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AN INSTRUMENT TO MEASURE VISUAL DISCRIMINATION OF YOUNG CHILDREN.

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AN INSTRUMENT FOR MEASURING VISUAL DISCRIMINATION ABILITY WITHOUT CONFOUNDING VARIABLES OF MOTOR SKILLS HAS BEEN CONSTRUCTED. TO AVOID THE EYE-HAND COORDINATION USUALLY REQUIRED ON THESE TESTS, A SELECTION, RATHER THAN A DRAWING, RESPONSE WAS DEVELOPED. THIS TEST, THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES DISCRIMINATION INVENTORY (VDI), CONSISTS OF 52 ITEMS ON FOUR SUBTESTS--FIGURE GROUND, FORM CONSTANCY, CLOSURE, AND POSITION IN SPACE. EACH OF THESE HAS BEEN ASSUMED TO REPRESENT PREREQUISITY SKILLS IMPORTANT IN LEARNING TO READ. CHILDREN THREE, FOUR, AND FIVE YEARS OLD WERE TESTED ON THE VDI AND TWO MEASURES OF MENTAL ABILITY. RESULTS INDICATE THAT SIGNIFICANT DIFFERENCES ARE ATTRIBUTABLE ONLY TO AGE AND RACE. CORRELATIONS BETWEEN THE VDI AND INTELLIGENCE MEASURES ARE WEAK. ALTHOUGH RELIABILITY, FACE VALIDITY, AND CONSTRUCT VALIDITY HAVE BEEN ESTABLISHED, A STUDY IS NOW BEING PLANNED TO MEASURE PREDICTIVE VALIDITY. ADDITIONAL WORK IS ALSO BEING DONE IN DEVELOPING THE FOUR SUBTESTS AS MEASURES OF COMPONENT ELEMENTS OF A BROAD VISUAL DISCRIMINATION ABILITY. IT IS EXPECTED THAT THE FINAL VDI WILL BE USED WITH CHILDREN FROM A WIDE RANGE OF SOCIOECONOMIC BACKGROUNDS AND WILL IDENTIFY THOSE CHILDREN WITH A VARIETY OF LEARNING DISORDERS, PARTICULARLY DYSLEXIA, BEFORE THEY BECOME SEVERE ENOUGH TO ALERT CLASSROOM TEACHERS. (AUTHORS/FR)

An Instrument to Measure Visual Discrimination of Young Children[1]

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ABSTRACT

Tests of visual discrimination which usually involve eye-hand coordination, produce scores which may confound motor skill with visual discrimination ability. To avoid this problem, a test which requires a selection rather than a drawing response has been developed at UCLA. There are 52 items, 13 in each of 4 categories: form-constancy, figure-ground, closure, and position-in-space. The test was administered to 291 children, Negro and Caucasian, in 3 age groups (3, 4, and 5) and 2 levels of socioeconomic status. Two measures of internal consistency, Spearman-Brown r = .91 and Kuder-Richardson r = .88, indicate an acceptable level of reliability. Analysis of variance showed significant main effects for age and race. Low positive correlations with mental age indicate a minimal intelligence component. The test should prove valuable for assessing a skill usually associated with beginning reading.

AN INSTRUMENT TO MEASURE VISUAL DISCRIMINATION OF YOUNG CHILDREN[1,2]

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A strong prima-facie case can be made for the relationship between visual discrimination ability and success in reading. The obvious need for the reader to make consistent and dependable responses to specific visual stimuli (graphemes) provides a persuasive logic for this widely held assumption. While reading, because of its basic role in all academ learning, is probably the most extensively studied subject in the curriculum, the literature is notable for the ease with which sweeping generalizations are propounded and accepted, with little support from experimental research. It is also notable for the large numbers of reports and articles deceptively decked out in the mini-skirt of experimental design.

William Gray has authored a series of reviews of research relating to reading dating back to 1925. He makes the statement that the accurate recognition of words involves a number of perceptual processes. Gertrude Hildreth (1950), an equally reputable reading specialist, recommended informal training in visual perception skills, with emphasis on matching and "looking", but on an experiential level rather than in a structured or formal workbook context.

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[2]A preliminary version of this research was presented at the American Psychological Association Annual Meeting, Washington D.C., September, 1967.

