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ABSTRACT

A U.S. Air Force study was designed to investigate simultaneously four cognitive styles--field dependence-independence, reflectivity-impulsivity, leveling-sharpening, and visual-haptics. A sample of 206 undergraduate volunteers at the University of Oklahoma were tested with the Successive Perceptual Test I (SPT-I), the Hidden Figures Test (HFT), Matching Familiar Figures (MFF), and the Leveling/Sharpening House Test (LSHT) in order to assess their cognitive styles. The obtained data were analyzed in three stages: (1) chi-square tests were used to compare obtained distributions of visual and haptic perceptual types in the field independent, field dependent, reflective, impulsive, leveling and sharpening groups with Lowenfeld's theoretical distribution of 50% visuals, 25% indefinites, and 25% haptics; (2) four variables of score on HFT, errors on MFF, mean latency on MFF, and leveling-sharpening ratio on LSHT were tested in a step-wise discriminant analysis to determine if they could predict or discriminate between visual and haptic perceptual types; and (3) finally, the relationships among the variables of the study were further explored with a factor analysis. Results indicated that although the constructs overlapped somewhat, each cognitive style has enough unique characteristics that each must be considered individually. It was suggested that when using cognitive styles as a variable in future research with Air Force Technical training, perhaps requirements of specific tasks involved in the training will dictate which of these cognitive styles holds the most promise. (BM)

AFHRL-TR-78-91(I)

AIR FORCE

HUMAN RESOURCES

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IMPACT OF LEARNING STYLES ON AIR FORCE TECHNICAL TRAINING: RELATIONSHIPS AMONG COGNITIVE STYLE FACTORS AND PERCEPTUAL TYPES

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May 1979
Interim Report for Period January 1977 – January 1978

Approved for public release; distribution unlimited.

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This technical report has been reviewed and is approved for publication.

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The study reported herein is basic research which may be of interest only to a limited audience.

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20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of the study was to investigate simultaneously the four cognitive styles, field dependence-independence, reflectivity-impulsivity, leveling-sharpening, and visual-haptics. Results indicated that although the constructs overlapped somewhat, each cognitive style has enough unique characteristics that each must be considered individually. When using cognitive styles as a variable in future research with Air Force technical training, perhaps requirements of specific tasks involved in the training will dictate which cognitive style discussed in this preliminary investigation holds the most promise.

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INTRODUCTION

Before research studies involving Air Force trainees as subjects are undertaken, two preliminary investigations were conducted at the University of Oklahoma. The purpose of these investigations was to seek empirical data concerning the following two concepts:

(1) Patterns of interrelationships among cognitive style factors.

(2) An approach for designing instruction to interact favorably with cognitive style characteristics.

The studies reported here have yielded data relevant to these two concepts. It is anticipated that the findings of the studies will be applicable to the planned research with Air Force trainees.

RELATIONSHIPS AMONG COGNITIVE STYLE FACTORS AND PERCEPTUAL TYPES

Introduction to the Study

Background

The past 30 years have seen the documentation in research literature of a group of individual difference variables not discussed until the 1940's. At that time, psychological inquiry into differences in the cognitive process revealed the variables which have crystallized in the concept of cognitive style. This concept refers to psychological dimensions which represent consistencies in an individual's manner of acquiring and processing information. It should be noted that cognitive style is not synonymous with ability. Kogan offers the following definition of cognitive styles which distinguishes them clearly from abilities:

> Cognitive styles can be most directly defined as individual variation in modes of perceiving, remembering, and thinking, or as distinctive ways of apprehending, storing, transforming, and utilizing information. It may be noted that abilities also involve the foregoing properties, but a difference in emphasis should be noted: Abilities concern level of skill - the more and less of performance - whereas cognitive styles give greater weight to the manner and form of cognition (Kagan, 1971, p. 244).

Several primary dimensions or factors of cognitive style have been identified, and tests have been developed for their assessment. Three of the primary dimensions of cognitive style and associated testing instruments which have emerged have come from three principal research "camps." The leaders of these "camps" have been Herman Witkin, Jerome Kagan, and George Klein. Each group has identified and studied the dimension of cognitive style which it considers to be most important. There has been little effort, however, to examine these dimensions of cognitive style in terms of their relationships to each other or to determine if they are related to another perceptual variable: the perceptual typology developed by Viktor Lowenfeld. An interrelatedness of cognitive style factors would lead to consideration of the possibility that an individual's typical performance on one dimension of cognitive style may be related to his or her performance on other dimensions, a possibility which has been almost completely ignored in available research literature. This study was therefore designed to initiate examination of relationships among cognitive style factors by investigating the relationships among three major dimensions of cognitive style and Lowenfeld's structure of perceptual types.

In the research literature dealing with cognitive style, three dimensions which have emerged as being stable and the subjects of the most intensive investigation are the following:

(1) The field independence/field dependence dimension.
(2) The reflectivity/impulsivity dimension.
(3) The leveling/sharpening dimension.

The field independence/field dependence dimension of cognitive style is concerned with the influence of the stimulus field on perception. Work in this area was begun by Gottschald and was continued by Witkin. Witkin and his associates conducted research which led to the conclusion that field factors influence some individuals far more than others. Work with this perceptual variable led to the identification of two distinct types of visual perception: (1) perception which is heavily influenced by field factors and the complexity of background, and (2) perception which is only slightly influenced by these factors.

These two styles of perception are referred to as field dependence and field independence, respectively. Field independence implies an analytical, as opposed to a global, way of perceiving stimuli which involves a tendency to perceive items as discrete from their background and demonstrates an ability to overcome an embedding context.

