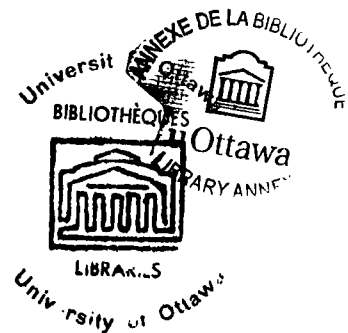


EXTENT OF PSYCHOLOGICAL DIFFERENTIATION  
AS RELATED TO ACHIEVEMENT IN  
SCIENCE AND ATTITUDE TOWARD SCIENCE

by Anna Bowles

Thesis presented to the Faculty of  
Education as partial fulfillment of  
the requirements for the degree of  
Masters of Arts in Education.



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## CURRICULUM STUDIORUM

Anna Bowles (nee Alekov), was born June 3, 1946, in Bamberg, Germany. She received her Bachelor of Science (Hon.) degree in Chemistry and Mathematics from Queen's University, Kingston, Ontario, in 1969. She received her Bachelor of Education degree from Queen's University, Kingston, Ontario in 1970.

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## INTRODUCTION

Previous work has suggested that there are relationships between the extent of psychological differentiation and both attitude toward science and achievement in science. The present study identifies and investigates these relationships.

Witkin's construct of field independence, including its origins, methods of assessment, personality correlates and related parameters such as intelligence and sex are reviewed in the first five sections of chapter one. The principle of psychological differentiation and its relationship to attitudes to science and achievement in science are also discussed. The statement of the problem and the basic hypothesis are contained in chapter one. In chapter two is described the experimental design utilized to test the hypothesis, including a discussion of the sample, the psychometric instruments and the general procedure. The results of this study are presented and discussed in chapter three.

## CHAPTER I

### REVIEW OF THE LITERATURE

Witkin's hypothesis that perceptual "field dependence" is a measure of the "extent of psychological differentiation" has initiated research linking perceptual style to a wide variety of personality and intellectual variables.

Presented within the first chapter is the theoretical basis for the inquiry into the relationship between achievement in science, attitude toward science and field independence. The theoretical rationale for the tests used to measure attitude toward science, achievement in science and field independence is included. The first section outlines Witkin's psychological differentiation hypothesis in which a continuum of field dependence-field independence is established. There follows a criticism of Witkin's hypothesis. The rationale for linking achievement in science and attitude toward science to field independence is considered and the problem and research proposal are presented.

#### 1. Perceptual Differentiation and the Psychological Differentiation Hypothesis.

The differentiation concept was first developed by Werner. "Differentiation", as stated by Werner<sup>1</sup>, stands for

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1 H. L. Werner, Comparative Psychology of Mental Development, New York, International University Press, Inc., 1948, p. 40-46.

increased structuralization and specialization of functions and systems. In his orthogenetic principle, Werner states that during development "organization is less differentiated, more homogeneous at earlier levels than at more advanced stages".<sup>2</sup>

This statement emphasizes that primitive modes of functioning are gradually built upon and taken over by higher more sophisticated modes. In this light, the ability to make differentiated perceptions is reflected in the total maturational process.

Witkin describes differentiation in several ways.<sup>3</sup> He refers to differentiation, in an all-inclusive sense, as the complexity of a system's structure; meaning that a property of a highly differentiated system is specialization; whereas, in less differentiated systems, functions are performed not in specialized groups but in groups which lump things together in an elementary fashion.

When referring to an individual's psychological system, a highly differentiated person can clearly separate within psychological areas such as feeling from perceiving, thinking from acting, whereas a less differentiated system

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2 H. L. Werner, Op. Cit., 1948, p. 56.

3 H. A. Witkin, R. B. Dyke, H. F. Faterson, D. R. Goodenough, S. A. Karp, Psychological Differentiation, New York, John Wiley, 1962, p. 2.

tends to diffuse these areas.<sup>4</sup>

When considering the relationship of the surrounding field, a highly differentiated person clearly separates that which belongs to itself and that which is external to self. A highly differentiated person experiences definite limits on the self, whereas a less differentiated person relies on an external source for guidance.

A central characteristic of psychological differentiation is style of experiencing. The undifferentiated person would tend to be field-dependent in his performance, whereas the person who is more differentiated would tend to perform in a field-independent manner. Witkin equates field-independence with analytical mindedness and field-dependence with global mindedness.

In developing his differentiation hypothesis, Witkin states that:<sup>4</sup>

"Implicit in this hypothesis is the view that greater inner differentiation is associated with greater articulation of experience of the world."

This quotation suggests that Witkin assumes a very close association between inner and outer differentiation, since he implies that a person who has greater inner differentiation tends to see the world in a more analytical manner

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<sup>4</sup> Witkin et al., Op. Cit., 1962, p. 9 -16.

and hence has more discrete experiences in the external world rather than a hazy image of the world. Thus it is possible to test his hypothesis of inner differentiation by measuring only the external differentiation.

In a group of experiments in the 1940's concerning the perception of the upright, Witkin et. al.<sup>5</sup> showed that the way people orient themselves in space was self-consistent and stable. This orientation was first measured by the Rod-and-Frame test (RFT) in which the subject is required to sit in a dark room facing a rod surrounded by a frame. Both the rod and frame are lit. While the frame is tilted, the subject is asked to adjust the rod to the position he thinks is upright. The subject is tested both while he is sitting erect and while he is tilted. A large deviation from the vertical of the rod, when the subject reports it as being vertical is taken to be an indication that the subject tends to use the visual field to align the rod. A small deviation from the vertical is taken as an indication that the subject is independent of the field and tends to use his body to establish the upright. Witkin labelled as field-dependent those subjects who determine the upright position with respect to the frame, i.e. the visual field that immediately surrounds it. Those subjects who are

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5 H. A. Witkin, H. P. Lewis, M. Hertzman, K. Machover, P. B. Meissner, S. Wapner, Personality Through Perception, New York, Harper, 1954, p. 1-10.

capable of bringing the rod close to the true upright position by perceiving it independently from the frame are labelled as field-independent. Witkin maintains that subjects who are field-independent experience their surroundings analytically so that objects are perceived as discrete from their background.<sup>6</sup> This enables field-independent subjects to consistently perform more effectively on embedded tasks than field-dependent subjects.

Field-dependent subjects tend to require a long time in finding a familiar figure embedded in a complex design.<sup>7</sup> Because field-dependent people tend to be less likely to try to decipher ambiguous stimuli, these stimuli appear vague and indefinite. They tend to have difficulty in picture completion and in the analytical section of intelligence tests. Field-dependent subjects have also been found to be very observant, as a whole, to things around them and have no problem at recognizing faces that they have seen only briefly.<sup>8</sup>

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6 Witkin et al., Op. Cit., 1962, p. 35.

7 H. A. Witkin, R. B. Dyke, H. F. Faterson, D. R. Goodenough, S. A. Karp, Psychological Differentiation, New York, John Wiley, 1962, p. 2.

8 Witkin, et al., Op. Cit., 1962, p. 3.

that Witkin conducted concerning incidental learning.<sup>12</sup> He tested the hypothesis that children with a global field approach would tend to show relatively little incidental learning. The children's incidental learning scores were compared to their perceptual scores, and a correlation of .37 (N = 38,  $p < .5$ ) tended to support the hypothesis.

Field-independent people have been found to have a more stable self-view, whereas people who are field-dependent have been found to be more sensitive to the evaluations that others make of them. Rudin and Stagner studied the stability of self-view<sup>13</sup>. They used the Self-Contextual Influence Test in which the subject is required to imagine himself in four situations and then rate himself on Osgood's Semantic Differential. The scoring is designed to reflect the similarity of the subject's self-view. These similarity scores were shown to be correlated significantly with Witkin's RFT and Thurstone's Embedded Figures Test - both tests of perceptual field dependence. Field-independent subjects tended to maintain a more consistent self-view.

The nature of controls and defenses of field-dependent and field-independent subjects is varied. In his studies with children, Witkin found that analytic children would use more complex forms of defense such as isolation or intellectual-

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12 Witkin et al., Op. Cit., 1962, p.141.

13 Stanley A. Rudin, and Ross Stagner, "Figure-Ground Phenomena in the Perception of Physical and Social Stimuli", Journal of Psychology, Vol. 45, 1958, p. 213-225.

Field-independent people, on the other hand, indicate a direct contrast in many of these characteristics. They tend to score highly on the analytical portion of intelligence tests.<sup>9</sup> They tend to have no problems with embedded figure-type tests.<sup>10</sup>

In his study on the child's behaviour while taking the Thematic Apperception Test (TAT), Witkin hypothesized that analytically minded children would react in a different way from global children where a task was defined in general terms.<sup>11</sup> A study of TAT records of thirty-eight ten-year old boys was done. Children, who were field-dependent, it was hypothesized, would tend to seek guidance from the examiner as to how to go about doing what they needed to do; whereas, children, who were field-independent would define their roles for themselves and would proceed with greater confidence. Witkin found support for his hypothesis on the behaviour of field-dependent and field-independent children. For these children, the TAT ratings related significantly to perceptual index scores ( $r = 0.70$ ,  $p < 0.01$ ) in the expected direction.

Another instance of contrast between the field-dependent and field-independent child was shown in a study

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9 Witkin et al., Op. Cit., 1962, p. 70.

10 Witkin et al., Op. Cit., 1962, p. 45.

11 Witkin et al., Op. Cit., 1962, p. 136.

zation<sup>14</sup>. Field-dependent children, however would tend to use massive repression and would have structured controls and defenses. Witkin also examined the nature of controls and defenses by studying the way children coped with themes of aggression in the Thematic Apperception Test (TAT). His findings showed that:

". . . children with a global field approach tend to be less able to contain, modulate and channelize aggressive ideas and feelings than children with an analytical field approach."<sup>15</sup>

A major finding of Witkin's earlier work was that young children tended to perceive in a field-dependent manner and as they became older they tended to become more field-independent<sup>16</sup>.

In a later study, Witkin and coworkers examined the stability of cognitive style from childhood to adulthood<sup>17</sup>. Their longitudinal study included two groups, one from eight to thirteen years of age and the other from twenty to twenty-four years of age. They concluded that children show a marked relative stability in field-dependence or field-independence even over a period of fourteen years. Their

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14 Witkin et al., Op. Cit., 1962, p. 157.

15 Witkin et al., Op. Cit., 1962, p. 169.

16 Witkin et al., Op. Cit., 1962, p. 377.

17 H. A. Witkin, D. R. Goodenough, S. Karp, "Stability of Cognitive Style from Childhood to Young Adulthood", in Journal of Personality and Social Psychology, Vol. 7, No. 3, 1967, p. 291-300.

findings, in their longitudinal study, demonstrated that despite a general increase in differentiation in perceptual functioning with age, each individual tended to maintain his relative position among his peers.

Some observed trends in the characteristics of field-dependent-field-independent persons have been given. Witkin's concept of psychological differentiation has been described. However, certain aspects of his work have come under sharp criticism.