This generalized perceptual training approach is supported by Anderson and Dearborn (1952) and Bond (1960). More recently, Arena (1965) recommended training in visualization and motor skills as remediation for "more subtle language problems." Delacato (1963) bases his entire system of reading instruction on the early acquisition of perceptual-motor skills.

In recent years, the emphasis on conducting learning research in the school setting has stimulated a great many studies, a large proportion of which have little claim to objective validity. Even experiments which maintain careful controls, however, produce conflicting results. Hillerich (1964) found that formal workbook training in pre-reading skills in kindergarten produced better readers at the end of the first grade, whereas Goins (1958), Ploghoft (1959), Gorelick (1962), and Fry (1965) found that children who had used readiness workbooks during kindergarten did not have greater success in beginning reading than children who had had unstructured readiness experiences.

Many pre-kindergarten programs today are placing great emphasis on "same-different" discrimination training in both auditory and visual modalities, although McKee (1948) had found that such exercises were not useful in developing word recognition. Instead, he demonstrated that the best way to improve word recognition was to provide drill in word recognition. Both King (1963) and Popp (1964) have obtained results which seem to support the position that training in discriminating letters and words does improve the ability to make such discriminations within a reading context.

While Dunn (1965) maintains that visual perception is more important than vocabulary in predicting ease of learning to read, Ashlock (1963) could find no support for a relationship between visual perception and reading in terms of either the task or the content of the training materials. However, it was found that the importance of visual perception skills in predicting levels of

reading achievement decreases with age. This may very well reflect the age-related changes in visual perception reported by Elkind, Koegler, and Go (1964), and Braine (1965.)

Although a strong correlation between reading and intelligence is well-established, the relationship between visual perception and intelligence is still unclear. Allen, Haupt, and Jones (1965) found low correlations between visual perception and the spatial-visual subtests of the WISC. Birch and Belmont (1964, 1965) noted that whereas the correlation between I.Q. and reading increased with age, this was not true with tests of auditory-visual integration. These investigators speculated that this may be due to the low ceiling of the auditory-visual integration test, or that the perceptual skills might be most important for initial acquisition whereas later reading emphasizes comprehension, which is more closely related to intelligence. Still another interpretation may be drawn from the work of Abravanel (1966) which indicated that performance on a "same-different" task did not approach asymptote level until about five years of age.

Gibson and Olum (1960) report a finding by Hemmendinger that young children respond globally to Rorschach ink blots at the age of three, increase their attention to details at about six or seven, and integrate parts into wholes at the age of nine or ten years. Gibson and Olum take the position that the perceptual factor in learning to read is closely related to the ability to discriminate meaningless or abstract forms. This type of reasoning provides the rationale for extensive use of matching exercises in "reading readiness" workbooks.

A major and critical problem in most studies of perceptual discrimination in young children is the inadequacy of criteria or instruments for measuring this ability. The most commonly used tests are Bender (1938), also Koppitz, (1964), Frostig (1964), and Winterhaven (1966). All of these, however, con-

found eye-hand coordination with perceptual discrimination skill. A new test developed by Rosenberg (1966) avoids this criticism by employing a pointing or selection response, but the highly structured and abstract stimuli have little intrinsic interest for the young child. In addition, there is no attempt to get at different types of discrimination tasks.

The test most frequently used for the assessment of visual discrimination with young children is the Frostig Developmental Test of Visual Perception. It is based on a delineation of five hypothetically distinct areas: eye-hand coordination, figure-ground, form-constancy, position-in-space, and spatial relationships. Age norms for children between the ages of three and nine are available. The use of this instrument with children demonstrating dyslexia as well as other learning disorders has yielded dependable correlations.

On the basis of this relationship (a "post-hoc, propter hoc" fallacy) a number of studies have investigated the value of using a training program especially prepared by the Frostig school for the remediation of perceptual deficits. Cohen (1966) and Arciszewski (1967) used these materials in training programs and found improved performance on the Frostig test, but no improvement in reading. Olson (1966) found a significant correlation between the Frostig training materials and the vocabulary subtest of the California Achievement Test, but there was no significant relationship with the Gates Word Recognition Test. Olson found only one dependable correlation, that between position-in-space and reversible-words-in-context ($r = .386$).