A second important dimension of cognitive style is the reflectivity/impulsivity dimension. This aspect of cognitive style, sometimes referred to as cognitive tempo, is basically concerned with the speed with which hypotheses are selected and information processed. The majority of the research on this cognitive dimension has been done by Kagan and his associates. In situations in which several response possibilities are available simultaneously, the impulsive individual reports the first hypothesis which occurs to him/her and is usually incorrect, while the reflective one considers all possibilities before making a response and is usually correct.

A third dimension which has emerged from the research on cognitive style is the leveling/sharpening dimension. This dimension originated in the research of Klein, and has been studied extensively by Santostefano. The leveling/sharpening dimension deals with the manner in which an individual perceives and stores gradual changes in sequentially experienced stimuli. Levelers tend to merge new experiences with memories of earlier ones and, therefore, to construct relatively undifferentiated memories and impressions of ongoing experiences. Sharpeners tend to maintain discrete impressions and memories of sequentially presented stimuli so that elements do not lose their individuality.

Another individual difference variable which may have important relationships to cognitive styles which have not been thoroughly investigated is perceptual type. In his research in art education, Viktor Lowenfeld identified individuals of two distinct perceptual types. These two types, which he called visual and haptic, he believed to have two unlike manners of perceiving and reacting to the world of experience (Lowenfeld, 1945; Lowenfeld and Brittain, 1970). An individual of the visual perceptual type tends, according to Lowenfeld, to use the eyes as the main intermediaries of sensory impressions. The visual type is perceptually an observer, usually approaching things from their appearance and feeling as a spectator. The tendency is to transfer kinesthetic and tactile experiences into visual ones. A haptic individual, on the other hand, is a normally-sighted person who uses the eyes as the primary sensory intermediaries only when compelled to do so, preferring to rely on touch and kinesthesis. The main intermediary for the haptic type is the "body-self" - muscular sensations, kinesthetic experiences, touch impressions, and other physical sensations. The haptic does not transform kinesthetic and tactile experiences into visual ones (Lowenfeld, 1945).

Lowenfeld's extensive studies revealed that the distribution of visual and haptic perceptual types is stable across populations. He found that while most people fall between the extremes of the two types, a few individuals have equal tendencies toward visual and haptic perception. He found consistently in all the subpopulations he tested that about 75% of the subjects showed appreciable tendency toward one type or the other. Not quite 50% showed visual tendency, and not quite 25% showed haptic tendency. He thus established the following approximated theoretical distribution of perceptual types for any given population: visual 50%, indefinite 25%, and haptic 25%. This distribution coincides closely with that found by Walter (1973) with the use of an electroencephalograph for assessing what he called "visualizers," "non-visualizers," and "mixed types."

Lowenfeld postulated several important distinctions between the perceptual functioning of visual and haptic individuals. These distinctions include the following:

(1) While the visual has the ability to see a whole, break it up, and see its component details and then to resynthesize the details back into a whole, the haptic is unable to do this.

(2) While the visual tends to react to stimuli as a spectator and to "see" experiences, the haptic tends to react emotionally, to "feel" stimuli, and to put himself or herself into the situations which are experienced.

(3) While the visual has the tendency and ability to visualize tactile experiences and to visually complete partial experiences, the haptic has neither this tendency nor ability.

(4) While the visual has the ability to mentally retain visual images, the haptic is unable to do this.

These distinctions form an important component of the theoretical rationale for the present study. A second important theoretical component is the model of cognitive processes proposed by Fletcher (1969). According to this model, cognition consists of the following four steps or groups of processes, all of which are linked to the memory and interact with it:

(1) Attentional processes are those which serve to detect the cues relevant to the particular problem at hand.

(2) Transformation processes are those which serve to encode appropriate information.

(3) Generation processes are those which serve to generate solutions to the problem.

(4) Evaluation processes are those which serve to determine whether a solution has been achieved.

Since an individual "responds only to encoded information, never to actual stimuli" (Fletcher, 1969, p. 8), the transformation step in the cognitive process is fundamental and vital. The generation of solutions is, according to Fletcher's model, based upon how input stimuli are transformed by the learner. Fletcher hypothesized two principal types or styles of transformation: the analytical style, in which stimuli are broken down into individually meaningful elements; and the synthetic style, in which stimuli are grouped globally into wholes. To Fletcher, the manner in which solutions to problems are generated is necessarily dependent upon which type of transformation is used by an individual. It therefore follows that a task which requires a specific type of transformation for its solution cannot be satisfactorily performed by a learner who is incapable of the necessary type of transformation.

The nature of all the tasks typically used to assess field independence/field dependence, reflectivity/ impulsivity, leveling/sharpening, and visual/haptic perception requires the discrimination and separation of visual stimuli. This means that, in Fletcher's terminology, analytic transformation and memory storage of visual stimuli are required for the correct generation of the solution to these tasks. It is apparent from Lowenfeld's distinctions between visuals and haptics that this manner of handling visual stimuli is theoretically readily available to persons of the visual perceptual type, but not readily available to persons of the haptic type. This implies that performance on these cognitive style assessment tasks could be expected to be influenced by an individual's perceptual type. This in turn implies that relationships could be expected to be observed among the various factors of cognitive style as measured by these instruments. This study was designed to test the validity of these implications.

The basic question investigated in this study is: Are the cognitive style factors of field independence/field dependence, reflectivity/impulsivity, and leveling/sharpening related to each other and to Lowenfeld's concept of visual and haptic perceptual types? To conduct this investigation, three general questions were explored:

(1) Are visual and haptic perceptual types distributed in various cognitive style sub-populations as predicted from Lowenfeld's theoretical distribution of perceptual types?

