEX interaction, a graphical depiction is presented in Figure 14.
The patterns represented in Figure 14 are rather intriguing, though interpretation should be tempered with the reminder that cell sizes were unbalanced and small. Low GEFT male graders appear to give ordinately higher grades to both male and female students than low GEFT female graders, with the advantage going to the females under either the male-grader or female-grader condition. The pattern would be identical for high GEFT graders if the female graders had given significantly lower grades to their male students. For the high GEFT graders, it appears that the advantage goes to the student with an opposite-sex grader. In general, there is more variance among the grades given by the low GEFT graders, than among grades given by the high GEFT graders, a result somewhat inconsistent with results in the field of appraisal research (Gruenfeld & Arbuthnot, 1969). (Based on their findings, Gruenfeld and Arbuthnot suggest that variability in ratings is significantly related to RFT but not to EFT performance of
the rater.) Moreover, if the high GEFT female graders had graded the males more severely, thus producing similar patterns for both high GEFT and low GEFT graders, the possibility exists that low grader GEFT (indicating field dependence) would be associated with higher student grades in general, an effect that has been predicted for the MRFT.

Univariate Analysis of Covariance of G1GRADE, Face-to-Face Arrangement, by Sex of Student and Sex of Grader, with Covariates TOTPRES, STURFT, and GIRFT.

The second analysis attempted in Stage 1 employed the same 2 x 2 model as previously employed, and tested the same effects as in the last analysis, with one exception: GEFT scores were replaced by MRFT scores for student and grader. Therefore with the following replacements, Table 36 represents the effects tested.

STUEFT replaced by STURFT
GEFT replaced by GIRFT

A test of the assumption of homogeneity of variance supported the assumption at the .01 level (Bartlett; F(3,1346) = 3.12236). Moreover, the assumption of parallel regression surfaces was tenable (F(9,26) = .5007, p > .85). The significance of all effects was tested via a univariate analysis of covariance. None of the effects achieved significance at the .05 level (p > .13 for all effects). This result was disappointing since it was predicted that grader MRFT scores would have a significant influence on grades in the face-to-face arrangement. It appears that the GEFT of the grader is a more promising measure in exploring grader differences and pathologies in the face-to-face grading situation.
Stage 2: Cognitive Style and Sex Effects: Non-Face-to-Face Grading

Descriptive Statistics

The second stage of the grading experiment focuses on effects of cognitive style and sex which might have been confounded by the interpersonal loading of the face-to-face grading arrangement. Specifically, to what extent do subtle cognitive effects of student/grader cognitive style matches and mismatches influence grading outcomes? And to what extent does the sex of the grader influence grading outcomes when no student/grader sex interaction effect is allowed to occur?

To address these questions the same 41 exams used in Stage 1 were used. Markings made by the "first graders" were removed and copies were assigned randomly to each of 41 graders employed by the Testing Center during a later semester. The individuals responsible for this regrading will be referred to as "non-face-to-face graders". The following codes have been used in referencing the variables relevant to the analysis of the second grading. (Some of these codes have already been introduced in the discussion of Stage 1, but will be repeated here since they also will be used in Stage 2 analysis.)

G2GRADE: The student's score on the first-try unit I test determined by the second (non face-to-face) grading.

G2EFT: The non-face-to-face grader's score on the GEFT.

G2RFT: The non-face-to-face grader's score on the MRFT.

STUEFT: The student's score on the GEFT.

STURFT: The student's score on the MRFT.

TOTPRE: The student's score on the pretest.
Means and standard deviations for the preceding variables are shown in Table 39, and breakdowns by sex follow in Table 40. Once again, the variable G2GRADE is of interest for what it tells us about both the student and the grader.

Table 39

Means and Standard Deviations for All Variables Pertinent to the Analysis of the 41 ExamS, Non-Face-to-Face Grading Arrangement

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>G2GRADE (15,100;100)</td>
<td>41</td>
<td>77.732</td>
<td>17.372</td>
</tr>
<tr>
<td>G2EFT (10,18;18)</td>
<td>41</td>
<td>15.732</td>
<td>1.803</td>
</tr>
<tr>
<td>G2RFT (2,40;0\textsuperscript{b})</td>
<td>41</td>
<td>13.610</td>
<td>8.933</td>
</tr>
<tr>
<td>STUEFT (3,18;18)</td>
<td>41</td>
<td>12.707</td>
<td>4.931</td>
</tr>
<tr>
<td>STURFT (4,43;0\textsuperscript{b})</td>
<td>41</td>
<td>17.317</td>
<td>9.493</td>
</tr>
<tr>
<td>TOTPRE (11,33;41)</td>
<td>41</td>
<td>19.268</td>
<td>5.167</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Numbers in parentheses are, respectively, the minimum score achieved in the sample, the maximum score achieved in the sample, and the maximum possible score.

\textsuperscript{b}For the MRFT the optimal score is 0, indicating a 0° total deviation of the rod (from true vertical).
Table 40

Means and Standard Deviations for All Variables Pertinent to the Analysis of the 41 Exams, Non Face-to-Face Grading Arrangement, by Sex

<table>
<thead>
<tr>
<th>Student's Sex</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>G2GRADE</td>
<td>23</td>
<td>73.913</td>
</tr>
<tr>
<td>STUEFT</td>
<td>23</td>
<td>12.696</td>
</tr>
<tr>
<td>TOTPRE</td>
<td>23</td>
<td>18.696</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Grader's Sex</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>G2GRADE</td>
<td>25</td>
<td>76.560</td>
</tr>
<tr>
<td>G2EFT</td>
<td>25</td>
<td>15.560</td>
</tr>
<tr>
<td>G2RFT</td>
<td>25</td>
<td>13.000</td>
</tr>
</tbody>
</table>

Zero-order (Pearson product-moment) correlation coefficients were computed for each pair of measures relevant to the analyses in Stage 2. These coefficients are presented in Table 41.
Table 41

Correlations for All Pairs of Variables Pertinent to the Analysis of Non-Face-to-Face Grading Outcomes