## 2. Criticism of Witkin's Work

One major criticism is Witkin's lack of control for intelligence. Zigler maintained that field independence was simply a reflection or extension of general intelligence.<sup>18</sup> He implied that if the general intelligence variable was taken out, then the magnitude of certain significant relationships reported would remain relatively undisturbed, certain others would be reduced and still others would be eliminated.<sup>19</sup>

Most tests for general intelligence have both an analytical component and a verbal comprehension component. Witkin argued that high correlations between field-independent

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18 E. Zigler, "Zigler Stands Firm", in Contemporary Psychology, Vol. 8, No. 11, 1963, p. 450-461.

19 E. Zigler, "A Measure in Search of a Theory" in Contemporary Psychology, Vol. 8, No. 4, p. 133-135.

tests and various subtests of intelligence tests are inevitable. However, he noted that there was no significant correlation between the perceptual tests and the verbal comprehension factor represented by vocabulary, information and comprehension subtests. In his study with thirty ten year old boys, Witkin found that for the perceptual index vs. intellectual index (analytical section),  $r = .66$  ( $p < .01$ ) and for the perceptual index vs. verbal index,  $r = .26$  (not significant).<sup>20</sup>

Some researchers have found that their evidence tended to contradict the findings of Witkin. Goodenough and Karp found support for their hypothesis that some intellectual and perceptual tests have a common requirement for overcoming embedded contexts.<sup>21</sup> The three major factors repeatedly isolated in studies of the Wechsler scales are: the verbal comprehension factor, the attention-concentration or memory factor, and the closure or spatial-perceptual factor. They found that the perceptual field dependence tests, have their highest loadings on the closure or spatial factor. From their results, the investigators concluded that the superiority of the field-independent subject on I. Q. tests resulted specifically from his better performance

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20 Witkin et al., Op. Cit., 1962, p. 70.

21 Donald Goodenough, and Stephen Karp, "Field Dependence and Intellectual Functioning", Journal of Abnormal and Social Psychology, Vol. LXIII, 1961, p. 241-246.

on those parts of the intelligence tests, which, like the perceptual test battery, require analytical functioning or the ability to overcome embedded contexts.

Spotts and Mackler examined the measures of field independence and their relationship to measures of intellectual ability.<sup>22</sup> They found that tests of field dependence-field independence correlated significantly with the Otis I.Q.'s ( $r = 0.28$  between the Otis and the Hidden Figures Test;  $r = 0.20$  between the Otis and the Embedded Figures Test, (EFT),  $N = 135$ ). Dickstein also reported a significant correlation of  $0.24$ ,  $N = 96$ , obtained between Thurstone's Concealed Figures Test and the Otis.<sup>23</sup> Although these correlations have been found to be significant, tests of intelligence do not account for a large proportion of the variance in field dependence-field independence.

Witkin maintained that significant relations reported between mental ability scores and perceptual tests of field independence might be expected on the basic requirement for overcoming embedded contexts. If significant findings could be shown to exist between measures of field independence and

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22 James Spotts and Bernard Mackler, "Relationships of Field-Dependent and Field-Independent Cognitive Styles to Creative Test Performance", in Perceptual and Motor Skills, Vol. 24, 1967, p. 239-268.

23 Louis S. Dickstein, "Field Independence in Concept Attainment", in Perceptual and Motor Skills, Vol. 27, 1968, p. 635-642.

various intelligence tests which have no requirement for overcoming embedded figures, then Witkin's notion could not be adequate. Dubois and Cohen considered this problem by recording correlations between the perceptual tests of RFT and EFT and ability measures (Verbal, Quantitative, Total Aptitude, English, Social Studies, Art and Music, Science, Mathematics, Total Achievement.)<sup>24</sup> All of the intercorrelations between the EFT and the ability measures were significant at  $p < .01$ . The range was from  $r = -.32$  to  $r = -.56$  ( $N=143$ ). All but two of the intercorrelations (English, Art and Music) between the RFT and the ability measures were significant at  $p < .01$ . The range was from  $r = -0.21$  to  $r = -0.42$  ( $N=143$ ).

From these researches, the degree to which mental ability affects scores from tests for field-independence is still an unresolved issue.

A second criticism is Witkin's use of statistics. Zimiles has criticized Witkin's statistics because Witkin constantly uses correlation.<sup>25</sup> The use of a correlation coefficient without any other descriptive information does

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24 Thomas E. Dubois and Walter Cohen, "Relationship Between Measures of Psychological Differentiation and Intellectual Ability", in Perceptual and Motor Skills, 1970, Vol. 31, p. 411-416.

25 Herbert Zimiles, "The Problem of Individuality in Systematic Research," in Merill-Palmer Quarterly, Vol. 10, No. 4, 1964, p. 375-383.

not provide meaningful interpretations. However, Witkin has always included the number of subjects in the sample and the level of significance which is sufficient information to make a meaningful interpretation.

Despite the criticism voiced, Witkin's treatise on psychological differentiation is a major contribution of a vigorous and dedicated research group. Young set about testing Witkin's field dependence hypothesis.<sup>26</sup> His results confirm Witkin's work.

Witkin's work laid the foundation for the field independence construct. As Korchin states<sup>27</sup>:

The largest part of the book (Psychological Differentiation, 1962), details the variety of perceptual, cognitive and personality functions which characterize greater and lesser differentiation. An impressive network of relationships are reported, consonant with the differentiation hypothesis.

Werner, who wrote the foreword to Witkin's Psychological Differentiation text, praises the work as being in the "new spirit" of developmental theory. Werner comments that Witkin's differentiation hypothesis:

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26 Harl H. Young, "A Test of Witkin's Field Dependence Hypothesis", in Journal of Abnormal and Social Psychology, Vol. 59, 1959, p. 188-192.

27 Sheldon J. Korchin, "More on Zigler on Witkin", in Contemporary Psychology, Vol. 8, No. 11, 1963, p. 365.

. . . becomes capable of channeling the inquiry toward significant particular questions, as well as recruiting powerful and revelant experimental methods; moreover, in spite of its generality, the hypothesis is sufficiently incisive to be validated and tested against the findings without undue ambiguity.<sup>28</sup>

In summary, it appears that the major issue with Witkin's work is the mental ability factor. Since there is evidence both for and against controlling for mental ability, this issue tends to be unsettled. In spite of this apparent deficit, Witkin has laid the basic ground work for studies relating to field independence and field dependence.

### 3. Tests of Field Independence

Witkin measured the extent of a person's psychological differentiation by the performance on the following perceptual tasks:<sup>29</sup> (a) the Rod-and-Frame Test (RFT), (b) the Tilting-Room-Tilting-Chair Test (TRTC), (c) the Body-Adjustment Test (BAT), and (d) the Embedded Figures Test (EFT).

The Rod-and-Frame test apparatus consists of a luminous frame pivoted at its center so that it can be tilted to the left or to the right, with a luminous rod pivoted at the same center but movable independently of the frame. The test is

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28 Witkin et al., Op. Cit., 1962, p.vi.

29 Witkin et al., Op. Cit., 1962, p. 36.

conducted in a completely darkened room so that the subject sees only the rod and the frame. Both the rod and the frame are presented in tilted positions. With the frame remaining tilted the subject is required, by giving verbal instructions to the examiner, to adjust the rod to a position that he perceives as upright. The subject's score is the total absolute error in degrees from the true upright. The subject is given eight trials under the usual conditions with the rod and frame tilted twenty eight degrees away from the upright, half the time in one direction and half the time in the other direction.

The Tilting-Room-Tilting-Chair Test provides a measure of the subject's perception of the position of his body and of the whole surrounding field in relation to the upright. The apparatus is a box-like room which can be tilted by any amount in either direction. The subject sits on a chair which can also be tilted left or right independently of the room. The subject is required to bring his body to a position that he perceives as upright. The standard test is made up of two parts: the Room-Adjustment Test (RAT) and the Body Adjustment Test (BAT). In the RAT, the chair remains in its initial position of the tilt and the subject instructs the examiner to move the room to a position that he perceives as upright.

In the BAT, the subject instructs the examiner to move the chair to the position that he perceives as upright.

Other tests were developed which require the subject to separate an item from the field in which it is incorporated, but involve neither orientation toward the upright nor body position. These tests in the literature are frequently referred to as Embedded Figures Tests.

In the Embedded Figures Test (EFT), the subject is required to find a particular simple figure within a larger complex figure. The figures making up the test were taken from those developed by Gottschaldt. The standard test of Witkin's uses a series of twenty-four figures which vary in terms of difficulty. A maximum of five minutes is allowed per trial. The subject's score is the mean time taken to find the simpler figure within the complex one. The raw score is converted to a standard score where a positive standard score reflects a relatively field-dependent subject and a negative standard score reflects a field-independent subject.

Following the development of the Witkin battery of tests, there appeared in the literature, a series of other tests which are similar to the Embedded Figures. These tests are similar to the EFT in that the subject is required to

identify a simple figure within a more complex one. A number of these tests may be administered in group form.

For example, Thurstone's test of Closure Flexibility, more commonly known as Thurstone's Concealed Figures Test, is similar to Witkin's Embedded Figures test in that both tests are a revision of the Gottschaldt Figures. The Thurstone version is a short group test which is very easily scored. Each item is composed of a simple figure and four complex figures. The subject's task is to identify those complex figures which contain the simple figure and those which do not. The score is the number of complex figures containing the simple figure correctly identified minus the number of complex figures containing the simple figure incorrectly identified.

That this test is a measure of field independence is supported in the literature. Witkin et al., concretely acknowledge the relationship between his measures of field independence and Thurstone's Closure Flexibility Test (Concealed Figures Test):

Thurstone suggested that this dimension (flexibility of closure) might involve "the ability to shake off one set in order to take a new one."

It was because of the similarity between this definition and our definition of field dependence...Performance (on Thurstone's

Concealed Figures test) . . . has been found to relate significantly to performance in the tests of our perceptual battery.<sup>30</sup>

The fact that researchers have found significant correlations between these tests further reinforces the supposition that the preceding tests of field independence tend to measure a common factor. The existence of construct validity has been demonstrated by the successful use of these tests in studies based on Witkin's hypothesis.

Dubois and Cohen reported a correlation between the RFT and the EFT in their research as 0.56, N = 143.<sup>31</sup> Elliott, in his study, examines three different types of perceptual tests: the Rod-and-Frame, Witkin's Embedded Figures Test and Thurstone's Concealed Figures Test. He found significant intercorrelations between all of the above tests. The RFT and EFT were shown to have a correlation of 0.42 (N=128); the EFT and the Concealed Figures Test were shown to have a correlation of 0.55 (N=128).<sup>32</sup>

Rudin and Stagner used both Thurstone's Concealed Figures Test and Witkin's Rod-and-Frame Test as their measures

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30 Witkin et al., Op. Cit., 1962, p. 49.

31 Dubois, Thomas E., and Cohen, Walter, "Relationship between Measures of Psychological Differentiation and Intellectual Ability". Perceptual and Motor Skills, Vol. 31, 1970, p. 411-416.

32 Rogers Elliott, "Interrelationships Among Measures of Field Dependence, Ability, and Personality Traits", Journal of Abnormal and Social Psychology, Vol. 63, No. 1, 1961.

of physical object perception.<sup>33</sup> The study tested one aspect of the hypothesis that social and non-social stimuli are perceived similarly. They hypothesized that there would be a significant positive correlation between the tendency to modify figure as a function of ground in the perception of physical objects, as measured by the RFT and the Concealed Figures Test, and the tendency to modify figure as a function of ground in the perception of social objects, as measured by the Self Contextual Influence test. A sub-hypothesis was that the tests of object perception will correlate significantly and positively among themselves. The experimental hypothesis was shown to hold as well as the sub-hypothesis. A correlation of 0.55,  $N=34$ , between the RFT and the Concealed Figures Test was obtained.