(2) Can performance on measures of cognitive style discriminate categories of perceptual type?

(3) What kind of factor structure do measures of cognitive style and perceptual type produce in a factor analysis?

Hypotheses

Application of the theoretical base provided by Lowenfeld and Fletcher leads to the conclusion that performance on a visual test of cognitive style is influenced by perceptual type. The haptic type could be expected to transform and store visual stimuli synthetically and to react emotionally, thus testing out as field dependent, impulsive, and leveling. The distribution of visual and haptics in field dependent, impulsive, and leveling populations would therefore be the reverse of Lowenfeld's theoretical distribution. This reversal should result in a statistically significant difference between expected (theoretical) and observed frequencies of visual and haptic types in these populations.

The visual type, on the other hand, could be expected to transform and store visual stimuli analytically and to react impersonally, thus testing out as field independent, reflective, and sharpening. Lowenfeld's theoretical distribution would place visuals and haptics in these populations in a ratio of two to one, thus making them predominantly visual. It might be expected that the actual observed frequencies of perceptual types in these populations would increase this ratio of visuals to haptics. Whether the difference in expected and observed frequencies is statistically significant could be expected to be largely a matter of statistical power and instrument sensitivity.

Finally, if visual and haptic performances on visual tests of cognitive style are typically different, performance on these tests might be expected to discriminate between the two perceptual types.

The expectations discussed above lead to the formation of the following specific hypotheses for this study:

H_1: The obtained frequency of visual types among field dependent subjects is smaller than the expected frequency.

H_2: The obtained frequency of haptic types among field independent subjects is smaller than the expected frequency.

H_3: The obtained frequency of haptic types among reflective subjects is smaller than the expected frequency.

H_4: The obtained frequency of visual types among impulsive subjects is smaller than the expected frequency.

H_5: The obtained frequency of haptic types among sharpening subjects is smaller than the expected frequency.

H_6: The obtained frequency of visual types among leveling subjects is smaller than the expected frequency.

H_7: The cognitive style predictor variables discriminate between the criterion categories of perceptual type.

METHOD

Subjects

The subjects for this study were a group of 206 undergraduate students enrolled in Education 4160, Media and Technology in Teaching, at the University of Oklahoma. All subjects were volunteers, ranging in age from 19 to 33 years. There were 12 subjects total from the racial minorities. The ratio of females to males was 2.3 to 1. While no test was actually given to determine whether any of the subjects had visual handicaps, all reported that they had none except those ameliorated by corrective lenses. It was assumed, on this basis, that all subjects were normally sighted or wore optics which gave them normal visual acuity. All subjects who reported that they wore corrective optics were required to wear them during all research testing.

Testing Instruments Used

The instrument used to assess perceptual type as defined by Lowenfeld was Successive Perception Test I (United States Army Corps, 1944), a test in motion picture form which was developed by Gibson for use in the World War II Aviation Psychology Program as a part of the pilot selection and training program. Successive Perception Test I (SPT-1) is a refined version of Lowenfeld's original Integration of Successive Impressions (Lowenfeld, 1945), and is based on the same rationale and construct. The primary distinction between individuals of the visual and haptic perceptual types which serves as the basis for both the Lowenfeld test and for SPT-1 is that while visuals have the tendency and ability to integrate partial perceptions into visual wholes, haptics are content to internalize the separate segments of partial impressions and show neither tendency nor ability to integrate them into whole units.

SPT-1 consists of three practice items and 35 actual test items. In each item, the subject views a pattern a small section at a time behind a moving slot and is then shown five similar variants from which must be selected the one which matches the pattern seen behind the slot.

SPT-1 was developed originally for use in the Army Air Corps cadet program and has been used extensively in that context. It has also been used numerous times in educational research dealing with perceptual type and visual aptitude with subjects ranging from seventh grade to university level (Erickson, 1968; 1969; Clark, 1971; Bruning, 1974; Ausburn, L.J., 1975; Ausburn, F.B., 1975). The test-retest reliability of SPT-1 was computed by Ausburn (F.B., 1975), using 80 subjects and a test-retest interval of 6 weeks, as .68. While this reliability coefficient is rather low, the test has yielded research results consistent with theory-based hypotheses. In addition, SPT-1 is the only currently available instrument for assessing perceptual type for which reliability has been established empirically.

The Hidden Figures Test (HFT; French, Ekstrom, & Price, 1963) was used to assess field independence/field dependence. The HFT, developed for research purposes as part of the Kit of Reference Tests for Cognitive Factors by Educational Testing Service, is cited by Kogan (1971) as an alternative test to Witkin's frequently used Embedded Figures Test (EFT). Like the EFT, the HFT is confined to the visual perception aspect of field independence, measuring the trait in terms of ability to overcome the embedding context of a visual field by locating a simple geometric figure within a complex one. However, while the dependent measure in the EFT is the time required to locate the embedded figure, the dependent measure in the HFT is the number of figures located within a specified time. The HFT has the practical advantage of being a group instrument rather than an individual one. Since no reliability coefficient for the HFT could be located, it was computed by the test-retest method using 60 subjects and a time interval of 12 weeks, and was found to be .92.

Reflectivity/impulsivity was measured with the adult form of Kagan's (1969) Matching Familiar Figures (MFF). While a specific reliability coefficient could not be located for MFF, the instrument is the standard one used in research on cognitive tempo. Kagan (1966) calls it the "most sensitive" measure of cognitive tempo, and Kogan (1971) states that it is "now consistently employed as the basic index" of the trait (p. 266). On this basis, it was accepted for use in this study.