<table>
<thead>
<tr>
<th>Variables G2GRADE</th>
<th>G2EFT</th>
<th>G2RFT</th>
<th>STUEFT</th>
<th>STURFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>G2EFT</td>
<td>.0016</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(41)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G2RFT</td>
<td>-.0648</td>
<td>.0834</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(41)</td>
<td></td>
<td>(41)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STUEFT</td>
<td>-.1215</td>
<td></td>
<td>.0791</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(41)</td>
<td></td>
<td>(41)</td>
<td>(41)</td>
<td></td>
</tr>
<tr>
<td>STURFT</td>
<td>.2826*</td>
<td>.2621*</td>
<td>-.0828</td>
<td>-.1320</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(41)</td>
<td>(41)</td>
</tr>
<tr>
<td>TOTPRE</td>
<td>.1239</td>
<td>.2387</td>
<td>-.0155</td>
<td>.4398***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(41)</td>
<td>(41)</td>
</tr>
<tr>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Note. The number of pairs used in computing each correlation coefficient is given in parentheses.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p < .05  
*** p < .005

Stage 2 (Non-Face-to-Face Grading): Analyses

The intent in stage 2 was to remove the interpersonal component from the grading arrangement, in order to determine whether the purely cognitive aspects of students' and graders' cognitive styles might exert influence on the grading outcome via the exam paper alone. Of course, in this "solitary grading" arrangement, the sex of the student was no longer known, and hence disallowed from exerting influence on the grade. Recall that the 41 exam papers used in Stage 1 were cleared of all grader markings, photocopied, and distributed randomly to a new group of 41 graders. As in Stage 1, two separate analyses were conducted: one in order to test the effects of student and grader GEFT
performance (STUEFT and G2EFT respectively), and the other to test the effects of student and grader MRFT performance (STURFT and G2RFT respectively) on G2GRADE, the grade assigned by the grader in the solitary situation.

Univariate Analysis of Covariance of G2GRADE, Non-Face-to-Face Arrangement, by Sex of Grader, with Covariates TOTPRE, STUEFT, and G2EFT

The analysis employed a one-way univariate analysis of covariance with sex of the grader, G2SEX, as the nominal independent variable, G2GRADE as the dependent variable, and TOTPRE, STUEFT, and G2EFT as covariates. The order of effects tested in the sequential procedure is given in Table 42.

Table 42
Order of Effects Tested in the Univariate Analysis of Covariance of G2GRADE, Non-Face-to-Face Arrangement, by Sex of Grader with Covariates TOTPRE, STUEFT, and G2EFT.

<table>
<thead>
<tr>
<th>Order</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TOTPRE</td>
</tr>
<tr>
<td>2</td>
<td>STUEFT</td>
</tr>
<tr>
<td>3</td>
<td>G2SEX</td>
</tr>
<tr>
<td>4</td>
<td>STUEFT x G2SEX</td>
</tr>
<tr>
<td>5</td>
<td>G2EFT</td>
</tr>
<tr>
<td>6</td>
<td>G2EFT x G2SEX</td>
</tr>
<tr>
<td>7</td>
<td>G2EFT x STUEFT</td>
</tr>
<tr>
<td>8</td>
<td>G2EFT x STUEFT x G2SEX</td>
</tr>
</tbody>
</table>
A test of the assumption of homogeneity of variance supported the assumption at the .01 level (Bartlett; $F(1,3949) = 4.54906$), and the assumption of parallel regression surfaces was supported ($F(3,33) = .2226, p > .88$). The significance of each of the effects listed in Table 42 was then tested by the univariate analysis of covariance. None of the effects achieved significance ($p > .25$ for all effects).

Univariate Analysis of Covariance of G2GRADE, Non-Face-to-Face Arrangement, by Sex of Grader, with Covariates TOTPRE, STURFT, and G2RFT

The second analysis in Stage 2 employed the same oneway model as the previous analysis, with MRFT scores replacing GEFT scores for student and grader. Therefore with the following replacements, Table 42 represents the effects tested.

STUFT replaced by STURFT
G2EFT replaced by G2RFT

A test of the assumption of homogeneity of variance was supported at the .01 level ($F(1,3949) = 4.55$), and the assumption of parallel regression surfaces was also supported ($F(3,33) = .9972, p > .40$). The significance of all effects was tested via a univariate analysis of covariance. None of the effects achieved significance at the .05 level. However, the effect of STURFT on G2GRADE was significant at the .08 level ($F(1,32) = 3.28$). In Table 41 we saw that the zero-order correlation coefficient between STURFT and G2GRADE is positive and significant at the .05 level. In fact, the second partial correlation coefficient between STURFT and G2GRADE, adjusting for TOTPRE and G2RFT, is .2828 ($p < .05$). For the female students in
the sample this partial is .2492 (ns), and for the men it is .4261 (£ p < .03).

**G1GRADEs vs. G2GRADEs**

As a final, though rather primitive comparison of the face-to-face vs. non-face-to-face assessments of the 41 tests, a paired samples t-test was performed on the means of the G1GRADEs and G2GRADEs. Results are reported in Table 43.

Table 43

Comparison of Face-to-Face Graders' and Non-Face-to-Face Graders' Mean Scores on 41 Randomly Selected Unit I Calculus Tests Using a Paired Samples t-test

<table>
<thead>
<tr>
<th>Method</th>
<th>M</th>
<th>SD</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face-to-Face</td>
<td>80.56</td>
<td>17.53</td>
<td>2.49*</td>
</tr>
<tr>
<td>Non-Face-to-Face</td>
<td>77.73</td>
<td>17.37</td>
<td></td>
</tr>
</tbody>
</table>

*P < .02

It appears that grades assigned in the Face-to-Face arrangement are indeed significantly higher than grades assigned in the Non-Face-to-Face arrangement.

**Stage 3: Common Measure**

**Descriptive Statistics**

To provide a final means of investigating grader cognitive style and sex effects on calculus grades, each of the second group of graders graded the same set of three exams, composed of 15 randomly selected
items drawn from the archives of graded exams for units I, II and VII of calculus I and II. These three common exams, referred to as COMM1, COMM2, and COMM3 will be combined into a single measure, COMM, for analysis.

Descriptive statistics for each of the three common exams, as well as the combined measure and grader cognitive style measures are given in Table 44. Breakdowns by sex follow in Table 45.