Phillips et al., in their work, obtained a correlation of 0.77 ( $p < .01$ ) between the Embedded Figures Test and the Concealed Figures Test.<sup>34</sup>

As measures of psychological differentiation, Witkin's battery of tests have been found to be reliable and valid.

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33 Stanley A. Rudin and Ross Stagner, *Op. Cit.*, 1958.

34 Phillips et al., in Witkin et al., *Op. Cit.*, 1962, p. 49.

Other researchers followed with the development of group tests. One such test is Thurstone's Concealed Figures Test which has been shown to be a measure of Witkin's field dependence-field independence construct.

#### 4. Sex Factor

Pervasive sex differences occur in most groups tested. Witkin acknowledges that there are sex differences in the mode of field approach. Males tend to be relatively more field-independent than females in perceptual situations.<sup>35</sup>

In their study, DeRussy and Futch randomly selected sixteen undergraduate science students (eight men, eight women) and sixteen liberal arts students (eight men, eight women).<sup>36</sup> They found that there was a significant difference between men and women on field dependence scores, women being more field-dependent than men ( $F=10.98$ ,  $p < 0.01$ ).

Jackson et al., also compared the correlational patterns of response of males and females on perceptual tests.<sup>37</sup> Their study had fifty-two males and sixty females. Again significant sex differences favoring males resulted ( $t=3.64$ ;  $p < .01$ ).

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35 Witkin et al., Op. Cit., 1962, p. 214.

36 Edith DeRussy and Emily Futch, "Field Dependence-Independence as Related to College Curricula", in Perceptual and Motor Skills, Vol. 33, 1971, p. 1235-1237.

37 Douglas N. Jackson, Samuel Messick and Charles T. Myers, "Evaluation of Group and Individual Forms of Embedded-Figures Measures of Field-Independence", in Educational and Psychological Measurement, Vol. XXIV, No. 2, 1964, p. 177-192.

There have been several explanations for these findings. Witkin suggested that this difference could be the result of a biological difference in male and female.<sup>38</sup> He speculated that because the female sex organs are hidden "may make it more difficult for them to develop a clear conception of the body" and thus females tend to be more field-dependent than males.

There has been work reported showing that perhaps the difference in perceptual style due to the sex factor is an inherited one. Hartlage, replicating Stafford's early work but using a different test representing a reasonably pure measure of visual ability, found that his results also lended support to the postulation of sex linked inheritance of spatial ability.<sup>39</sup>

Other researchers ascribe sex differences in field dependence entirely to cultural norms. Sherman suggested that sex differences in analytical ability appeared unwarranted since sex differences could be due to sex typing from a very early age.<sup>40</sup>

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38 Witkin et al., Op. Cit., 1962, p. 220.

39 Lawrence C. Hartlage, "Sex-Linked Inheritance of Spatial Ability", in Perceptual and Motor Skills, Vol. 31, 1970, p. 610.

40 Julia A. Sherman, "Problem of Sex Differences in Space Perception and Aspects of Intellectual Functioning", in Psychological Review, Vol. 74, No. 4, 1967, p. 290-299.

There have been shown to be sex differences although their origins are uncertain. Because of these differences, numerous researchers have controlled for sex in their studies.

### 5. Attitude toward Science

Researchers have looked at the relationship between a field-independent-field-dependent way of perceiving and attitude toward partaking in analytical type activities.

Witkin described the extremely differentiated (field-independent) person by considering a typical example: the case study of Neal.<sup>41</sup> Neal was interested mainly in the sciences. He had been president of the mathematics, science and chess clubs. He had won several national awards in the science and mathematics field. These interests provided inherent satisfaction for the typically highly differentiated person. Witkin, in summary, states that highly differentiated children appear to derive a genuine satisfaction out of their interests and that examples of typical interests of highly differentiated children would be science, chess and going to museums.<sup>42</sup>

An example of a limitedly differentiated child was Phil whose interests were quite poorly developed.<sup>43</sup> He tended to lose interest quickly in anything he began. Witkin, from

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41 Witkin et al., Op. Cit., 1962, p. 238.

42 Witkin et al., Op. Cit., 1962, p. 248.

43 Witkin et al., Op. Cit., 1962, p. 264.

his case studies formulated the opinion that the over-all impression that limitedly differentiated children gave was that the interests were casually pursued and with the exception of single passions such as collecting pictures of baseball players, these interests appeared to be time fillers rather than genuine sources of satisfaction.

Pemberton, in his study, administered Thurstone's Concealed Figures Test along with Thurstone's Interest Schedule and sixteen other tests.<sup>44</sup> He concluded that the theoretical and scientific interests exhibited by those who scored high on the Concealed Figures Test were indicative of the pleasure these subjects derived from analyzing. In addition "ability and interests in analytical reasoning go hand in hand." Again further support is generated for the view that highly differentiated subjects genuinely enjoy scientific interests. However, Pemberton did not control for intelligence which could be a confounding variable as discussed in an earlier section.

Recently, Vernon undertook an investigation of creativity, field dependence and personality measures using 198 boys and 189 girls as subjects.<sup>45</sup> In addition to the Witkin

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<sup>44</sup> Carl L. Pemberton, "The Closure Factors Related to Temperament", in Journal of Personality, Vol. 21, p. 159-155, 1952.

<sup>45</sup> Vernon, "The Distinctiveness of Field Independence", Journal of Personality, Vol. 40, No. 3, 1972, p. 366-391.

'battery of tests', Vernon also administered Thurstone's Concealed Figures Test. He reported that with boys, interest in science did not correlate significantly with field independence. Although Vernon controlled for general intelligence, the present researcher questions the validity of the attitude test Vernon used. Vernon used a general test for determining various attitudes such as attitudes toward school, toward various subjects, and toward friends.<sup>46</sup> He used a Sentence Completion Test and several questionnaire measures of leisure time and vocational interests. In addition, no reliability data or field validation for the test were provided. It would seem that when studying specific attitudes for field-independent and field-dependent groups, it would be more valid to use an attitude test developed to measure the specific attitude.

#### 6. Achievement in Science

Few studies have investigated the relationship between achievement scores and the extent of field independence.

In his case studies, Witkin considers several case studies, such as Keith, Chris and Neal, from the highly differentiated group as being representative of the field-independent group. In each case, there is a consistent "high attainment

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<sup>46</sup> Vernon, Op. Cit., 1972.

in school".<sup>47</sup> Case studies of children who are typically of the limitedly differentiated group tend to be below capacity level in school work.<sup>48</sup>

Vernon used school achievement marks in addition to two essays which were scored for grammar, imagination, creativity and concept maturity.<sup>49</sup> His study showed that school achievement in science yielded significant correlations with field dependence tests.

In summary, the few previous studies in this area support the hypothesis that there is a relationship between field independence and achievement in science.

7. Relationship between Attitude toward Science, Achievement in Science and Mental Ability.

The variables of achievement in science, mental ability, and attitude toward science have been shown in the literature to be related. Martens examined the relationships among academic marks, general attitude toward school and school subjects and mental ability.<sup>50</sup> Of particular interest here is

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47 Witkin et al., Op. Cit., 1962, p. 234.

48 Witkin et al., Op. Cit., 1962, p. 249.

49 Vernon, Op. Cit., 1972.

50 Bruno Martens, "The Relationship of Intelligence, Attitudes and Study Habits to Academic Achievement", in Canadian Education and Research Digest, 1964, p. 268-272.

that science achievement marks could be predicted from mental ability scores and the Survey of Study Habits and Attitudes Inventory Scores ( $F=3.48$ , significant at  $p < 0.05$  level). It would appear that both attitude toward school and mental ability are related to achievement in science.

Harris and Lee studied the relationship between achievement concerning science concepts and mental ability.<sup>51</sup> Their study was conducted at the grade four, five and six level for which there was a total of sixty-nine subjects in the experimental group. The group was separated according to mental age (intelligence) into Low ( $N=21$ ), Average ( $N=34$ ) and High ( $N=14$ ). Analysis of the correct responses on the science concepts test (which had ten questions) indicated that fifty percent of the children in the Low Group had given correct responses to only three questions. In the Average Group, fifty percent of the children gave correct responses to eight of the questions, while in the High Group, fifty percent of the children obtained correct responses to all of the questions. Achievement in science seems to be related to intelligence.

W. Welch undertook to assess some of the characteristics of high school physics students.<sup>52</sup> He used the Academic

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51 William Harris and Verlin Lee, "Mental Age and Science Concepts, A Pilot Study", in Journal of Research in Science Teaching, Vol. 4, 1966, p. 275-288.

52 Wayne W. Welch, "Some Characteristics of High School Physics Students: circa 1968", in Journal of Research in Science Teaching, Vol. 6, 1969, p. 242-247.

Interest Measure (AIM) to assess the attitude of high school students toward scientific subject matter. He administered the Henmon-Nelson Test of Mental Ability to 2,414 physics students of which twenty-three percent were girls. The results of the AIM and the Henmon-Nelson were compared indirectly. Each test was compared (t-test) with the norms available in the Test Manual. It was found that attitude toward science was significantly higher for these high school students as compared to the norm values ( $t=5.2^{**}$  for males and  $t=13.5^{**}$  for females). Furthermore the mental ability scores for these science students were significantly higher than the norms in the Test Manual ( $t=13.7^{**}$  for males and  $t=11.7^{**}$  for females).

There seems to be a relationship among achievement in science, attitude toward science and mental ability. It would appear that any study related to achievement in science or attitude toward science should consider mental ability as a covariate.

## 8. Summary and Basic Hypothesis

Before proceeding with the statement of the research problem, it may be useful to summarize some of the key points discussed:

(1) There is, in Witkin's work a basis for hypothesizing a relationship between extent of differentiation and both attitude to science and achievement in science. Subjects, who are field-independent have been shown to be higher achievers in analytically orientated tasks. In addition, subjects who are field-independent have been described as deriving a genuine satisfaction in pursuing science interests.

(2) Males have been shown to be more field-independent than females. Since sex differences prevail in the performance on perceptual tests, control for sex is essential.

(3) A relationship has been shown to exist between attitude toward science, achievement in science and mental ability. In studying attitude toward science and achievement in science, the variable of mental ability should be considered.

(4) To date no study, using a validated attitude test which is specific to science, has been undertaken to determine whether field independence is reflected in positive attitudes toward science.

(5) The variables of achievement in science and attitude toward science are related and thus should be considered in a multivariate analysis.

The basic research problem can thus be proposed. It is hypothesized that after controlling for mental ability, students

who manifest a field-independent cognitive style have a more positive attitude toward science and are higher achievers in science than students who manifest a field-dependent cognitive style.

## CHAPTER II

### EXPERIMENTAL DESIGN

The experimental method used to implement the general research proposal advanced in the previous chapter is presented under the following headings: (1) Research Hypothesis, (2) the Sample, (3) Psychometric Instruments, (4) the Procedure, and (5) the Statistical Techniques used to analyze the data.