In the MFF, the subject must examine a standard in the form of a black-and-white line drawing of a figure (such as a lion, a bed, or a flower) and then look at a group of similar variants and select the one which is identical to the standard. The standard and all variants remain in the subject's view at all times, thus eliminating memory as a variable. The adult form of MFF consists of 12 items with eight variants per item. Dependent measures obtained on the test are response latency and number of errors on each item. These two variables show a negative correlation for all age groups ranging in magnitude from the low .40's to the high .60's (Kogan, 1971).

The instrument used to assess leveling/sharpening was Santostefano's (1971) Leveling-Sharpening House Test (LSHT). This test consists of 60 black line drawings of a scene containing a two-story house with windows, a door, a weather-vane, a chimney, a sidewalk, a fence, a cloud, a tree, and a sun. The intact picture is displayed three times. Then one element (the door knob) is omitted, and the picture is again shown three times. An additional element is omitted every three trials until a total of 19 elements are omitted from the original display, with the least conspicuous element eliminated first and the most conspicuous last. Each picture is displayed for 5 seconds. The subject is asked to tell the examiner when something looks different from the previous picture. This task yields three measures. The "first stop score" indicates the point at which the subject first correctly reports that something is different. Early detection reflects sharpening. A high total number of correct changes reported also reflects sharpening. A "leveling-sharpening ratio," the third dependent measure, reflects a mean number of changes which go undetected -- the smaller the ratio is, the greater the operation of sharpening will be.

Santostefano (1971) reports that LSHT has been used for research purposes with children from the age of 4 through adolescence and with adults. He reports no reliability coefficient for the test, so test-retest reliability was computed as part of the present study, using 30 subjects and a time interval of 5 weeks, it was found to be .86. However, Santostefano states the extensive research is being conducted concerning the reliability of LSHT, and this data, when released, will be far more conclusive than those reported here. He states that at this time the test is being "made available to those professionals interested in including the procedure in their clinical research on an experimental basis" (Santostefano, 1975, p. 2), and it was primarily on this basis that the LSHT was accepted for use in this study.

Procedures

The 206 subjects were administered SPT-1 via a video tape made from the black-and-white motion picture version in groups ranging from 21 to 38 persons. They were asked to indicate their response on each test item by circling the appropriate letter on an answer sheet. The subjects were classified as visual, haptic, or indefinite in perceptual type according to procedures developed by Lowenfeld (1945) for his Integration of Successive Impressions. Subjects scoring 60% or more items correct (scores of 21 to 35) were classified as visual, while those scoring 60% or more incorrect (scores of 0 to 14) were classified as haptic.

The HFT was given to the subjects in the same groups and at the same sitting as the administration of SPT-1. It was administered and scored according to procedures given in the test manual provided with the test. Responses were indicated on the test forms by placing a mark through the letter of the simple figure located in each complex one. The score made on the test was computed by subtracting, as a correction for guessing, one-fourth of the number of items answered incorrectly from the total number of items answered correctly. Items for which no response was made were not counted as either correct or incorrect. Subjects scoring in the upper one-third of the sample were classified as field independent; those scoring in the lower one-third were classified as field dependent. Table 1 shows the number of subjects classified and the score ranges included in each classification. The unequal group sizes were caused by tied scores at the cut-off points.

TABLE 1

Subject Classification on HFT

Classification	Number Classified	Score Range Included
Field Independent	76	27 to 13
Indefinite	57	12.5 to 6.5
Field Dependent	73	6 to -2

The MFF was administered to subjects individually and was scored according to procedures developed by Kagan (1966). The response latency and number of errors made on each of the 12 test items were recorded, and the error total and mean response latency were computed for each subject. When all subjects had been tested, the median error (M = 3.0) and latency (M = 64.66) scores for the entire sample were calculated. Subjects scoring above-median latency and below-median errors were classified as reflective; those scoring below-median latency and above-median errors were classified as impulsive.

The LSHT was administered to the subjects individually during the same testing period as the MFF. It was administered using test forms and instructions contained in the test manual (Santostefano, 1971). The leveling-sharpening ratio was computed for each subject according to instruction in the manual, and subjects whose ratio was in the lower one-third of the sample were classified as sharpeners, while those whose ratio was in the upper one-third were classified as levelers. Table 2 shows the number of students classified and the leveling-sharpening ratio ranges included in each classification.

TABLE 2

Subject Classification on LSHT

Classification	Number Classified	Range of Leveling-Sharpening Ratios Included
Sharpeners	69	6.16 to 11.47
Indefinite	68	11.53 to 14.63
Levelers	69	14.68 to 23.26

Table 3 summarizes the test instruments and classification procedures used and the number of subjects classified on each instrument.

TABLE 3

Subject Classifications on Testing Instruments

Variable and Instrument	Classification Procedure	Number Classified
Perceptual Type (Measured by SPT-1)	Visual (60% or more items correct)	99
	Indefinite (neither 60% correct nor 60% incorrect)	52
	Haptic (60% or more items incorrect)	55
Field Independence/ Field Dependence (Measured by HFT)	Field Independent (upper 1/3 of the sample)	76*
	Indefinite (middle 1/3 of sample)	57
	Field Dependent (lower 1/3 of sample)	73
Reflectivity/ Impulsivity (Measured by MFF)	Reflective (above median latency and below median errors)	74
	Impulsive (below median latency and above median errors)	75
	Not Classified (at or below median latency and errors OR at or above median latency and errors)	57
Leveling/Sharpening (Measured by LSHT)	Sharpeners (L-S ratio in lower 1/3 of sample	69
	Indefinite (L-S ratio in middle 1/3 of sample)	68
	Levelers (L-S ratio in upper 1/3 of sample)	69

* Unequal groups caused by tied scores at cut-off points

Since much of the planned data analysis was to be based on Lowenfeld's theoretical distribution of visual (50%), indefinite (25%), and haptic (25%), perceptual types, a chi-square test for goodness-of-fit was performed using the following formula:

$$X^2 = \sum \frac{(O - E)^2}{E}$$

The test was performed to verify that the obtained distribution of perceptual types (visuals = 48%; indefinites = 25%; haptics = 27%) was not significantly different from the theoretical one. The results of the chi-square test are summarized in Table 4.