Table 44
Means and Standard Deviations for All Variables Pertinent to the Analysis of the Common Exams

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>G2EFT (10,18;18)</td>
<td>41</td>
<td>15.732</td>
<td>1.803</td>
</tr>
<tr>
<td>G2RFT (2,40;0)</td>
<td>41</td>
<td>13.610</td>
<td>8.933</td>
</tr>
<tr>
<td>COMM1 (43,74;100)</td>
<td>41</td>
<td>57.049</td>
<td>7.018</td>
</tr>
<tr>
<td>COMM2 (11,51;100)</td>
<td>41</td>
<td>30.244</td>
<td>8.851</td>
</tr>
<tr>
<td>COMM3 (42,77;100)</td>
<td>41</td>
<td>65.073</td>
<td>8.250</td>
</tr>
<tr>
<td>COMM (121,185;300)</td>
<td>41</td>
<td>152.366</td>
<td>15.21</td>
</tr>
</tbody>
</table>

aN umbers in parentheses are, respectively, the minimum score achieved in the sample, the maximum score achieved in the sample, and the maximum possible score.

bFor the MRFT the optimal score is 0, indicating a 0° total deviation of the rod (from true vertical).
Table 45

Means and Standard Deviations for All Variables Pertinent to the Analysis of the Common Exams, by Sex

<table>
<thead>
<tr>
<th>Variable</th>
<th>Male</th>
<th></th>
<th></th>
<th>Female</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>SD</td>
<td>n</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>G2EFT</td>
<td>25</td>
<td>15.560</td>
<td>1.873</td>
<td>16</td>
<td>16.000</td>
<td>1.713</td>
</tr>
<tr>
<td>G2RFT</td>
<td>25</td>
<td>13.000</td>
<td>9.600</td>
<td>16</td>
<td>14.563</td>
<td>7.983</td>
</tr>
<tr>
<td>COMM1</td>
<td>25</td>
<td>54.760</td>
<td>6.547</td>
<td>16</td>
<td>60.625</td>
<td>6.355</td>
</tr>
<tr>
<td>COMM2</td>
<td>25</td>
<td>31.120</td>
<td>10.341</td>
<td>16</td>
<td>28.875</td>
<td>5.875</td>
</tr>
<tr>
<td>COMM3</td>
<td>25</td>
<td>65.800</td>
<td>8.067</td>
<td>16</td>
<td>63.937</td>
<td>8.668</td>
</tr>
</tbody>
</table>

Zero-order (Pearson product-moment) correlation coefficients were computed for each pair of variables. These coefficients are presented in Table 46.
Table 46

Correlations for All Pairs of Variables Pertinent to the Analysis of the Common Exams.

<table>
<thead>
<tr>
<th>Variables</th>
<th>G2EFT</th>
<th>G2RFT</th>
<th>COMM1</th>
<th>COMM2</th>
<th>COMM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>G2RFT</td>
<td>.0834</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(41)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMM1</td>
<td>.2046</td>
<td>.0857</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(41)</td>
<td>(41)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMM2</td>
<td>.0371</td>
<td>-.1167</td>
<td>.0851</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMM3</td>
<td>.0148</td>
<td>.1982</td>
<td>.0846</td>
<td>.1049</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
<td></td>
</tr>
<tr>
<td>COMM</td>
<td>.1240</td>
<td>.0791</td>
<td>.5568***</td>
<td>.6781****</td>
<td>.6425****</td>
</tr>
<tr>
<td></td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
<td>(41)</td>
</tr>
</tbody>
</table>

Note. The number of pairs used in computing each correlation coefficient is given in parentheses.

**** p < .001

Stage 3 (Solitary Grading of a Common Measure): Analysis

For this analysis the compilation of 15 items randomly selected from the archives of graded exams was used. This measure is referred to as COMM. Each of the graders in the second group graded COMM, thus producing 41 estimates of COMM. The analysis that follows was aimed at detecting any cognitive style or sex effects that may be operant in the solitary grading situation.
Univariate Analysis of Covariance of COMM by Sex of Grader, with Covariates G2EFT and G2RFT.

This analysis employed a oneway model (with G2SEX as the factor) to test the effects on COMM listed in Table 47.

Table 47
Order of Effects Tested in the Univariate Analysis of Covariance of COMM, by Sex of Grader, with Covariates G2EFT and G2RFT.

<table>
<thead>
<tr>
<th>Order</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G2RFT</td>
</tr>
<tr>
<td>2</td>
<td>G2EFT</td>
</tr>
<tr>
<td>3</td>
<td>G2SEX</td>
</tr>
<tr>
<td>4</td>
<td>G2RFT x G2SEX</td>
</tr>
<tr>
<td>5</td>
<td>G2EFT x G2SEX</td>
</tr>
</tbody>
</table>

A test of the assumption of homogeneity of variance supported the assumption (Bartlett; $F(1,3949) = 1.35153, p > .24$). Moreover, a test of the assumption of parallel regression surfaces supported that assumption ($F(2,35) = .3370, p > .70$). The univariate analysis of covariance revealed no significant effects ($p > .48$ for all effects tested).

The analyses conducted in exploring the questions that motivated the present study have failed to corroborate some of our conjectures. The expectation of a cognitive style by treatment group interaction was not supported. In addition, the expectation that MRFT-field-dependent graders would demonstrate a tendency to accede to the pressure of the student (and respond with significantly higher grades than
MRFT-field-independent graders) was not supported. However, several significant main effects and interactions were detected, and some new directions for future research are suggested. These issues will be considered in chapter V.
CHAPTER V

CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

Examination of Results

The purpose of the present study was to exploit the field dependence/independence construct (f-d/i) in the context of two experiments focusing on instruction and evaluation. More specifically, the study assessed the role of f-d/i in explaining the differential effectiveness of different types of audio-visual instruction, and in explaining differences in grading outcomes. One common thread, woven through the designs for analyzing the data in these experiments, binds a consideration of sex differences inextricably to the study of f-d/i. This concern for sex differences is not capricious but reflects the acknowledgment of persistent differences between the sexes on measures of f-d/i. Moreover, that identical cognitive style profiles may have different behavioral implications for two individuals of opposite sex is a possibility that should not be disregarded. It is with some comments on such sex differences that we begin a review of the present study.

Correlational Findings

As is frequently reported in the literature, the men in the present sample scored slightly higher than the women on the GEFT, and slightly lower than the women on the MRFT, however neither difference was significant. Moreover, the correlation between the two measures...
of cognitive style was significant for the men ($r = -0.2690, p < .005$) but not for the women ($r = -0.1700, ns$), a result consistent with that of Witkin and his associates (1954).