#### 1. Research Hypothesis

As indicated, in the general statement of the basic problem in the previous chapter, the following is the specific research hypothesis:

With effects of mental ability controlled, students who manifest a field-independent cognitive style have a more positive attitude toward science and are higher science achievers than students who manifest a field-dependent cognitive style.

## 2. The Sample

The sample included all the 101 grade nine male students enrolled in science in an academic English-speaking high school in a large Eastern Canadian city. Although science is not compulsory, almost all students take science at the general or the advanced level in grade nine. Both the general and advanced ninth grade science students study the same textbook<sup>53</sup> and the same topics are covered at both levels. The difference between the two levels is the depth in which the topics are covered.

Since males have tended to be more field-independent than females, the immediate research implication is that sex differences must be controlled. Sex was experimentally controlled by selecting only males. Any student for whom the data was incomplete was eliminated from the research analysis. For example, some students arrived late in the year (came from another school) and so missed the Henmon-Nelson test of Mental Ability, other students were absent during a part of the testing. As a result, fifteen subjects were eliminated.

To test the hypothesis, it was necessary to identify the extreme groups on the field dependence-field independence

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<sup>53</sup> Norman Abraham, Patrick Balch, Donald Chaney, Lawrence M. Rohrbaugh, Interaction of Matter and Energy, Rand McNally and Company, Chicago, 1969.

continuum. In order to ensure against the overlap of the extreme groups, a method used by Cooper indicated that no more than 32.3 percent of the cases should be in either of the extreme groups.<sup>54</sup> In the present study, the thirty lowest and the thirty highest scores formed the extreme groups which was thirty percent of the cases.

### 3. The Psychometric Instruments

For each subject scores were obtained for mental ability, achievement in science, field independence and attitude toward science. Mental ability was measured by the Henmon-Nelson Test of Mental Ability Grades 9 - 12 Form A. The test was administered by the Guidance personnel in October to each student upon his entry into the school for the first time.

Achievement in science scores were obtained from the results of multiple choice classroom tests which were administered to all students at the end of a unit of work. Results of each of the three tests were expressed as z-scores. The score assigned for each subject was the mean of the three z-scores. This procedure was performed to ensure that each test was given the same weight in the averaging process since

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<sup>54</sup> Martin Cooper, Cattell's Personality Factors as Predictors of High School Performance, unpublished doctoral thesis presented to the Faculty of Education of the University of Ottawa, Ontario, 1972, p. 81.

all the units of work took approximately the same amount of classroom time. The resultant z-score for each subject was converted to a T-score to avoid working with negative numbers. A Kuder-Richardson-21 reliability coefficient for each multiple choice test was calculated by the author.

Thurstone's Concealed Figures test was used as a measure for field dependence-field independence. Information regarding this test has been reported in the Review of the Literature. Correlations in the 0.55 range were reported with both Witkin's RFT<sup>55</sup> and EFT<sup>56</sup>. Thurstone's Concealed Figures Test is a paper-and-pencil test which can be administered individually or in group form (See Appendix 7). The split-half reliability coefficient for the test is reported in the manual as 0.78.<sup>57</sup>

Although the correlations of Thurstone's Concealed Figures Test with Witkin's RFT and EFT are not as high as one would expect, the Concealed Figures Test has been used by researchers in furthering Witkin's hypothesis and thus construct validity has been demonstrated.

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55 Rogers Elliott, Op. Cit., 1961, p. 31.

56 Rudin and Stagner, Op. Cit., 1958, p. 213-225.

57 L. L. Thurstone, A Factorial Study of Perception, Psychometric Monographs, No. 4, Chicago, University of Chicago Press, 1944.

Moore's Scientific Attitude Inventory was used to measure attitudes toward science. This four point Likert type scale consists of sixty items. Some statements are about the nature of science, some are about how scientists work, and yet other statements describe how the subject might feel about science. The test yields two subscores: an "A" scale which represents a positive attitude and a "B" scale which represents a negative attitude. The test is scored in the positive direction, i.e. the higher the total score (sum of subscores) the more positive the attitude toward science. The range of scores is from zero to one hundred eighty.

Moore's Scientific Attitude Inventory is the only attitude toward science inventory that the present researcher was able to find validated in the literature.

The attitudes to be assessed were based on the objectives of science teaching as indicated in the Fifty-ninth Yearbook of the National Society for the Study of Education.<sup>58</sup> An initial pool of 112 items was developed with the sixty best attitude statements appearing in the final forms. The items selected were those which received the greatest support from

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<sup>58</sup> Richard W. Moore and Frank X. Sutman, "The Development, Field Test and Validation of an Inventory of Scientific Attitudes", in Journal of Research in Science Teaching, Vol. 7, 1970, p. 85.

a panel of judges and which were not unanimously endorsed or rejected by the students.

The Scientific Attitude Inventory has been field tested and validated in two administrations to three groups of students.<sup>59</sup>

Using the test-retest method of Winer, Moore obtained a reliability coefficient of 0.93.<sup>60</sup>

#### 4. The Procedure

The students partaking in the study were informed by the researcher as to the general nature of the study as outlined in Appendix 4.

The sample was contained in six classroom groups. Each group met separately as a class at a specified time of day for forty minutes on every day of the week. Each of the classes were held in the same room but at different times. The two tests that were administered by the researcher (Moore's Scientific Attitude Inventory and Thurstone's Concealed Figures Test) were counterbalanced. Three classes wrote the Scientific Attitude Inventory on the first day and Thurstone's Concealed Figures Test on the following day; the remaining

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59 R. Moore and F. Sutman, Op. Cit., 1970.

60 Moore, Op. Cit., 1970, p. 89.

three classes wrote Thurstone's Concealed Figures Test on the first day and Moore's Scientific Attitude Inventory on the second day. The two tests were written on two consecutive days, Tuesday and Wednesday.

Classroom groups were used since this arrangement provided a minimum of classroom disruption. Monday and Friday were avoided because it was felt that these days are not particularly good for testing.

Thurstone's Concealed Figures test was timed for ten minutes and the procedure in the manual was strictly adhered to.<sup>61</sup> For the Scientific Attitude Inventory, the students were allowed to use as much time as they needed as stated in the instructions preceding the test. Most students used about twenty-five minutes for the Inventory. Each student had enough time to complete the Inventory in the forty minute classroom period.

The results of the Henmon-Nelson Test of Mental Ability (given in September) were obtained from the records made available for this study by the personnel in the Guidance Department.

The achievement scores were obtained from classroom records as described above.

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<sup>61</sup> L. L. Thurstone, T. E. Jeffrey, Concealed Figures Test, University of North Carolina, 1965, U. S. A.

## 5. Statistical Techniques for Analyzing the Data

A Kuder-Richardson-21 reliability coefficient was computed by the researcher to test the internal consistency of each of the three Achievement Tests and Thurstone's Concealed Figures Test.

The hypothesis was tested in the null form using a multivariate analysis of covariance, with field dependence-field independence as the independent variable and both attitude to science and achievement in science as the dependent variables. Mental Ability was used as the covariate.

A multivariate approach was justified, since it was demonstrated in the Review of the Literature that the dependent variables of attitude to science and achievement in science and the covariate of mental ability are all interdependent.

The level of significance was set at the 0.05 level.

## CHAPTER III

### PRESENTATION AND DISCUSSION OF THE RESULTS

In this chapter, the results of the study are presented and discussed under the following headings:

(1) Reliability of the Instruments, (2) Control Variables, (3) Results of Testing the Hypothesis, (4) Results of Post Hoc Analysis and (5) Discussion of the Results.

#### 1. Reliability of the Instrument

As indicated previously, estimates of internal consistency were obtained for the three achievement multiple choice tests and Thurstone's Concealed Figures Test. The summary of the results are presented in Table I. The Kuder-Richardson-21 (KR-21) reliabilities were 0.74, 0.81 and 0.78 for the teacher constructed multiple choice tests. These results are quite satisfactory for teacher-made tests. The KR-21 for Thurstone's test was calculated to be 0.93 which is sufficiently high to show that the test is consistently measuring the same property.

Table I.-

Reliabilities for the Achievement in Science Tests and Thurstone's Concealed Figures Test as Measured by the Kuder-Richardson-21.

	No. of items in test	Standard Deviation of test	Mean	KR-21 value
Achievement Test 1	25	4.46	15.76	0.74
Achievement Test 2	30	5.69	19.22	0.81
Achievement Test 3	25	4.80	15.97	0.78
Thurstone's Concealed Figures Test	196	23.58	64.19	0.93

## 2. Control Variables

As reported above, studies have shown that mental ability is related significantly to attitude toward science and achievement in science. From Table II, the mean mental ability of the field-independent group is 119.8 and that of the field-dependent group is 106.7. From the summary of multivariate analysis of covariance in Table III, the correlation between mental ability and the two dependent variables is shown to be significantly different than zero. ( $F=8.88$ , significant at  $\alpha=.05$ ). Thus the researcher was justified in using mental ability as a covariate in the statistical analysis.

Because of certain suggestions in the literature that a subject becomes more field-independent with age, it was decided to compare differences between the extreme groups on age. (See Table II). A t-test showed that these differences were non significant.

Table II.-

Means and Standard Deviations for Age, Achievement in Science, Scientific Attitude Inventory, and Henmon-Nelson Test of Mental Ability.

	Achievement in Science		Scientific Attitude Inventory		Henmon-Nelson Test of Mental Ability		Age in years	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Field Independent Group	57.03	7.6	126.4	14.58	119.8	10.05	14.5	.73
Field Dependent Group	43.7	7.1	110.5	15.48	106.7	10.58	14.6	.22

N = 30 for both groups

### 3. Results of Testing the Hypothesis

The results of the multivariate analysis of covariance are summarized in Table III. With mental ability as the covariate, the dependent variables of attitude to science and achievement in science are significantly different in the two groups (field-independent group vs. field-dependent group),  $F = 11.67$ , significant at  $\alpha = .05$ .

Table III.-

Results of the Multivariate Analysis of Covariance with Psychological Differentiation as the Independent Variable, Attitude toward Science and Achievement in Science as the Dependent Variable and Mental Ability as the Covariate

Source	Log (Generalized Variance)	U-Statistic	F-Statistic	Degrees of Freedom	
T (independent variable)	17.64146	0.705771	11.6729	2	56
Covariate	22.77643	0.759250	8.8785	2	56
Error	17.29300				

From the Tables  $F(2, 56) = 3.15$ ,  $\alpha = .05$

#### 4. Results of the Post Hoc Analysis

It was decided to examine each dependent variable, with mental ability as a covariate, on an individual basis. This examination was undertaken to compare the field-dependent-field-independent groups on the scores of each dependent variable. The adjusted cell means were calculated and reported for the univariate analyses. (See Appendix 2 and Appendix 3). In comparing the two extreme groups, significant differences were found for each of the two dependent variables.

#### 5. Discussion of the Results

The research hypothesis was supported. After controlling for mental ability, students who manifest a field-independent cognitive style were found to be higher achievers in science and more positive in their attitude toward science than students who manifest a field-dependent cognitive style. Hence, further support was accumulated for Witkin's theory of psychological differentiation.

Vernon found that after controlling for mental ability, achievement was significantly different in the extreme groups of field dependence-field independence.<sup>62</sup> The results of the present study are in agreement with these findings of Vernon.

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<sup>62</sup> Vernon, Op. Cit., 1972, p. 366-391.