TABLE 4

Chi-Square Test for Goodness-of-Fit on Obtained and Expected Distributions of Perceptual Types

Perceptual Type	Expected N	Obtained N
Visual	103	99
Indefinite	51.5	52
Haptic	51.5	55
Total N = 206	df = 2	Chi^2 = .398*

* $p > .80$

The analysis of the data obtained in this study was performed in three major stages. In the first stage of analysis, the frequencies of visual, haptic, and indefinite perceptual types obtained in field independent, field dependent, reflective, impulsive, sharpening, and leveling groups were compared with Lowenfeld's theoretical distribution using chi-square tests for goodness-of-fit. This analysis served to test hypotheses one through six.

In the second stage of data analysis, the ability of the cognitive style measures of score on SPT-1, score on HFT, errors on MFF, mean latency on MFF, and leveling-sharpening ratio on LSHT to predict or discriminate between visual and haptic perceptual types was examined with a step-wise discriminant analysis. This procedure tested hypothesis seven.

Finally, relationships among the variables of the study were further explored through the use of factor analysis.

RESULTS

Chi-Square Tests

The chi-square tests computed on the field dependent, field independent, reflective, impulsive, sharpening, and leveling groups identified by the testing instruments utilized allowed the acceptance of the six relevant hypotheses at the .001 level of significance.

This indicated significant differences in the obtained and expected frequencies of perceptual types in the cognitive style groups in the predicted directions. The results of the chi-square tests are summarized in Tables 5 to 10. The critical value for chi-square at the .001 level of significance with two degrees of freedom is 13.815.

TABLE 5

Chi-Square Test of Goodness-of-Fit on Obtained and Expected Distributions of Perceptual Types Among Field Dependent Subjects

Perceptual Type	Expected N	Obtained N
Visual	36.5	8
Indefinite	18.25	23
Haptic	18.25	42
Total N = 73	df = 2	$Chi^2 = 54.41$*

* $p < .001$

TABLE 6

Chi-Square Test of Goodness-of-Fit on Obtained and Expected Distributions of Perceptual Types among Field Independent Subjects

Perceptual Type	Expected N	Obtained N
Visual	38	67
Indefinite	19	4
Haptic	19	5
Total N = 76	df = 2	$Chi^2 = 44.28$*

* $p < .001$

TABLE 7

Chi-Square Test of Goodness-of-Fit on Obtained and Expected Distributions of Perceptual Types among Reflective Subjects

Perceptual Type	Expected N	Obtained N
Visual	37	53
Indefinite	18.5	15
Haptic	18.5	6
Total N = 74	df = 2	$Chi^2 = 16.03$*

* $p < .001$

TABLE 8

Chi-Square Test of Goodness-of-Fit on Obtained and Expected Distributions of Perceptual Types among Impulsive Subjects

Perceptual Type	Expected N	Obtained N
Visual	37.5	16
Indefinite	18.75	21
Haptic	18.75	38
Total N = 75	df = 2	$Chi^2 = 32.36$*

* $p < .001$

TABLE 9

Chi-Square Test of Goodness-of-Fit on Obtained and Expected Distributions of Perceptual Types among Sharpening Subjects

Perceptual Type	Expected N	Obtained N
Visual	34.5	54
Indefinite	17.25	12
Haptic	17.25	3
Total N = 69	df = 2	$Chi^2 = 24.39$*

* $p < .001$

TABLE 10

Chi-Square Test of Goodness-of-Fit on Obtained and Expected Distributions of Perceptual Types among Leveling Subjects

Perceptual	Expected N	Obtained N
Visual	34.5	11
Indefinite	17.25	21
Haptic	17.25	37
Total N = 69	df = 2	Chi^2 = 39.43*

* p < .001

Discriminant Analysis

In order to test the hypothesis that cognitive style predictor variables would discriminate between visual and haptic perceptual types, a step-wise discriminant analysis was performed. The cognitive style predictor variables used were score on HFT, errors on MFF, mean latency on MFF, and leveling-sharpening ratio on LSHT. The two criterion categories to be discriminated were visual and haptic perceptual types as measured by SPT-1.

The analysis indicated that, considered individually as single predictors, score on HFT (df = 1,152; F to enter = 115.2803; p < .001), errors on MFF (df = 1,152; F to enter = 96.6521; p < .001), mean latency on MFF (df = 1,152; F to enter = 10.0975; p < .005), and leveling-sharpening ratio on LSHT (df = 1,152; F to enter = 10.0948; p < .005) were each significant predictors of visual and haptic perceptual types.

Since it was the best single predictor of the perceptual type dichotomy, score on HFT was the first variable entered into the four-variable prediction system. The prediction of perceptual type from this single variable alone was, of course, significant beyond the .001 level as shown by the F value reported above for HFT. Table 11 shows the number of cases classified into the criterion groups with only this single variable entered into the prediction system.