It also should be pointed out that the correlates of a given $f-d/i$ measure for one sex were not necessarily the correlates for the other sex. In the present sample this was particularly true with respect to mathematics achievement measures. For example, for men, the GEFT was significantly (and positively) correlated with PREQ and POSTQ ($p < .05$), while for the women these correlations were not significant. On the other hand, MRFT was significantly correlated with PREQ and CALCIV performance for women, but not for men. Moreover, for women, the correlation between MRFT and CALCIV was positive and significant ($p < .05$), suggesting that field-dependence might sometimes be associated with greater achievement in mathematics (as measured by CALCIV), a result that contradicts expectations based on many reported findings. For men, the correlation between MRFT and CALCIV was also positive but did not achieve significance at the .05 level. The sample-wide correlation between MRFT and CALCIV was positive and significant ($p < .02$).

The correlational findings suggest that the MRFT's correlational structure might include measures of mathematics achievement for women, while the GEFT's correlational structure does so for men. It would be interesting to pursue the nature of this sex difference in future research, particularly in an effort to understand the association of MRFT performance with mathematics achievement in women. Perhaps a study focusing on error analysis in calculus students might explore the possibility that error patterns in females are related to a
strategy selection deficiency or a mismanaged interrupt function (Pascuale-Leone, 1974), which leads the women to close prematurely in the solution of problems. In the theoretical framework developed here, we have implicated both strategy selection capabilities and the action of the interrupt function with MRFT performance.

**SEX x GROUP Effect in Experiment I**

In the experiment focusing on the two different methods of delivering audio-visual remedial instruction in trigonometry, three different experimental groups were used (DIALOG, MONOLOG, and CONTROL). A multivariate analysis of covariance revealed a significant SEX x GROUP effect on POSTQ scores when GEFT had been entered as the measure of cognitive style, but this effect was not significant in the analysis which entered MRFT as the measure of cognitive style. Two comments are in order.

First, the significant SEX x GROUP effect (Figure 12) suggests that the women outperformed the men following treatment of either DIALOG or MONOLOG type, while the pattern is reversed under the control condition. It had been hypothesized that field-dependent individuals might benefit more from the DIALOG treatment, while field-independents might benefit more from the MONOLOG condition. Clearly it seems that some aspect of both treatments was more facilitative to the learning of the women than the men. It is tempting to conclude that the dialogs were more facilitative for the women than the monologs. We would then conclude that the relaxed relationship between the female student and the instructor in the dialogs served a motivational
purpose for the women, or perhaps the interpersonal milieu was simply more congenial as a learning environment for the women, a statement which, in the planning phases of this study, had been applied to the field dependent learner. The fact that social aspects of inter­
ventionist treatment have been shown to be important to female learners in mathematics has already been discussed (Brady & Fox, 1980).

The second comment on the significant SEX x GROUP effect simply raises the question as to why the effect was significant in the analysis employing the GEFT but not in the analysis employing the MRFT. It is possible that the correlational structure existing between the MRFT and measures of mathematics achievement might in some way diminish the SEX x GROUP effect in the latter case.

GEFT x SEX Effect in Experiment I

The fact that high GEFT female students demonstrated a depression in POSTQ scores (Figure 13) is not surprising in the light of the weak correlational structure existing between the GEFT and measures of mathematics achievement for the women. In addition, it may be that the low and midrange GEFT women are more open to intervention in general and this openness had a positive influence on their achievement following the treatments. This result is totally consis­tent with the view explicated in chapter II that the learning of the field-dependent individual is both characterized by and enhanced by reliance on external sources of information.
GROUP and SEX Effects in Experiment I

In both analyses (GEFT and MRFT) in Experiment I, GROUP and SEX emerged as significant main effects, favoring treated vs. untreated groups on POSTQ and favoring females over males on POSTQ. Of some concern here is the fact that there was no group effect on CALCIV. Perhaps such a group effect is not to be expected when so many uncontrolled effects intervene between remedial instruction and unit IV testing. It also should be noted that students in both CONTROL groups (pretested and unpretested) were given a complete set of trigonometry remedial materials to work on at home.

GEFT x STUSEX x GISEX Effect in Experiment II

This effect was most intriguing and has been discussed earlier (Figure 14). The existence of the effect in the face-to-face grading arrangement may be in large measure due to the interaction of high GEFT female graders with male students. It is possible that the high GEFT females extended a grading advantage to male students, with whom they identify more closely.

STURFT Effect on G2GRADE in Experiment II

Once again we saw evidence of a positive relationship between performance on the MRFT and performance on a calculus test. This result suggests an advantage to the MRFT field-dependent individuals. Earlier we noted such an effect on the unit IV test. It may be that test-specific characteristics favor the more global processor. However, it seems more likely that the observed relationship might be related to the way high MRFT as opposed to low MRFT individuals use the system.
of mastery testing as a learning mechanism. Recall that students may take up to three tries on each unit calculus test. Some students use the first try or even the first two tries as a means of gathering information regarding the nature of the test questions. It seems quite plausible that field-dependent individuals are more likely to employ such a compensatory strategy than field-independents. The question of why MRFT-field-dependent as opposed to GEFT-field-dependent individuals would exhibit this behavior merits further study.

**G1GRADEs vs. G2GRADEs**

The average grade on the 41 randomly selected unit I calculus tests was significantly higher when the grading took place in the grader/student face-to-face arrangement than when the grading took place without the student present. This result suggests the importance of carefully monitoring the (face-to-face) grading scheme in the calculus course. Apparently all graders tend to inflate grades in the face-to-face setting (not just the high-MRFT graders, as was hypothesized). One remedy may be provided by making the allocation of points so specific in the grading manual that the grader is not quite as free to make judgments affecting large numbers of points. In most cases such an approach might come as a relief to the grader who can cite the solutions manual when an argument arises in the grading encounter.

One further note is in order. As mentioned above, the hypothesized relationship between MRFT performance and grades in the
face-to-face arrangement was not statistically significant. It is possible that this lack of significance is the result of two characteristics of MRFT-field-dependent graders working in tandem. It may be that MRFT-field-dependent graders are, in fact, more likely than the MRFT-field-independent graders to submit to the pressure of the student in the face-to-face grading situation, but that this effect is attenuated by the field-dependent's strict adherence to the grading manual, as an external source of information. Further research is needed to separate these two phenomena in such a way that their separate effects can be assessed.