However, in comparing the groups on attitude toward science, results of the present study are in disagreement with the work of Vernon. Vernon did not find a significant difference between the extreme groups of field dependence-field independence and attitude toward science. It is suggested that this disparity arises because Vernon used a test to measure attitude that was general in nature and not tailored to measure attitude toward science specifically.

The results from the present study confirm Pemberton's work. Pemberton found that those who scored high on the Concealed Figures Test (field-independent subjects) also obtained significantly more positive attitude toward science scores than those who scored low on the Concealed Figures Test (field-dependent subjects).<sup>63</sup>

One limitation of the present research is that the three tests of achievement in science used multiple choice items exclusively. The present researcher suggests that further work might be done to investigate the relationship between a field-dependent-field-independent cognitive style and the results of the type of test taken: multiple choice or essay.

There is some evidence that the Rod-and-Frame test of field independence measures a different property from the

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<sup>63</sup> Carl L. Pemberton, Op. Cit., 1952.

embedded figures type of test. It is suggested that the present study be replicated using the Rod-and-Frame as a measure of field independence.

A major possible contribution of this research could be in the grouping of classes (either for regular or tutorial purposes). The mode of presentation could be modified to suit the nature of the perceptual style of the individual. The mode of presentation for a field-dependent individual would probably start with the whole (since field-dependent people see things more diffusely), whereas the method of presentation for a field-independent individual would start with the parts and put the whole solution together. Cognitive style mapping, in this manner could be of invaluable assistance to the student.

This type of approach has been reported in the literature by Nunney and Hill.<sup>64</sup> They report a program which is in progress at Oakland Community College where an individualized approach to education is being used by diagnosing each individual's cognitive style (field-dependent or field-independent) and his academic strengths. The task is to match the cognitive style to the mode of presentation. It is yet too early to discuss the full implications of the results

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<sup>64</sup> Derek N. Nunney and Joseph E. Hill, "Personalized Educational Programs", in Audiovisual Instruction, Vol. 1972, p. 10-15.

of the project. However, initial reports show a marked improvement in achievement as compared to past years when this program was not in use.

## CONCLUSIONS

Witkin's concept of field dependence-field independence is attracting interest and stimulating much research. It appears to provide an objectively measureable dimension of cognition which has important implications for personality and academic achievement studies.

Measures used in this study of 101 boys at the grade nine level included the Concealed Figures test (as a field independence measure), the Scientific Attitude Inventory, classroom achievement scores in science and the Henmon-Nelson Test of Mental Ability. The results of the study showed that when mental ability is controlled, there is a significant difference between the extreme groups on the field independence continuum for both attitude toward science and achievement in science. Students who manifested a field-independent cognitive style exhibited a more positive attitude toward science and were higher achievers in science than students who manifested a field-dependent cognitive style.

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Their research confirms that there is a significant sex difference on field independence scores with women being more field-dependent than men.

Goodenough, D. and S. Karp, "Field Dependence and Intellectual Functioning", in Journal of Abnormal and Social Psychology, Vol. LXIII, 1961, p. 241-246.

Again the necessity for controlling for I.Q. in field independence studies is given experimental backing.

Martens, Bruno, "The Relationship of Intelligence, Attitudes and Study Habits to Academic Achievement", in Canadian Education and Research Digest, Vol. 4, 1964, p. 268-272.

The article demonstrates the interrelationship between intelligence, attitude and achievement and hence the use of a multivariate analysis.

Moore, R. and F. Sutman, "The Development, Field Test and Validation of an Inventory of Scientific Attitudes", in Journal of Research in Science Teaching, Vol. 7, 1970, p. 85-94.

In this article is shown the principles behind the setting up of the Scientific Attitude Inventory.

Nunney, Derek N. and Joseph E. Hull, "Personalized Educational Programs", in Audiovisual Instruction, Vol. 17, 1972, p. 10-15.

This is a report of a program in which cognitive style mapping is actually used in developing a mode of instruction which is best suited to an individual's needs.

Spotts, James V. and Bernard Mackler, "Relationships of Field-Dependent and Field-Independent Styles to Creative Test Performance", in Perceptual and Motor Skills, Vol. 24, No. 1, 1967, p. 239-268.

As part of this investigation, it was found that tests of field independence correlated significantly with intelligence tests.

Witkin, Herman A., H. B. Lewis, M. Hertzman, K. Machover, P. S. Meissner and S. Wapner, Personality Through Perception, New York, Harper, 1954, xxvi-571p.

In this first major publication, Witkin and his associates present the origins of the field dependence construct and its distinctive features, as well as the results of a vast research project relating style of cognitive functioning to personality variables and individual patterns of adaptation.

Witkin, H. A., R. B. Dyke, H. F. Faterson, D. R. Goodenough, and S. A. Karp, Psychological Differentiation, New York, Wiley, 1962, p. v-418.

This second major work by Witkin and his coworkers consists of a confirmation and extension of the first, as well as the placing of the total research within a developmental framework under the guiding principle of psychological differentiation.

Young, Harl H., "A Test of Witkin's Field Dependence Hypothesis", in Journal of Abnormal and Social Psychology, Vol. 59, 1959, p. 188-192.

This work gives experimental support for Witkin's work by testing Witkin's original hypothesis.

Zigler, E., "A Measure in Search of a Theory", in Contemporary Psychology, Vol. 8, No. 4, 1963, p. 133-135.

A critical review of Witkin's 1962 text. Among other things, the author strongly criticized Witkin et al. for their explanation of the relationship between intelligence tests and field dependency. He suggested that field independency is but an extension of general intelligence.

APPENDIX 1

Scores for the Concealed Figures Test, Achievement  
in Science, Scientific Attitude Inventory,  
Henmon-Nelson Test of Mental Ability and Age in Years

Concealed Figures Test	Achievement in Science Average z-score	Achievement in Science T-score	Scientific Attitude Inventory	Henmon- Nelson Test of Mental Ability	Age
High Group on the Field Dependence-Field Independence Continuum					
104	1.5	65	144	123	14.50
81	-0.3	47	129	99	16.00
80	0.2	52	143	116	14.33
86	1.3	63	237	122	13.75
118	0.0	50	94	127	13.67
88	1.0	60	129	118	14.83
85	0.7	57	128	118	14.42
88	1.6	66	135	115	15.75
100	1.4	64	110	127	14.92
95	0.7	57	147	123	14.33
88	0.2	52	157	120	14.27
102	-0.3	47	110	108	15.67
86	1.2	62	122	134	14.00
101	1.2	62	121	121	15.00
82	1.1	61	115	110	14.27
87	0.4	54	120	117	13.92
94	0.1	51	115	117	14.17
91	1.3	63	131	149	14.83
88	0.5	58	131	132	14.17
80	0.0	60	112	115	14.33
86	-0.6	44	117	109	15.00
80	1.8	68	154	121	13.33
113	1.1	61	138	118	15.00
80	1.8	68	115	120	13.27
102	0.4	54	125	124	14.83
89	1.5	65	137	128	14.17
83	-1.0	40	106	100	15.67
89	1.5	65	125	133	13.83
80	-0.1	49	109	107	15.83
110	-0.4	46	136	123	14.27

Concealed Figures Test	Achievement in Science Average z-score	Achievement in Science T-score	Scientific Attitude Inventory	Henmon- Nelson Test of Mental Ability	Age
Middle Group on the Field Dependence-Field Independence Continuum					
56	0.3	53	128	111	13.58
73	1.5	65	117	129	13.27
62	0.0	50	115	101	14.92
61	-1.4	36	117	110	14.50
56	1.0	60	116	115	14.50
74	0.0	50	128	115	14.58
78	0.7	57	125	123	15.50
62	1.5	65	141	115	14.17
64	1.1	61	117	112	14.27
60	0.9	59	117	117	13.92
60	0.1	51	96	106	14.67
62	0.7	57	130	120	14.27
63	-0.7	43	105	112	15.00
62	0.7	57	108	112	14.67
57	-1.6	34	141	100	15.27
79	1.7	67	122	130	13.75
76	-0.3	47	143	112	14.50
60	0.8	58	113	114	13.92
56	-0.6	44	116	104	13.27
64	0.0	50	129	102	14.83
70	0.5	55	130	115	14.67
78	-0.5	45	107	116	14.58
68	0.8	58	127	127	13.58
68	0.0	50	124	112	15.00
61	0.7	57	118	128	13.27
60	0.1	51	107	113	14.75
65	0.0	50	124	142	14.27
74	0.2	52	138	100	15.50
72	0.6	56	122	115	14.92
54	0.3	53	130	116	14.33
56	0.6	56	133	100	14.83
72	-0.4	46	100	99	15.58
68	0.7	57	143	119	14.00
57	-0.2	48	133	115	13.17
56	0.7	57	112	104	14.83
69	-0.5	45	98	112	14.58
51	1.3	63	153	111	13.50
72	0.1	51	116	117	14.75

Concealed Figures Test	Achievement in Science Average z-score	Achievement in Science T-score	Scientific Attitude Inventory	Henmon- Nelson Test of Mental Ability	Age
Middle Group on the Field-Dependence-Field Independence Continuum Continued					
76	-0.6	44	124	104	15.00
66	0.9	59	131	115	14.50
69	1.7	67	127	108	15.33
Low Group on the Field-Dependence-Field Independence Continuum					
50	-0.9	41	138	119	15.67
46	-0.8	42	101	88	15.08
42	-1.2	38	102	88	15.58
21	0.1	51	92	110	14.67
38	0.1	51	83	119	14.27
48	-0.7	43	116	103	14.27
49	-0.6	44	119	116	14.75
26	-1.1	39	106	113	13.17
42	-1.1	39	101	92	15.17
27	-1.4	36	92	98	15.83
39	-1.4	36	139	108	13.33
39	-0.6	44	93	92	15.50
18	-2.2	28	90	100	15.00
18	0.3	53	93	94	15.67
50	-0.8	42	121	105	15.33
33	0.5	55	129	107	14.67
34	-0.2	48	123	113	15.17
44	1.3	63	133	113	13.33
38	-0.7	43	119	108	14.75
28	0.0	50	105	102	14.42
29	-0.8	42	110	122	13.75
44	-1.0	40	134	105	14.58
39	-1.2	38	118	95	14.83
29	-0.5	45	90	115	14.33
43	-1.2	38	107	110	14.75
47	-0.5	45	123	110	14.42
6	-1.2	38	104	100	15.00
15	0.7	57	99	136	14.27
50	-0.9	41	118	111	13.27
42	-1.0	40	124	108	14.17

PRESENTATION AND DISCUSSION OF RESULTS

APPENDIX 2

Results of an Univariate Analysis of Covariance  
with Psychological Differentiation as the Independent  
Variable, Attitude toward Science as the Dependent Variable  
and Mental Ability as the Covariate

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Source	Sum of Squares	Degrees of Freedom	Mean Square	F- Statistic
T(independent variable)	1491.0117	1	1491.0117	6.5575
Covariate	608.0703	1	608.0703	2.6743
Error	12960.4297	57	227.3759	

Adjusted Cell Means

T =       1 (field-dependent group)   2 (field-independent group)  
      112.55847                           124.37485

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From the Tables  $F(1,57) = 4.00, \alpha = .05$

APPENDIX 3

Results of an Univariate Analysis of Covariance  
with Psychological Differentiation as the Independent  
Variable, Achievement in Science as the Dependent Variable  
and Mental Ability as the Covariate

Source	Sum of Squares	Degrees of Freedom	Mean Square	F- Statistic
T(independent variable)	849.9805	1	849.9805	19.2012
Covariate	732.3516	1	732.3516	16.5439
Error	2523.2246	57	44.2671	

Adjusted Cell Means

T = 1 (Field-Dependent Group)      2 (Field-Independent Group)  
45.88914                                      54.81084

From the Tables  $F(1, 57) = 4.00, \alpha = .05$

#### APPENDIX 4

##### Information given to the Students Concerning the Research Project

The students were told the following concerning the research project:

"My name is Mrs. Bowles and I am conducting a project relating the way male students see an object to their attitude toward science and scientific facts.