TABLE 11

Number of Cases Classified into Criterion Groups with HFT Entered

(Observed)	(Classified) Visual	Haptic
Visual	89	10
Haptic	10	45

Percentage of cases correctly classified = 87.01

The second variable entered was errors on MFF. This variable added significantly to the prediction system, as indicated by the value of its F to remove (df = 1,151; F to remove = 44.2962; p < .001). With two variables entered (score on HFT and errors on MFF), the predictions system remained significant beyond the .001 level (df = 2,151; F = 96.20659; p < .001). Table 12 shows the number of cases classified into the criterion groups with two variables entered into the prediction system. It can be seen by comparing Tables 11 and 12 that the prediction accuracy gained by adding the second variable was gained in predicting the occurrence of visual types rather than haptic ones.

TABLE 12

Number of Cases Classified into Criterion Groups with HFT and Errors on MFF Entered

(Observed)	(Classified) Visual	Haptic
Visual	93	6
Haptic	12	43

Percentage of cases correctly classified = 88.31%

The third variable entered was leveling-sharpening ratio on LSHT. With three variables entered, the overall prediction system remained significant beyond the .001 level (df = 3,150; F = 64.64581; p < .001), but the newly-added variable made no significant new contribution (df = 1,150; F to remove = 1.2305; p > .25). Table 13 shows the number of cases classified into the criterion groups with three variables entered into the prediction system.

TABLE 13

Number of Cases Classified into Criterion Groups with HFT, Errors on MFF, and LSHT Entered

(Observed)	(Classified)	
	Visual	Haptic
Visual	94	5
Haptic	11	44

Percentage of cases correctly classified = 89.61%

The reason for the failure of the leveling-sharpening variable to add significantly to the prediction system after the entry of HFT and errors on MFF is seen by examining the correlation coefficients among variables, computed with visual and haptic subjects only, with the indefinite perceptual type group removed as it was for the discriminant analysis. While leveling-sharpening ratio on LSHT is modestly but significantly correlated with the criterion variable of score on SPT-1 (r = -.23; df = 152; p = .02), it is also significantly correlated with both HFT (r = -.21; df = 152; p = .05) and errors on MFF (r = .23; df = 152; p = .02). Therefore, although it could be expected to discriminate fairly well between visuals and haptics when considered by itself as a single predictor, the leveling-sharpening ratio could not be expected to add significantly to a multivariable prediction system into which the variables HFT and errors on MFF had already been entered. It contributes nothing significant which was not already accounted for by the two previously entered variables because of its correlation with them.

The last variable entered into the prediction system on the discriminant analysis was mean latency on MFF. The overall prediction system remained significant when this final variable was added ($df = 4,149$; $F = 48.25345$; $p < .001$), thus allowing the acceptance of the prediction hypothesis. The variable made no significant new contribution to the system however ($df = 1,149$; F to remove = 0.1610; $p > .25$). The reason for this is that while mean latency on MFF is correlated with the criterion variable of perceptual type as measured by SPT-1 ($r = .2559$; $df = 152$; $p = .01$) it is also highly correlated with errors on MFF ($r = -.5888$; $df = 152$; $p < .01$), which was already entered into the system, and therefore, added no significant prediction power not already contributed by the latter variable. Table 14 shows the number of cases classified into the criterion groups with all four predictor variables entered into the prediction system.

TABLE 14

Number of Cases Classified into Criterion Groups with HFT, Errors on MFF, LSHT, and Mean Latency on MFF Entered

(Observed)	(Classified)	
	Visual	Haptic
Visual	94	5
Haptic	12	43

Percentage of cases correctly classified = 88.96%

Factor Analysis

In the final stage of data analysis, relationships among the variables of the study were further explored with a factor analysis. Table 15 shows the correlation matrix on which the generated factor matrix was based.

From the correlation matrix shown in Table 15, a two-factor factor matrix rotated to Varimax criterion. This factor matrix accounts for 100% of all common variance among the variables and for 45.87% of the total score variance. This can be interpreted as meaning that the factor matrix accounts for all of the variance, given the existing correlation matrix among the variables. It would, however, account for not quite half of the score variance if all the variables were perfectly correlated. There thus appears to be considerable specific variance in the individual variables.

TABLE 15

Correlation Matrix for All Variables

	SPT-1	HFT	MFF Errors	MFF Latency	LSHT
SPT-1	1.000	.575***	-.540***	.240**	-.226*
HFT		1.000	-.367***	.012	-.179
MFF Errors			1.000	-.596***	.189
MFF Latency				1.000	-.012
LSHT					1.000

* $p < .05$ ** $p < .02$ *** $p < .01$

TABLE 16

Factor Matrix Rotated to Varimax Criterion

	Factor I	Factor II
SPT-1	.6911	.3024
HFT	.6817	.0639
MFF Errors	-.4346	-.6915
MFF Latency	.0269	.7076
LSHT	-.2906	-.0487

Interpreting factor loadings as correlations between the variable and the factor, the variables of SPT-1, HFT, and errors on MFF show substantial loadings on Factor I. LSHT also shows a modest loading on the factor. Factor II is defined by substantial loadings of errors on MFF and latency on MFF and a modest loading of SPT-1.

SUMMARY AND DISCUSSION

Summary

A sample of 206 undergraduate volunteers were tested with Successive Perceptual Test I (SPT-1), the Hidden Figures Test (HFT), Matching Familiar Figures (MFF), and the Leveling/Sharpening House Test (LSHT) in order to assess the cognitive style factors of perceptual type as defined by Lowenfeld, field independence/field dependence as defined by Witkin, reflectivity/impulsivity as defined by Kagan, and leveling/sharpening as defined by Santostefano, respectively. After the subjects were classified on all four instruments, the obtained data were analyzed in three stages.