GEFT and MRFT: A Metacomment

The hypothesized association of GEFT with the generation of problem solving templates and MRFT with the selection of problem solving templates is far from being substantiated. However the different correlational patterns that have been observed for the MRFT and GEFT, together with the different patterns of significant effects observed in the several pairs of GEFT vs. MRFT analyses lend support to the notion that the two measures are not equivalent. Indeed the possibility exists that not only do the GEFT and MRFT measure different aspects of cognitive functioning, but each measure may have different explanatory power for each of the sexes. The suggestion of Linn and Kyllonan (1981) that this possibility be accounted for in studies of f-d/i is heartily endorsed.
Questions and Answers

The research questions stated in Chapter I will now be repeated with responses suggested by the present study.

Primary Questions

1. What are the effects of remedial treatment conditions (dialog, monolog, and control) cognitive style, and sex upon three types of criterion measures: post-session quizzes (POSTQ), post-remedial program trigonometry achievement test, and delayed calculus achievement test (CALCIV) drawing on knowledge of trigonometry?

Response. First of all, the post-remedial program trigonometry test was dropped from all analyses because of poor reliability. As already discussed, GROUP x SEX, GEFT x SEX, GROUP, and SEX effects were significant on POSTQ, but not on CALCIV. However, neither the GEFT x GROUP nor MRFT x GROUP effect was significant, thus failing to support a cognitive style by treatment effect.

2. Are the GEFT and MRFT equivalent as cognitive style measures in producing patterns of effects of cognitive style and modality of instructional delivery on criterion measures?

Response. In the analysis employing the GEFT, SEX x GROUP, GEFT x SEX, GROUP, and SEX effects emerged as significant, while in the analysis employing the MRFT only the main effects, GROUP and SEX, emerged as significant. Thus the GEFT was more sensitive to the detection of interaction effects in this remedial setting.

3. How are calculus test scores affected by students' and graders' cognitive styles and sex?
Response. There was a GEFT x STUSEX x G1SEX interaction effect on calculus grades in the face-to-face grading arrangement. No such effect was detected when the MRFT was replaced as the grader cognitive style measure, nor was any such interaction effect detected in the non-face-to-face grading arrangement. In neither face-to-face (Stage 1), nor non-face-to-face grading (Stages 2 and 3), was there a main effect of grader cognitive style, measured either by the GEFT or MRFT.

4. Are the GEFT and MRFT equivalent as cognitive style measures in detecting grader or student effects on calculus test scores?

Response. The EFT was useful in detecting the significant interaction (GEFT x STUSEX x G1SEX) in the face-to-face grading situation, while the MRFT was useful in detecting a student cognitive style main effect on the unit I test graded in the solitary situation.

Secondary Questions

1. Are there significant sex differences present on either cognitive style measure, the course pretest, or the unit IV calculus test?

Response. No significant sex differences were detected on any one of these measures.

2. Are the same patterns of cognitive style effects present in both face-to-face and non-face-to-face grading situations?

Response. No. In the face-to-face setting, a grader cognitive style (GEFT) x student sex x grader sex interaction was significant. In the non face-to-face setting no grader effects were significant.

3. Are there significant treatment effects on the unit IV calculus test?
Response. There is no evidence to support the claim that the difference is significant.

4. Are scores given in the face-to-face situation significantly higher than scores given in the non-face-to-face situation?
Response. Yes.

New Questions

When one attempts to suggest questions that follow logically and constructively along the lines established by prior research, one is often best advised to begin by trying to answer some old questions with data supplied by new subjects or analyzed by different techniques. The grader cognitive style x student sex x grader sex interaction observed in the present study was certainly intriguing. However because of small unbalanced cells, it should be interpreted with caution. A replication study might enlist a larger number of subjects and employ blocking techniques so that cells would be balanced and moderately large. Such methodology would greatly enhance the validity of a statistically significant finding.

Another question that warrants detailed study involves the claim made by the investigator that the EFT correlates with the ability to generate possible solutions or templates to a problem situation, while the RFT correlates more with the ability to select productive solutions from among a list including salient, but nonproductive ones. The present setting was far too "overnourished" to test out such a claim. It seems reasonable that problem solving aptitude measures could be constructed (for some area of mathematics) in such a way that the two skills of "potential solution generation" and "correct selection of
available potential solutions" might be separated. A study could then be designed to test the hypothesis regarding the explanatory value of the EFT and RFT for these two skills.

Finally, exploratory studies seem to be warranted which identify activities for which a certain fixed level of performance in one of the f-d/i measures predicts significantly different performance by men and women. The generation of a class of activities sharing this common characteristic might help greatly in the generation of hypotheses regarding the cognitive processes which are functions of one's position on the f-d/i continuum as well as one's sex.


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APPENDICES
APPENDIX A

SCATTERGRAMS FOR SELECTED PAIRS OF VARIABLES RELEVANT TO EXPERIMENT I
Figure A-1. Scattergram of MRFT (vertical) vs. GEFT (horizontal), entire remedial group.
Figure A-2. Scattergram of POSTQ (vertical) vs. GEFT (horizontal), entire remedial group.
Figure A-3. Scattergram of POSTQ (vertical) vs. MRFT (horizontal), entire remedial group.
Figure A-4. Scattergram of CALCIV (vertical) vs. GEFT (horizontal), entire remedial group.
Figure A-5. Scattergram of CALCIV (vertical) vs. MRFT (horizontal), entire remedial group.
Figure A-6. Scattergram of MRFT (vertical) vs. GEFT (horizontal), remedial women.
Figure A-7. Scattergram of POSTQ (vertical) vs. GEFT (horizontal), remedial women.
Figure A-8. Scattergram of POSTQ (vertical) vs. MRFT (horizontal), remedial women.
Figure A-9. Scattergram of CALCIV (vertical) vs. GEFT (horizontal), remedial women.
Figure A-10. Scattergram of CALC IV (vertical) vs. MRFT (horizontal), remedial women.
Figure A-11. Scattergram of MRFT (vertical) vs. GEFT (horizontal), remedial men.
Figure A-12. Scattergram of POSTQ (vertical) vs. GEFT (horizontal), remedial men.
Figure A-13. Scattergram of POSTQ (vertical) vs. MRFT (horizontal), remedial men.
Figure A-14. Scattergram of CALCIV (vertical) vs. GEFT (horizontal), remedial men.
Figure 15-A. Scattergram of CALCIV (vertical) vs. MRFT (horizontal), remedial men.
APPENDIX B

PRESESSION AND POSTSESSION QUIZZES
PRE-TEST!