In the course of these two days, I will ask you to do a test called the Concealed Figures Test, which will establish how you see objects and a survey called a Scientific Attitude Inventory which will establish your attitude toward science and scientific facts.

Your results will be ready towards the end of May if you wish to know them. Furthermore, the results will be strictly confidential; that is, no one else will know your results. If you do not wish to participate then please do not answer the questions at all. Are there any questions?

All of the questions were answered by the author. Typical questions were about the various ways people perceived objects. A number of students were concerned whether these results could be used to influence their term mark in science. The author assured them that complete anonymity would prevail and pointed out that only the males were tested. No females partook in the study.

APPENDIX 5

The Closure Flexibility Test  
(Concealed Figures Test)

# CLOSURE FLEXIBILITY

## (Concealed Figures)

### (Form A)

Please fill in:

Name \_\_\_\_\_

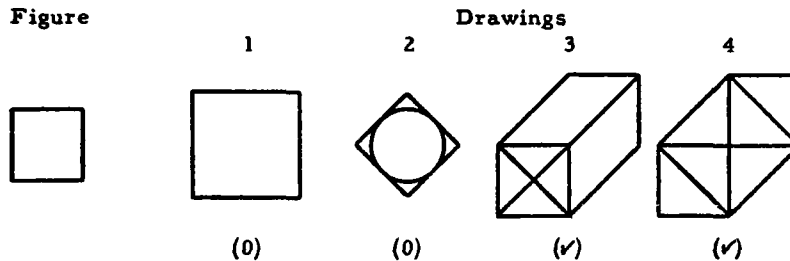
Age \_\_\_\_\_ Sex \_\_\_\_\_ Date \_\_\_\_\_

Occupation \_\_\_\_\_

Developed by: L.L. Thurstone, Ph.D. and T.E. Jeffrey, Ph.D. - The Psychometric Laboratory - The University of North Carolina

#### Directions:

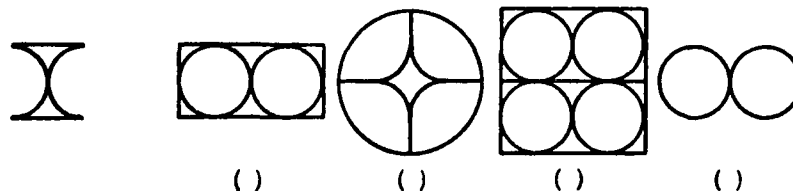
The row of designs below is a sample item of this test. The parts have been labeled to make description easier. These labels do not appear in the test items. The left hand design in each row is the figure. You are to decide whether or not the figure is concealed in each of the four drawings to the right. Put a check mark (✓) in the parentheses under a drawing, if it contains the figure. Put a zero (0) in the parentheses under a drawing, if it does not contain the figure. Look at the row of designs below.



In the row above a zero (0) has been written in the parentheses under drawing 1. The first drawing is a square but it is larger than the figure. A zero (0) has been written under drawing 2. Although the second drawing contains a square of exactly the same size as the figure, it has been turned. Check marks (✓) have been written under the third and fourth drawings since they each contain a square of exactly the same size as the figure and have not been turned. It does not matter that the figure contained in drawings three and four is on a different level from the figure at the left.

#### Sample:

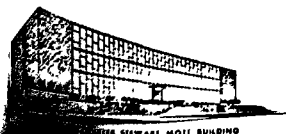
Here is another example for practice. Try it.

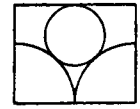
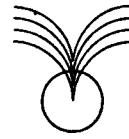
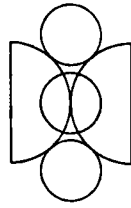
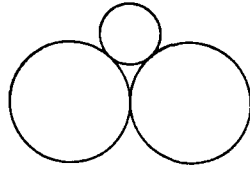


You should have placed check marks (✓) in the parentheses under the first and third drawings and zeros (0) in the parentheses under the second and fourth drawings.

WHEN YOU GET THE SIGNAL TO BEGIN, turn the page and mark more problems of the same kind. Work as fast and as accurately as you can, but do not guess. Wrong answers will count against you. You are not expected to finish in the time allowed. You will have exactly ten minutes to do as much as you can.

TMNF-119  
2-8-4000



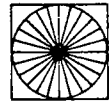
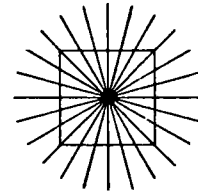
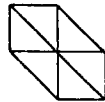
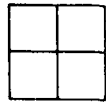
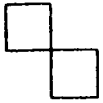


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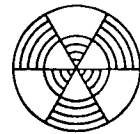
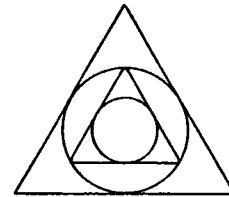
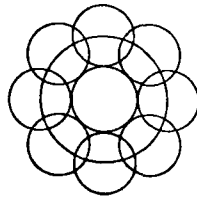
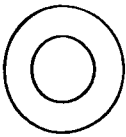


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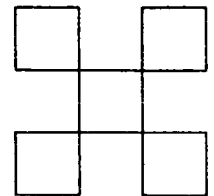
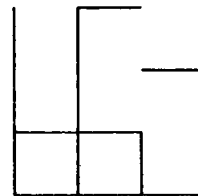
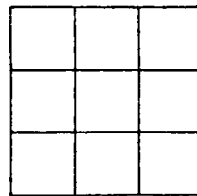
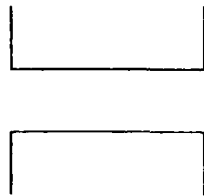
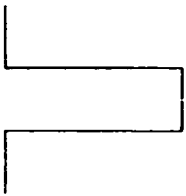


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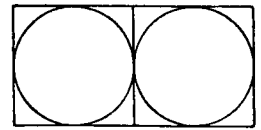
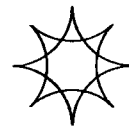
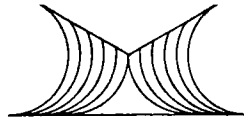
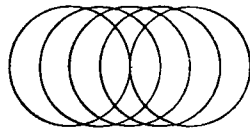


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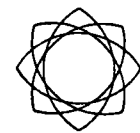
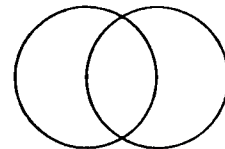
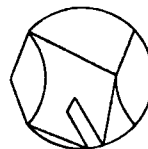
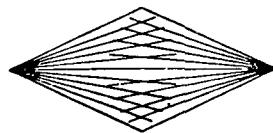


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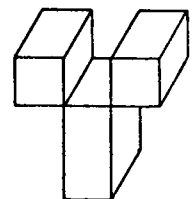
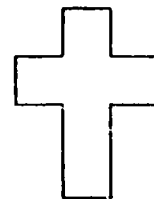
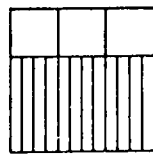
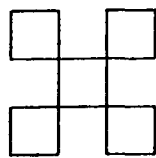
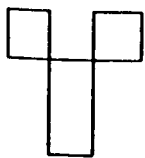