In the first stage of analysis, chi-square tests were used to compare obtained distributions of visual and haptic perceptual types in the field independent, field dependent, reflective, impulsive, leveling and sharpening groups with Lowenfeld's theoretical distribution of 50% visuals, 25% indefinites, and 25% haptics. In all cases, the obtained distribution was significantly different from the theoretical one.

In the second stage of data analysis, the four variables of score on HFT, errors on MFF, mean latency on MFF, and leveling-sharpening ratio on LSHT were tested in a step-wise discriminant analysis to determine if they could predict or discriminate between visual and haptic perceptual types. It was found that while the four-variable system could significantly predict perceptual type, a two-variable system composed of score on HFT and errors on MFF could make the prediction with equal accuracy. Latency on MFF and score on LSHT, while sufficiently correlated with the criterion variable to be significant predictors when considered alone, were also sufficiently correlated with the former two variables to fail to add any prediction accuracy not already contributed by them.

In the final stage of analysis, the relationships among the variables of the study were further explored with a factor analysis. The analysis produced a two-factor matrix rotated to Varimax criterion, with SPT-1, HFT, errors on MFF, and LSHT showing substantial to modest loading on Factor I, and errors on MFF, latency on MFF, and SPT-1 showing substantial to modest loadings on Factor II.

Discussion

Chi-square tests. Lowenfeld's theoretical distribution of perceptual types provides for 50% visuals, 25% indefinites, and 25% haptics in any given population. A significant deviation from this distribution in a population would indicate an occurrence of perceptual types which is different from the predicted and usually occurring one.

Chi-square tests revealed the occurrence of significantly more visuals and fewer haptics than expected in the field independent (88.16% visuals; 6.58% haptics), reflective (71.62% visuals; 8.11% haptics), and sharpening (78.26% visuals; 4.34% haptics) groups. They also revealed significantly fewer visuals and more haptics in the field dependent (10.96% visuals; 57.53% haptics), impulsive (21.33% visuals; 50.67% haptics), and leveling (15.94% visuals; 53.62% haptics) groups. A proportion of visuals to haptics greater than the expected two-to-one ratio in the field independent, reflective, and sharpening groups and a reversal of the expected distribution of visuals and haptics in the field dependent, impulsive, and leveling groups lead to the conclusion that perceptual type is related to the dimension of cognitive style represented by the groups identified. Visuals tend to display field independence, reflectivity, and sharpening in their cognitive styles, while haptics tend to display field dependence, impulsivity, and leveling tendencies. These results were predicted, as indicated in the hypotheses for this study, because the presence or absence of ability to separate and analyze visual details characteristic of visuals and haptics respectively, was expected to be related to the visual discrimination required in the tasks used to assess the other cognitive traits. This relationship appears to be supported by the obtained distributions of visuals and haptics in the cognitive style groups.

Discriminant analysis. The discriminant analysis added further support to the postulated relationship between the characteristics of visual and haptic perceptual functioning and the other cognitive style factors examined. It indicates that the performance on four tests for field independence/field dependence, reflectivity/impulsivity, and leveling/sharpening could predict perceptual type with significant (p .001) and substantial (88.96%, or 137 cases out of 154) accuracy. It also indicates, because all predictors are significant single discriminators of perceptual type, that the means of the visual and haptic groups on all four cognitive style variables, shown in Table 17, are significantly different.

TABLE 17

Visual and Haptic Group Means on Cognitive Style Tests

Variable	Visual Group Mean	Haptic Group Mean
HFT	14.43	4.60
MFF Errors	2.10	5.94
MFF Latency	72.89	55.11
LSHT	12.52	15.90

By using a step-wise discriminant analysis, it was possible to determine that visuals are more field independent, reflective, and sharpening than haptics, as indicated by the significantly different mean scores. This supports the results of the chi-square tests. It was also possible to determine not only that performance on the cognitive style tests can predict visual and haptic perceptual type, but also whether each variable can be used as a significant predictor by itself, exactly which variables are the best predictors, and how many variables need be used for optimal prediction in terms of accuracy and parsimony. It was learned from the analysis that HFT, MFF errors, MFF latency, and LSHT are all significant predictors when considered alone, that HFT and errors on MFF are considerably stronger predictors than the other two variables, and that only these two variables need be entered into a prediction system, since the others add no significant contribution.

Another important interpretation allowable from a discriminant analysis in which the prediction system is significant, as in the present case, is that, knowing that individuals fail in given criterion categories, it is possible to make statements about their probable performance on the tests used as predictors in the analysis. From the results of the discriminant analysis, it can be predicted that visual individuals will make higher scores on HFT, fewer errors and longer latencies on MFF, and lower leveling/sharpening ratios on LSHT than haptic individuals. By knowing perceptual type, prediction can be made concerning field independence/dependence, reflectivity/impulsivity, and leveling/sharpening as assessed by the instruments used in this study.

The discriminant analysis revealed that both field independence as measured by HFT and errors on MFF were strong predictors of perceptual type, and thus highly correlated with it. Latency on MFF and ratio on LSHT were shown to be significant individual predictors, but much less so than the former variables, and therefore less closely related to perceptual type. A greater degree of relationship, or correlation, between perceptual type as measured by SPT-1 and the variables of score on HFT and errors on MFF indicated that a greater degree of the variance in these two variables can be accounted for by variance in the perceptual functioning measured by SPT-1. This idea is further clarified by the results of the factor analysis.