Instructions: (1) Leave answers in irrational form; for example, \( \frac{\pi}{2} \) \( \sqrt{3}/2 \) are acceptable answers. Don't waste time finding decimal approximations to \( \pi \), \( \sqrt{2} \) etc.
(2) Do all work on this paper.
(3) There's a clock in this room. Give yourself no more than 10 minutes to work on these questions.
(4) Don't refer to any notes as you do these questions.

1. State the Pythagorean Theorem as it applies to the following triangle.

Note: The symbol \( \square \) represents a right angle (90°)

2. Find the length of side \( a \) in the right triangle below.

3. Define: isosceles right triangle.

4. Find the length of side \( P \) in the right triangle below.

5. Define: acute angle.

(continued on other side)
6. Find the length of side $t$ in the right triangle below.

7. What is the formula for the circumference of a circle of radius $R$?

8. What is the circumference of a circle with radius equal to 7 inches?

9. Identify the angle (in degrees) that subtends (cuts) an arc of length $\pi/6$ on the unit circle.

10. Find the coordinates of point $P$ in the following diagram.
PRE-TEST!

Instructions: (1) Leave answers in irrational form; for example, $9\pi/2$, $\sqrt{3}/2$ are acceptable answers. Don’t waste time finding decimal approximations to $\pi$, $\sqrt{2}$ etc.
(2) Do all work on this paper.
(3) There's a clock in this room. Give yourself no more than 10 minutes to work on these questions.
(4) Don't refer to any notes as you do these questions.

1. What do we mean when we say that an angle is in standard position? (Use a diagram if you want to.)

2,3. What is the approximate measurement of angle $A$ (in degrees) in each of the following diagrams?

Answer: 

Answer: 

4. Convert $\pi/4$ radians to degree measurement.

5. Convert $135^\circ$ to radian measurement.

(more questions on the other side...)
6.7.8. The coordinates of point $P$ are $(x,y)$. Find the values of the following trig functions of angle $t$ in terms of the coordinates of $P$.

\[ \sin t = \ \ \ \ \cos t = \ \ \ \ \tan t = \ \ \ \ \]

9. Find: $\sin \pi/4$

10. Find: $\tan 150^\circ$
PRE-TEST!

PRE-3

Name:

Instructions:  (1) Leave answers in irrational form; for example, $9\pi/2, \sqrt{3}/2$ are acceptable answers. Don’t waste time finding decimal approximations to $\pi, \sqrt{2}$ etc.

(2) Do all work on this paper.

(3) There’s a clock in this room. Give yourself no more than 10 minutes to work on these questions.

(4) Don’t refer to any notes as you do these questions.

(5) TRY to do your best!

1,2,3. Fill in the blanks with something that makes the statement correct.

\[
\sin^2 t + \underline{\phantom{0000000000}} = 1 \\
1 + \underline{\phantom{0000000000}} = \sec^2 t \\
\sin(-t) = \underline{\phantom{0000000000}}
\]

4. Name one value of $x$ where the function $y = \tan x$ is not defined.

5. Multiply and simplify (the only trig function involved in your answer should be $\sin x$):

\[\cos y (\tan y - \sec y)\]

(More questions on the other side...)
6. Expand and simplify:

\[(\sin x + \cos x)^2\]

7. Prove the following identity:

\[\frac{1 + \cos \theta}{\sin \theta} + \frac{\sin \theta}{\cos \theta} = \frac{\cos \theta + 1}{\sin \theta \cos \theta}\]

8. The period of the sine function is ________________.

9. The period of the tangent function is ________________.

10. Give a rough sketch of the function:

\[f(x) = \cos 2x\]
PRE-TEST!

Instructions: (1) Leave answers to numerical problems in irrational form; for example, \((\sqrt{2} + 3)/\sqrt{5}\) is a perfectly acceptable form: don't waste time finding decimal approximations to \(-\sqrt{2}, \sqrt{2}\) etc.
(2) Do all work on this paper.
(3) There's a clock in this room. Give yourself no more than 10 minutes to work on these questions.
(4) Don't refer to any notes as you do these questions.
(5) Try to do your best!

FILL IN THE BLANKS WITH SOMETHING THAT MAKES THE RESULTING STATEMENT A USEFUL IDENTITY.

1. \(\cos(A - B) = \) .................................................................

2. \(\sin(A + B) = \) .................................................................

3. \(\tan(A + B) = \) .................................................................

4. \(\sin 2A = \) .................................................................

5. \(\cos 2A = \) .................................................................

(More questions on the other side...)
6. If \( A \) is an acute angle, and \( \cos A = \frac{3}{5} \), calculate \( \sin 2A \). (HINT: draw a picture.)

7. Use one of the identities on the other side of this page to calculate \( \sin 75^\circ \).

8. Find: \( \cos 15^\circ \)

9. Prove the identity: \( \frac{1 + \cos 2\theta}{\sin 2\theta} = \cot \theta \)

10. Solve the equation for \( A \) in the interval \([0, 2\pi)\):
    \[
    \sin 2A + \cos^2 A = 0
    \]
PRE-TEST!

INSTRUCTIONS: (1) Graphs need not be exact. A good sketch will do. Don't waste time plotting a lot of points.
(2) Do all your work on this paper.
(3) There's a clock in this room. Give yourself no more than 10 minutes for these 10 questions.
(4) Don't refer to any notes as you do these questions.
(5) Try to do your best!

1. \( f = \{(1,2), (3,5), (2,8), (4,3)\} \)
   
   \( f^{-1} = \) ________________.

2. Below you see a graph of function \( g \). Draw \( g^{-1} \) on the same set of axes.

   ![Graph of Function g](image)

3. Given that \( f(x) = 2x + 1 \), find a formula for \( f^{-1}(x) \).

4. Give an example of a one-to-one function.

(MORE ON REVERSE SIDE...)
5. Graph: \( y = \arcsin x \).