In the studies cited, where the children are in the elementary grades and can perform the motor tasks on which the tests are based, there seems to be no problem with the existing measures of visual discrimination. However, at this level the best experimental evidence indicates that providing remedial discrimination training for children who obtain low scores on such tests is not the

most efficient method of producing improvement in reading skills. If the goal is increasing the child's ability to discriminate letter and word forms and to associate auditory responses with visual stimuli, it is far more effective to provide direct practice with the relevant materials.

However, for the very young child, especially those from disadvantaged homes where opportunities to use paper-and-pencil are exceedingly limited, the available instruments for the measurement of visual discrimination are not appropriate. This statement is supported by data obtained by the authors, using the Frostig with a group of 17 four-year-old children, eight from a low socioeconomic group and nine from a middle socioeconomic group. For the first group, no child scored above the 20th percentile according to the Frostig norms. All the highly advantaged nursery school children, who had had considerable experience in similar tasks, scored below the 58th percentile. Three features of the test seemed to be most important in producing these results. 1) The language in which the tasks are presented tended to confuse rather than instruct; 2) The test took, on the average, about 40 minutes to administer and most of the children lost interest about half way through. It is of course possible to avoid this difficulty by administering the test in two parts on separate occasions, but this would not be consonant with the instructions in the test manual. 3) The use of different colors for marking was not only confusing, but also served to distract children from the task since there was a general tendency to use the colors in drawing pictures.

If there is predictive as well as face validity to the hypothesis that visual discrimination skills are important prerequisites to beginning reading, a way of measuring this skill in young children, without the confounding variables of motor skill, task comprehension, and experience with paper-and-pencil activities, must be developed. The present paper is a report of the construction of one such instrument, as a first step in a more comprehensive study of

variables affecting children's ability to learn to read.

Method

Rationale and Description of Test

The UCLA Discrimination Inventory (VDI) consists of 52 items in four subtests: figure-ground, form-constancy, closure, and position-in-space. These subtests are designed to measure separate aspects of visual discrimination, each of which has been assumed to represent prerequisite skills important in learning to read. For instance, figure-ground may relate to the ability of a child to recognize familiar letters in new words; form-constancy seems to be prerequisite to identifying letters presented in different sizes, such as upper and lower case; position-in-space may be involved when children read "b" as "d" or "p" as "q"; and closure in the process of integrating letters into words. It is important to remember that these are hypothetical assumptions which must be subjected to empirical exploration.

The test can be presented to groups of children, takes approximately 15 minutes to administer, and very little time to score.

The test items consist of 8 1/2" x 11" frames (sheets of paper encased in plastic page protectors) with black-and-white drawings. (See Figure 1 for sample items.) Each frame contains a model in the center of the top

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Insert Figure 1 about here

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half of the page and alternatives in three boxes across the lower half of the page. The task for the child is to select the one of the three alternatives which is most like the model.

Test Forms

In the preliminary work, there seemed to be a tendency for children to

select the middle picture when the discriminations became too difficult. To estimate the effect of this position bias, as well as that of right-left preference, three forms of the test were constructed. In each form, the correct answer was in a different box. Thus, if in Form A the correct picture was the left alternative, in Form B it might be in the middle box, and in Form C the right-hand box. The three forms were randomly presented over the total population.

Subjects

All the children, (291) between the ages of 3-0 and 5-11 in seven Day Care Centers and four private nursery schools were tested. There were 139 boys and 152 girls, including 199 Negro and 92 Caucasian children, from two levels of economic status. Two measures of mental ability, the Peabody Picture Vocabulary and the Goodenough Draw-A-Man Test, were administered.

Procedure

All tests were individually administered in a small anteroom, if available, or in a screened corner of the regular classroom. The child was asked to point to one of three pictures which corresponded to a model. However, when the first item with which the child was confronted showed the model on the same page as the alternatives, many children pointed to this picture when asked to find "another one" like it rather than to the one of three alternatives which was most like the model. Task training was therefore necessary. It began by presenting the model on a separate card and gradually moving it into position in the center of the top half of the frame. If the child did not respond correctly to six consecutive items, the task-training program was repeated. The VDI was administered to children only after they had reached criterion on the basic task instructions.

Table 1 presents the mean scores on the total 52 item UCLA Visual

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Insert Table 1 about here

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Discrimination Inventory for 291 children, by sex, race, two levels of socioeconomic status, and three levels of age (3, 4, and 5 years). Since the test involves a three-choice selection, a score of 17 can be obtained by chance. Even the lowest mean score reported is significantly above this level.