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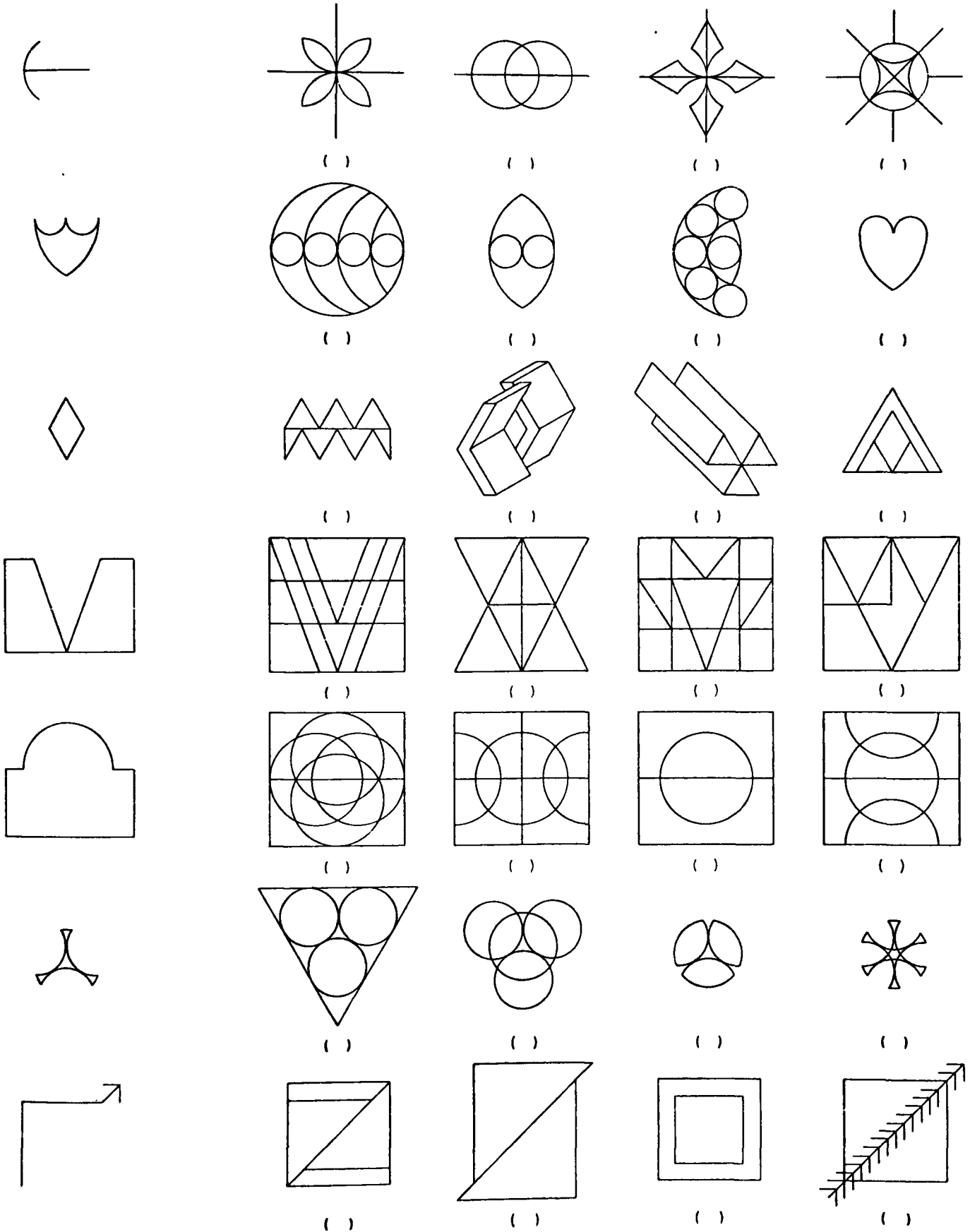
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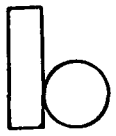
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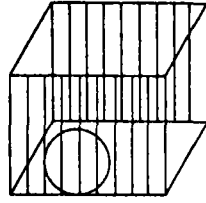
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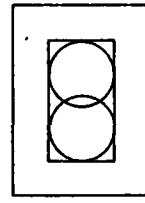
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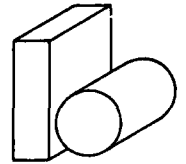
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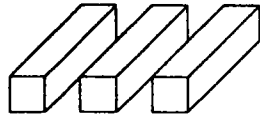
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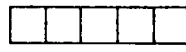
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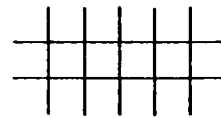
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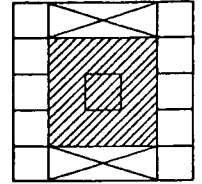
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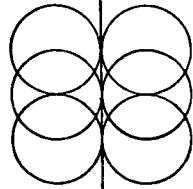
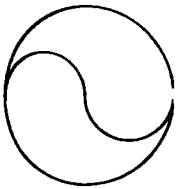
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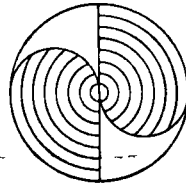
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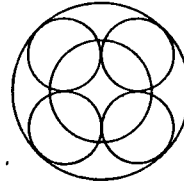
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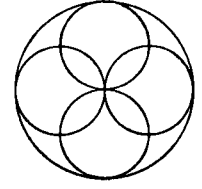
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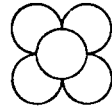
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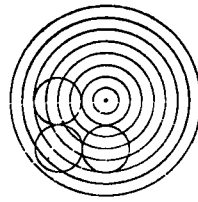
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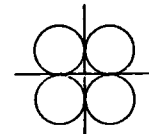
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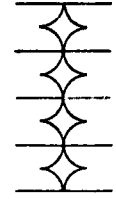
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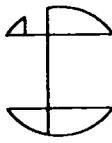
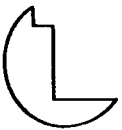
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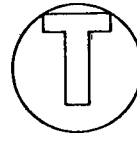
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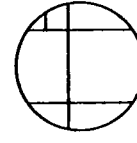
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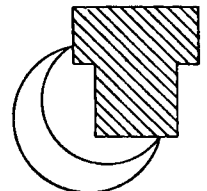
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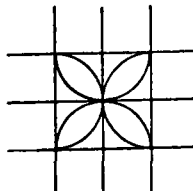
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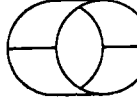
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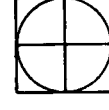
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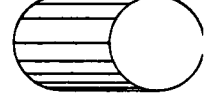
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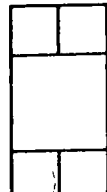
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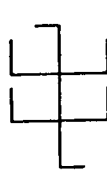
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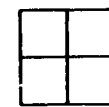
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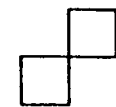
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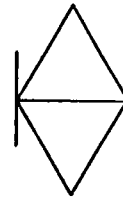
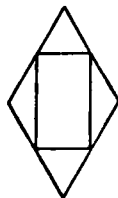
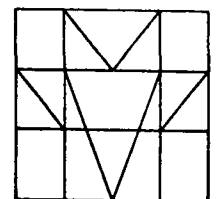
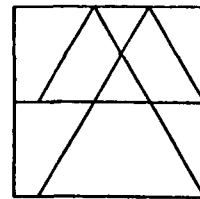
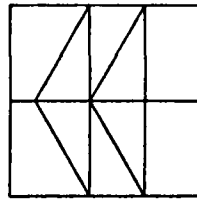
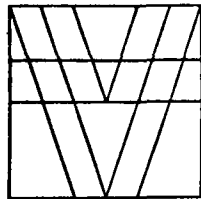
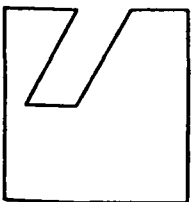
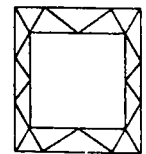
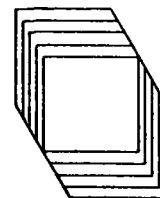
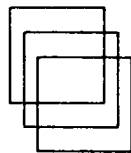
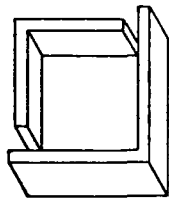
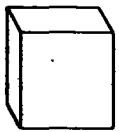
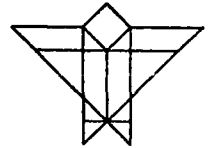
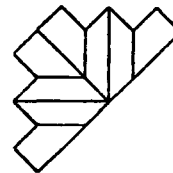
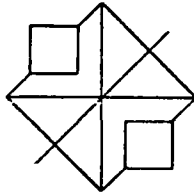
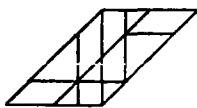
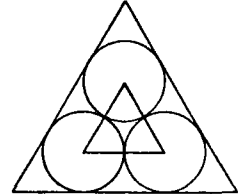
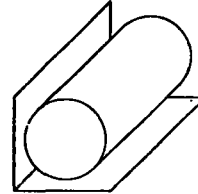
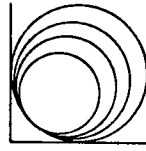
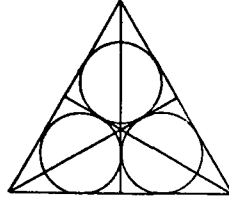
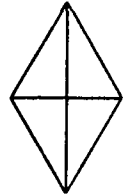
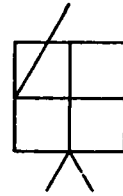
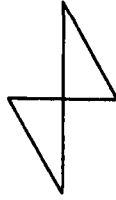
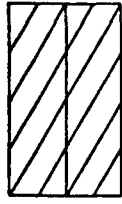


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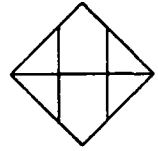
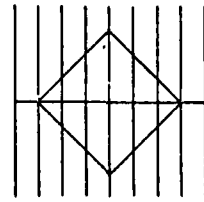
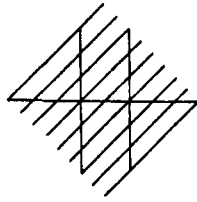
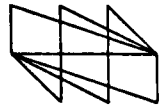


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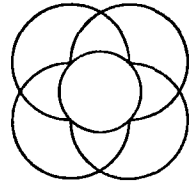
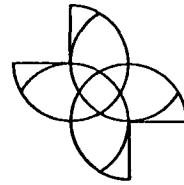
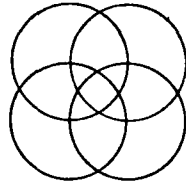
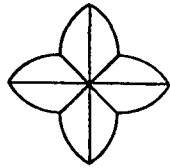
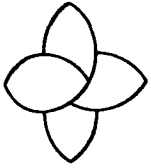


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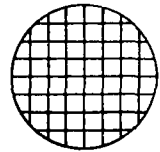
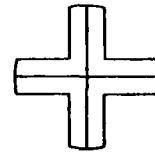
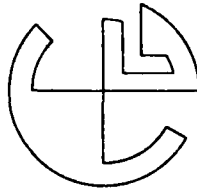
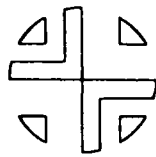


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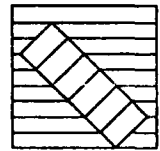
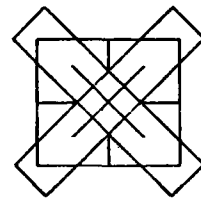
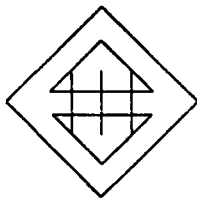
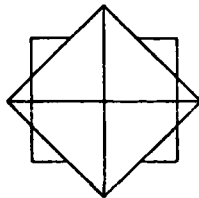
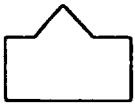


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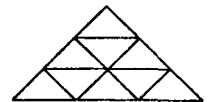
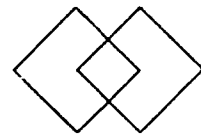
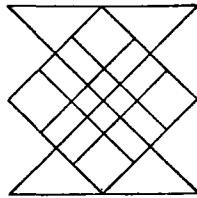
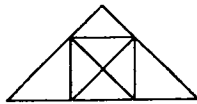


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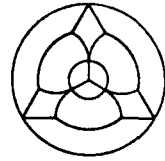
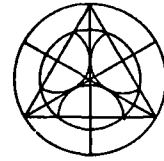
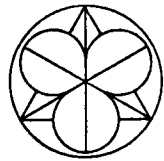
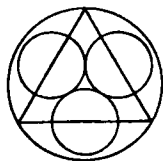


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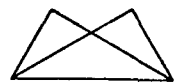
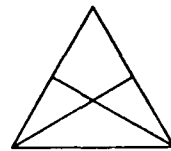
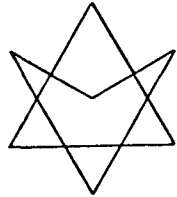
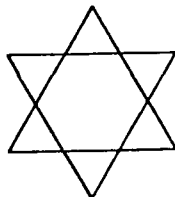