6. Graph: \( y = \arccos x \).

7. Graph: \( y = \arctan x \).

8. Find: \( \arcsin \left(-\frac{\sqrt{3}}{2}\right) \)

9. Find: \( \arccos \left(\frac{\sqrt{3}}{2}\right) \)

10. Find: \( \cos(\arctan (-1)) \)
POST-TEST

POST-I Name: __________________________

Instructions: (1) Leave answers in irrational form; for example, $9\pi/2$, $\sqrt{3}/2$ are acceptable answers. Don't waste time finding decimal approximations to $\pi$, $\sqrt{2}$ etc.
(2) Do all work on this paper.
(3) There's a clock in this room. Give yourself no more than 10 minutes to work on these questions.
(4) Don't refer to any notes as you do these questions.

1. State the Pythagorean Theorem as it applies to the following triangle.

   ![Diagram of a right triangle]

   Note: The symbol $\angle B$ represents a right angle ($90^\circ$)

2. Find the length of side $a$ in the right triangle below.

   ![Diagram of a right triangle with sides 3 and 7]

3. Define: *isosceles right triangle*.

4. Find the length of side $T$ in the right triangle below.

   ![Diagram of a right triangle with sides 8 and 30°]

5. Define: *acute angle*

   (continued on other side)
6. Find the length of side \( n \) in the right triangle below.

```
\[ \text{\textbf{G}} \]
```

7. What is the formula for the circumference of a circle of radius \( R \)?

8. Find the circumference of a circle with radius equal to 9 cm.

9. Identify the angle (in degrees) that subtends (cuts) an arc of length \( \pi/4 \) on the unit circle.

10. Find the coordinates of point \( P \) in the following diagram.

```
\[ (0, 1) \leftarrow (1, 0) \]
```
POST-TEST

POST-2

Name: ____________________________________

Instructions: (1) Leave answers in irrational form; for example, 9π/2, \sqrt{3}/2 are acceptable answers. Don't waste time finding decimal approximations to π, \sqrt{2} etc.
(2) Do all work on this paper.
(3) There's a clock in this room. Give yourself no more than 10 minutes to work on these questions.
(4) Don't refer to any notes as you do these questions.

1. Define: **standard position** of angle \( t \) (use a diagram if necessary).

2.3. What is the approximate measurement of angle \( A \) (in degrees) in each of the following diagrams?

![Diagram 1]

Answer: 

![Diagram 2]

Answer: 

4. Convert 2π/3 radians to degree measurement.

5. Convert 120° to radian measurement.

(more questions on the other side...)
6, 7, 8. The coordinates of point $P$ are $(x, y)$. Find the values of the following trig functions of angle $t$ in terms of the coordinates of $P$.

$$
\sin t = \quad \cos t = \quad \tan t =
$$

9. Find: $\cos 240^\circ$

10. Find: $\tan \pi/6$
POST-TEST

POST-3

Instructions: (1) Leave answers in irrational form; for example, $\frac{\pi}{2}, \sqrt{2}/2$ are acceptable answers. Don't waste time finding decimal approximations to $\pi, \sqrt{2}$ etc.

(2) Do all work on this paper.

(3) There's a clock in this room. Give yourself no more than 10 minutes to work on these questions.

(4) Don't refer to any notes as you do these questions.

(5) TRY to do your best!

1,2,3. Fill in the blanks with something that makes the statement correct.

\[ \quad + \cos^2 t = 1 \]
\[ 1 + \cot^2 t = \quad \]
\[ \cos(-t) = \quad \]

4. Name one value of $x$ where the function $y = \tan x$ is not defined.

5. Multiply and simplify (the only trig function involved in your answer should be $\cos x$):

\[ \sin y (\cot y - \csc y) \]

(More questions on the other side...)
6. Expand where necessary and simplify:

\[(\tan x + \cot x)^2 - \cot^2 x\]

7. Prove the following identity:

\[\sec x - \sin x \tan x = \cos x\]

8. The period of the cosine function is

9. The period of the tangent function is

10. Give a rough sketch of the function:

\[f(x) = \cos 2x\]
FILL IN THE BLANKS WITH SOMETHING THAT MAKES THE RESULTING STATEMENT A USEFUL IDENTITY.

1. \( \cos(A + B) = \) ________________________________________________________.

2. \( \sin(A - B) = \) ________________________________________________________.

3. \( \tan(A - B) = \) ________________________________________________________.

4. \( \sin 2A = \) ____________________________________________________________.

5. \( \cos 2A = \) ____________________________________________________________.

(More questions on the other side...)

POST-TEST

POST-4

Instructions: (1) Leave answers to numerical problems in irrational form; for example \( (\sqrt{2} + \sqrt{3})/\sqrt{6} \) is a perfectly acceptable form; don't waste time finding decimal approximations to \( \pi, \sqrt{2} \) etc.
(2) Do all work on this paper.
(3) There's a clock in this room. Give yourself no more than 10 minutes to work on these questions.
(4) Don't refer to any notes as you do these questions.
(5) Try to do your best!
6. If \( A \) is an acute angle and \( \sin A = \frac{5}{13} \), find \( \sin 2A \).

7. Use one of the identities on the other side of this page to calculate \( \sin 15^\circ \).

8. Find: \( \cos 75^\circ \)

9. Prove the identity: \( \frac{\sin 2\theta}{1 + \cos 2\theta} = \tan \theta \)

10. Solve the equation for \( A \) in the interval \( [0, 2\pi) \):
    \[
    \sin 2A + \cos^2 A = 0
    \]
POST-TEST
BEFORE YOU BEGIN, READ THE INSTRUCTIONS CAREFULLY!!

INSTRUCTIONS: (1) Graphs need not be exact. A good sketch will do. Don't waste time plotting a lot of points.
(2) Do all your work on this paper.
(3) There's a clock in this room. Give yourself no more than 10 minutes for these 10 questions.
(4) Don't refer to any notes as you do these questions.
(5) Do your best!
(6) When you have completed the problems on this paper, detach it from the other pages and give it to the lab assistant, then proceed with the summary post-test—it is imperative that you try your best on it!