Factor analysis. The factor analysis generated two factors which accounted for 100% of the common variance among the variables of the study. Factor I was characterized by heavy loadings by SPT-1 and HFT, a substantial loading by errors on MFF, and a modest loading by LSHT. Factor II showed heavy loadings by errors on MFF and latency on MFF, and a modest loading by SPT-1.

The measurements which define Factor I have one common element: they all require discrimination of visual details and the ability to either separate them from a field or integrate them into a whole. This suggests the title of Separation and Integration of Visual Details for Factor I. Visual/haptic perceptual types and field independence/dependence in particular, and the errors component of reflectivity/impulsivity to a somewhat lesser extent, appear to be definitely related to this factor. Leveling/sharpening also appears to be moderately related to the factor. Thus, at least a part of performance on the pictorial leveling/sharpening task is related to ability to separate and/or integrated visual detail rather than to memory function. However, since the factor loading for leveling/sharpening on Factor I is not great and is almost zero on Factor II, this suggests that the majority of the variance in the trait is attributable to some factor other than perceptual abilities, presumably the memory function which the dimension purports to define.

Factor II is characterized by strong loadings by errors and latency on MFF and a moderate loading by SPT-1. Since its strongest loadings come from the two measures on the visual task assessing cognitive tempo, the name suggested for the factor is Control of Visual Impulsivity. The modest loading of SPT-1 on this factor indicated that reflectivity/impulsivity is not completely independent of visual/haptic perceptual type. The rather large loading of MFF errors on Factor I as well as Factor II suggests that the relationship between perceptual type and cognitive tempo is more pronounced for the error component of tempo than for the latency component, with latency somewhat independent of perceptual type. It should be remembered that, although error and latency scores on MFF were significant predictors of perceptual type when considered as single predictors in the discriminant analysis, errors were the far more powerful predictor. The chi-square tests and the discriminant analysis did, however, clearly indicate that visuals, as a group, are more reflective than are haptics, which takes into account both errors and latency and establishes the following general relationship patterns between perceptual types and the cognitive tempo variables:

Visual type: Low errors and long latency
Haptic type: High errors and short latency

It should be noticed, however, that these patterns concern only those individuals actually classified as impulsive or reflective on MFF; that is, those who scored above-median errors and below-median latency, or below-median errors and above-median latency, respectively. An examination of the 39 visuals and haptics who were not classified as either impulsive or reflective shows why errors were more closely related than latency to perceptual type. Of the 39 unclassified cases, only the eight cases summarized in Table 18 are not relevant to the analysis at hand.

TABLE 18

Irrelevant Unclassified Cases

Case Number(s)	Perceptual Type	Errors	Latency	Comments
1	Haptic	Below Median	Below Median	Typical haptic latency; typical visual errors.
2 - 5	Visual	At Median	Above Median	Typical visual latency, borderline errors.
6 - 8	Visual	Above Median	Above Median	Typical visual latency; typical haptic errors.

None of the cases summarized in Table 18 is an instance in which error score is typical of the perceptual type of the individual, but latency score is typical of the opposite perceptual type. The remaining 31 unclassified cases, however, do display such a pattern. These cases are summarized in Table 19. These 31 cases show that several haptics, while taking adequate time with the MFF task and thus not classified as impulsive, were unable to perform accurately. These individuals therefore produced error scores typical of haptics (at or above median), but latency scores typical of visuals (above median). Table 18 shows that only three visuals displayed this pattern. A group of visuals, on the other hand, were able to perform the task both very quickly and accurately, thus producing error scores typical of visuals (below median), but latency scores typical of haptics (below median). Table 18 shows that only one haptic displayed this pattern. It is suggested that the unclassified cases in which typical error patterns but atypical latency patterns are responsible for the stronger relationship between perceptual type and errors on MFF than between the former variable and latency on MFF.

TABLE 19

Relevant Unclassified Cases

Case Numbers	Perceptual Type	Errors	Latency	Comments
1 - 3	Haptic	At Median	Above Median	Borderline errors; typical visual latency
4 - 10	Haptic	Above Median	Above Median	Typical haptic errors; typical visual latency
11 - 16	Visual	At Median	Below Median	Borderline errors; typical haptic latency
17 - 31	Visual	Below Median	Below Median	Typical visual errors; typical haptic latency

Major conclusions. The major conclusions of the study are the following:

1. On assessment tasks using visual stimuli, the visual perceptual type tends to display the cognitive style traits of field independence, reflectivity, and sharpening; while the haptic type tends to display field dependence, impulsivity, and leveling.
2. Of the variables used in this study, the best predictors, or discriminators, of perceptual type are field independence as measured by HFT and errors on MFF.
3. Leveling/sharpening as measured by LSHT contains a major component which is not related to the perceptual functioning measured in this study.
4. Due to patterns in unclassified cases, the error component of cognitive tempo as measured by MFF is more closely related to perceptual type as measured by SPT-1 than is the latency component.

This study should be replicated, and if similar results occur in other samples, then it can be determined to what extent the results are generalizable. In replicating the discriminant analysis, the variables should be forced into the prediction system in the order they were entered in this study. A computer program for discriminant analysis produces the optimal prediction system possible from the data, thus taking advantage of relationships which are perhaps artifactual. Forcing variables to enter the prediction system in a verification study rather than allowing the program to enter them for optimal effect can locate these artifactual relationships.

Future research efforts will attempt to locate instructional situations in which cognitive styles and perceptual type result in superior or inferior academic performance and to develop instructional treatments which compensate for perceptual-cognitive problems in these situations. It is possible that, through such research, a body of prescriptive theory can be developed which will allow the accurate prediction of the performance outcomes in learning situations composed of a specific type of task, a learner with specific perceptual-cognitive styles, and a specific instructional modality or method.

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