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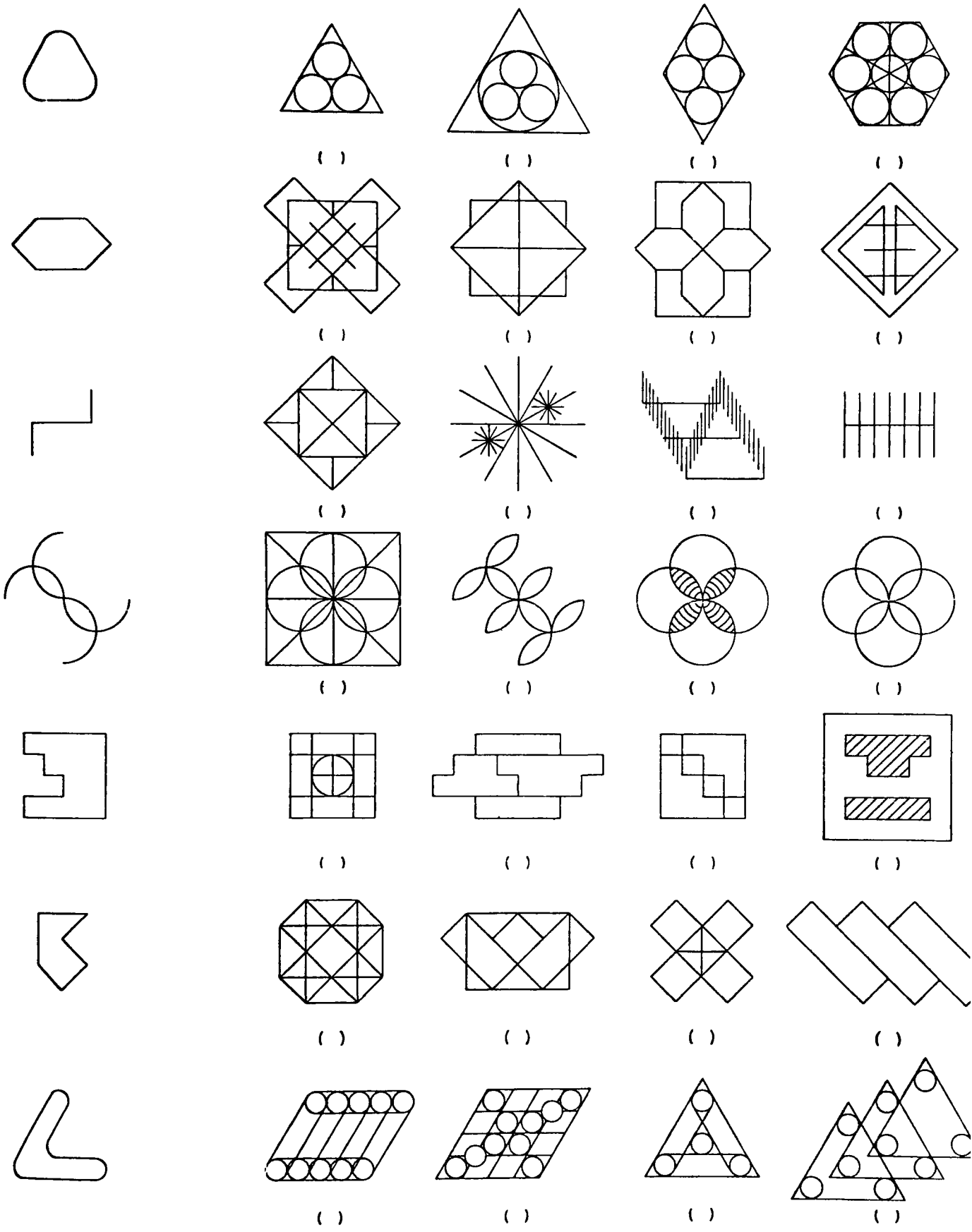
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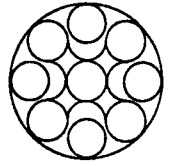
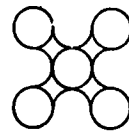
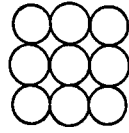
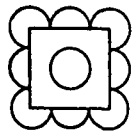
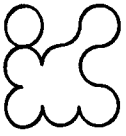
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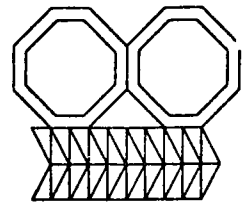
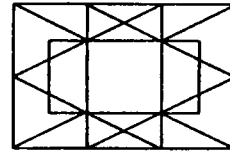
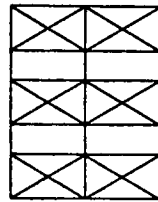
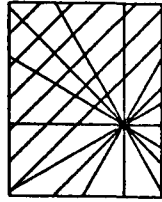
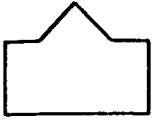


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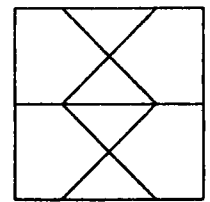
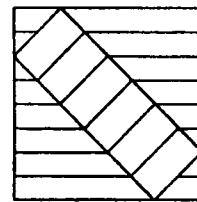
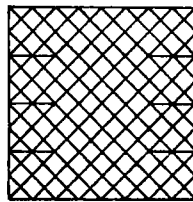
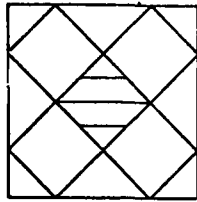
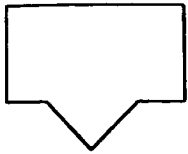


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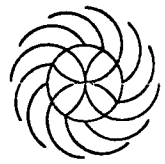
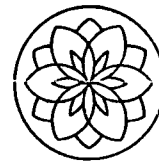
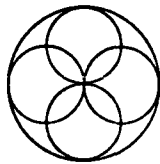


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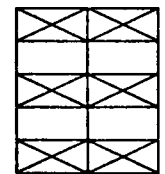
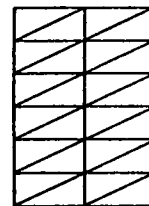
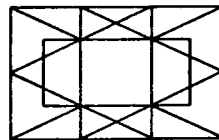
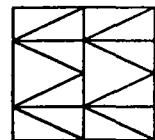
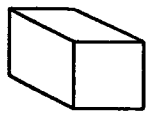


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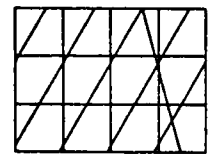
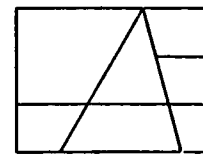
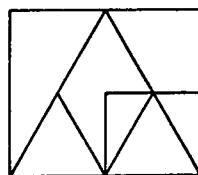
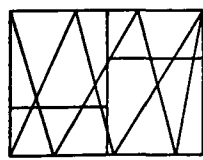
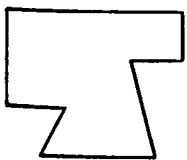


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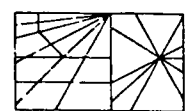
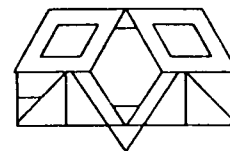
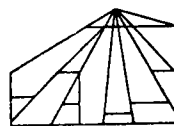
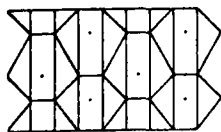


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STOP HERE -- WAIT FOR FURTHER INSTRUCTIONS.

## APPENDIX 6

### The Scientific Attitude Inventory

## WHAT IS YOUR ATTITUDE TOWARD SCIENCE?

### (A Scientific Attitude Inventory)

There are some statements about science on the next few pages. Some statements are about the nature of science, some are about how scientists work. Some of these statements describe how you might feel about science. You may agree with some of the statements and you may disagree with others. That is exactly what you will be asked to do. By doing this, you will show your attitude toward science.

After you have carefully read a statement, decide whether or not you agree with it. If you agree, decide whether you agree mildly or strongly. If you disagree, decide whether you disagree mildly or strongly. Then, find the number of that statement on the answer sheet, and blacken the space by the

- 1 if you agree strongly.
  - 2 if you agree mildly.
  - 3 if you disagree mildly.
  - 4 if you disagree strongly.
- 

#### Example:

00. I would like to have a lot of money.

00. 1  2    3    4   

(The person who marked this example agrees strongly with the statement, "I would like to have a lot of money.")

---

Please respond to each statement and blacken only one space for each statement.

Please do not make any marks on this test booklet.

## WHAT IS YOUR ATTITUDE TOWARD SCIENCE?

1. I would enjoy studying science and using this knowledge in some scientific field.
2. Anything we need to know can be found out through science.
3. Scientific explanations can be made only by scientists.
4. Once they have developed a good theory, scientists must stick together to prevent others from saying it is wrong.
5. It is useless to listen to a new idea unless everybody agrees with the idea.
6. Science may be described as being primarily an idea-generating activity.
7. Scientists are always interested in improving their explanations of natural events.
8. If one scientist says a theory is true, all other scientists will believe him.
9. Science is so difficult that only highly trained scientists can understand it.
10. A useful scientific theory may not be entirely correct, but it is the best idea scientists have been able to think up.
11. We can always get answers to our questions by asking a scientist.
12. There are some things which are known by science to be absolutely true.
13. Most people are not able to understand the work of science.
14. Today's electric appliances are examples of the really valuable products of science.
15. Scientists cannot always find the answers to their questions.
16. When something is explained well, there is no reason to look for another explanation.
17. Most people are able to understand the work of science.
18. A scientific theory is no better than the objective observations upon which it is based.
19. Scientists believe that they can find explanations for what they observe by looking at natural phenomena.

20. The day after day search for scientific knowledge would become boring for me.
21. Scientific work would be too hard for me.
22. Scientists discover laws which tell us exactly what is going on in nature.
23. Scientific ideas may be said to undergo a process of evolution in their development.
24. The value of science lies in its usefulness in solving practical problems.
25. When one asks questions in science, he gets information by observing natural phenomena.
26. A good scientist doesn't have any ideas he is not willing to change.
27. Looking at natural phenomena is a most important source of scientific information.
28. Public understanding of science is necessary because scientific research requires financial support through the government.
29. Some questions cannot be answered by science.
30. Rapid progress in science requires public support.
31. Scientists do not need public support, they can get along quite well without it.
32. A scientist must be imaginative in developing ideas which explain natural events.
33. The value of science lies in its theoretical products.
34. Ideas are one of the more important products of science.
35. I do not want to be a scientist because it takes too much education.
36. There is no need for the public to understand science in order for scientific progress to occur.
37. When a scientist is shown enough evidence that one of his ideas is a poor one, he should change his idea.
38. All one has to do to learn to work in a scientific manner is to study the writings of great scientists.
39. Before one can do anything in science, he must study the writings of the great scientists.

40. People need to understand the nature of science because it has such a great affect upon their lives.
41. A major purpose of science is to produce new drugs and save lives.
42. One of the most important jobs of a scientist is to report exactly what his senses tell him.
43. If a scientist cannot answer a question, all he has to do is to ask another scientist.
44. An important purpose of science is to help man to live longer.
45. I would enjoy working with other scientists in an effort to solve scientific problems.
46. Scientific laws cannot be changed.
47. Science is devoted to describing how things happen.
48. Every citizen should understand science because we are living in an age of science.
49. I may not make many great discoveries, but working in science would still be interesting to me.
50. A major purpose of science is to help man live more comfortably.
51. Scientists should not criticize each other's work.
52. His senses are one of the most important tools a scientist has.
53. Scientists believe that nothing is known to be true with absolute certainty.
54. Scientific laws have been proven beyond all possible doubt.
55. I would like to work in a scientific field.
56. A new theory may be accepted when it can be shown to explain things as well as another theory.
57. Scientists do not have enough time for their families or for fun.
58. The products of scientific work are mainly useful to scientists, they are not very useful to the average person.
59. Scientists have to study too much and I would not want to be one for this reason.
60. Working in a laboratory would be an interesting way to earn a living.

## APPENDIX 7

### ABSTRACT OF

#### Extent of Psychological Differentiation as Related to Achievement in Science and Attitude toward Science

Measures of psychological differentiation have been shown and other related numerous variables. There is in Witkin's work a basis for hypothesizing a relationship between field independence and both attitude toward science and achievement in science. To test this relationship the scores from the Concealed Figures Test, the Scientific Attitude Inventory, Achievement classroom tests and the Henmon-Nelson Test of Mental Ability were used. On the basis of the Concealed Figures Test, two extreme groups, one field-dependent and the other field-independent were identified. It was predicted that with mental ability controlled, field-independent subjects would score higher on the achievement tests and also have a more positive attitude toward science. Using a multivariate analysis of covariance, a significant difference was obtained in the predicted direction. Some of the theoretical contributions of these findings are discussed.