1. \( f = \{(8,9), (9,10), (9,11), (9,12)\} \)
\[ f^{-1} = \]

2. Below you see a graph of function \( g \). Draw \( g^{-1} \) on the same set of axes.

3. Given that \( f(x) = 9x - 7 \), find a formula for \( f^{-1}(x) \).

4. Give an example of a function that is NOT one-to-one.
5. Graph: \( y = \arcsin x \).

6. Graph: \( y = \arccos x \).

7. Graph: \( y = \arctan x \).

8. Find: \( \arcsin \left( \frac{\sqrt{2}}{2} \right) \)

9. Find: \( \arccos \left( -\frac{\sqrt{2}}{2} \right) \)

10. Find: \( \sin(\arctan \frac{\sqrt{3}}{3}) \)
### Experiment I

The raw data used in the analyses for Experiment I are given in this appendix. The variables and codes corresponding to the given columns of data are provided below. Codes for missing data are also given. It should be noted that the missing data codes have been used in those cases where the given variable was not applicable. For example, a student whose experimental group code is 7 (column 2), will, by definition, have missing data codes in columns 12-21, since that student was not required to take any of the pre- or postsession quizzes.

<table>
<thead>
<tr>
<th>Column</th>
<th>Variables and Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Student Identification Number</td>
</tr>
<tr>
<td>2.</td>
<td>Experimental Group</td>
</tr>
<tr>
<td></td>
<td>1 = Dialog with presession quizzes</td>
</tr>
<tr>
<td></td>
<td>2 = Dialog with no presession quizzes</td>
</tr>
<tr>
<td></td>
<td>3 = Monolog with presession quizzes</td>
</tr>
<tr>
<td></td>
<td>4 = Monolog with no presession quizzes</td>
</tr>
<tr>
<td></td>
<td>5 = Control with presession quizzes</td>
</tr>
<tr>
<td></td>
<td>6 = Control with no presession quizzes</td>
</tr>
<tr>
<td></td>
<td>7 = No remediation necessary; not in study</td>
</tr>
<tr>
<td>3.</td>
<td>Class</td>
</tr>
<tr>
<td></td>
<td>1 = Freshman</td>
</tr>
<tr>
<td></td>
<td>2 = Sophomore</td>
</tr>
<tr>
<td></td>
<td>3 = Junior</td>
</tr>
<tr>
<td></td>
<td>4 = Senior</td>
</tr>
<tr>
<td></td>
<td>5 = Graduate Student</td>
</tr>
<tr>
<td></td>
<td>6 = Special Student</td>
</tr>
<tr>
<td></td>
<td>9 = Missing datum</td>
</tr>
<tr>
<td>4.</td>
<td>College</td>
</tr>
<tr>
<td></td>
<td>1 = Division of Continuing Education</td>
</tr>
<tr>
<td></td>
<td>2 = Life Science and Agriculture</td>
</tr>
<tr>
<td></td>
<td>3 = Liberal Arts</td>
</tr>
<tr>
<td></td>
<td>4 = Engineering and Physical Sciences</td>
</tr>
<tr>
<td></td>
<td>5 = Graduate School</td>
</tr>
<tr>
<td></td>
<td>6 = Health Studies</td>
</tr>
<tr>
<td></td>
<td>7 = Thompson School</td>
</tr>
<tr>
<td></td>
<td>8 = Whittemore School (Business)</td>
</tr>
<tr>
<td></td>
<td>9 = Missing datum</td>
</tr>
<tr>
<td>5.</td>
<td>Sex</td>
</tr>
<tr>
<td></td>
<td>1 = Female</td>
</tr>
<tr>
<td></td>
<td>2 = Male</td>
</tr>
</tbody>
</table>
6. Pretest: algebra subtest score
7. Pretest: trigonometry subtest score
8. Group Embedded Figures Test score
9. Miniaturized Rod and Frame Test score
   99 = Missing datum
10. Trigonometry program posttest score (dropped from all analyses due to poor reliability)
    99 = Missing datum
11. Unit IV calculus test score
    999 = Missing datum
12. Presession 1 quiz
13. Postsession 1 quiz
14. Presession 2 quiz
15. Postsession 2 quiz
16. Presession 3 quiz
17. Postsession 3 quiz
18. Presession 4 quiz
19. Postsession 4 quiz
20. Presession 5 quiz
21. Postsession 5 quiz
Experiment II

The raw data used in the analyses for Experiment II are given below, following a description of the variables and codes corresponding to the various columns of data. There were no missing values in the data set.

<table>
<thead>
<tr>
<th>Column</th>
<th>Variables and Codes</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Face-to-face grader's score on the Miniaturized Rod and Frame Test</td>
</tr>
<tr>
<td>2.</td>
<td>Face-to-face grader's score on the Group Embedded Figures Test</td>
</tr>
<tr>
<td>3.</td>
<td>Face-to-face grader's sex</td>
</tr>
<tr>
<td>4.</td>
<td>Score on unit I calculus test given by face-to-face grader</td>
</tr>
<tr>
<td>5.</td>
<td>Non-face-to-face grader's score on the Miniaturized Rod and Frame Test</td>
</tr>
<tr>
<td>6.</td>
<td>Non-face-to-face grader's score on the Group Embedded Figures Test</td>
</tr>
<tr>
<td>7.</td>
<td>Non-face-to-face grader's sex</td>
</tr>
<tr>
<td>8.</td>
<td>Score on unit I calculus test given by non-face-to-face grader</td>
</tr>
<tr>
<td>9.</td>
<td>Student's sex</td>
</tr>
<tr>
<td>10.</td>
<td>Student's score on the algebra subtest of the pretest</td>
</tr>
<tr>
<td>11.</td>
<td>Student's score on the trigonometry subtest of the pretest</td>
</tr>
<tr>
<td>12.</td>
<td>Student's score on the Group Embedded Figures Test</td>
</tr>
<tr>
<td>13.</td>
<td>Student's score on the Miniaturized Rod and Frame Test</td>
</tr>
<tr>
<td>14.</td>
<td>Score given by non-face-to-face grader on common exam 1</td>
</tr>
<tr>
<td>15.</td>
<td>Score given by non-face-to-face grader on common exam 2</td>
</tr>
<tr>
<td>16.</td>
<td>Score given by non-face-to-face grader on common exam 3</td>
</tr>
</tbody>
</table>