The uneven distribution of subjects within the 24 cells determined by the 2 x 2 x 2 x 3 design would have provided too few cases in several of these cells; therefore two separate 2 x 2 x 3 analyses of variance were computed. A principal objective of the first analysis (Table 2) was to

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Insert Table 2 about here

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determine whether any significant difference in visual discrimination could be attributed to sex, within age and race groupings. An F of .2 with almost 300 cases provided assurance that, contrary to a number of studies which report important sex differences, there was little likelihood that boys would differ significantly from girls in their performance on this type of task. Whatever the factors that produce more beginning reading problems in boys than girls, they are probably not integrally related to the ability to make appropriate visual discriminations. In the same analysis, significant differences (.01 level) were found for both age and race, although no interaction effects were dependable.

The second analysis of variance (Table 3) was concerned with the

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Insert Table 3 about here

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main effect of socioeconomic status, again within age and race groupings. While the F of 3.4 approaches significance, it is not sufficient to disprove the null hypothesis that differences in visual discrimination are not related to socioeconomic status. However, the main effects of race and age were verified, with again no interaction effects supported. A Newman-Keuls analysis shows that main effect differences are primarily attributable to the lower scores of the three-year-old and Negro children in the lower SES groups.

Of the 291 children, 161 were given the Peabody Picture Vocabulary and the Goodenough Draw-a-Man Test. The relationship among these measures and the VDI, as well as the relevant means and standard deviations, are presented in Table 4.

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Insert Table 4 about here

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As indicated earlier, three forms of the VDI were used to control for the effects of position preference. Intra-form reliability for the four subtests and the total test are presented in Table 5. Using Horst's re-

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Insert Table 5 about here

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vision of the Kuder-Richardson Formula 20, total test reliabilities of .90 to

.92 were found for the three forms. When data for items across forms are summed, the K-R reliability coefficient is .88. The Spearman-Brown prophesy formula for the same data produces a reliability estimate of .91.

Discussion

Although the design of the present investigation anticipated differences in performance due to sex, age, race, and socioeconomic status, the data presented in Tables 1 through 3 indicate that primary differences are attributable only to age and race. According to a Newman-Keuls analysis, the performance of all three-year-old children does not differ significantly as a function of sex, race, or SES. Also, within these groups, particularly with Caucasian children of either high or low socioeconomic status, performance at ages four and five are not significantly different; it is between the ages of three and four that major changes seem to take place. This is in line with other studies which demonstrate that visual discrimination skills attain almost maximum development by the 5th to 7th years.

With Negro children, high SES groups show gradual growth from the third to the fifth year; the low SES children have very meager gains and at the fifth year are still not significantly superior to the average three-year-old Caucasian child. This evidence provides additional support for the "cumulative deficit" which characterizes disadvantaged children in so many areas related to academic performance. If this difference is found between nursery and day care populations, where there is a considerable degree of overlap, it suggests that more severely disadvantaged children will demonstrate even greater deficits. It is highly likely that an analysis including data from Headstart classes would show significant main effects for socioeconomic status.

A number of studies have indicated that there is a positive, albeit weak, relationship between intelligence and visual discrimination. In Table 4 the correlations of the VDI with the Peabody and the Goodenough support this finding. However, the data of the present study show that Caucasian high SES children have significantly higher correlations between the VDI and either of the measures of mental ability than do the Negro low SES children. It is also worth noting here that the advantaged groups obtain higher scores on the PPVT, which is a test of verbal ability, than they do on the Goodenough, with the reverse true for the disadvantaged children. Evidently, while superior verbal ability usually accompanies high scores on the VDI, the discrimination task seems to tap a type of ability which is not necessarily tied to conventional measures of intelligence.

In establishing the usefulness of any instrument, data concerning validity and reliability are of paramount importance. At the present stage of its development, the UCLA VDI has established considerable construct validity, as evidenced by the subtest reliability. It also has a high level of face validity, based on traditional, commonsense association of certain reading subskills with ability to respond appropriately to differences and likenesses in visual stimuli. A more critical type of validity relates to an instrument's ability to predict performance on a criterion measure. A study is now being planned to obtain a measure of predictive validity, using performance in beginning reading as one important criterion.

With reference to reliability, several measures have been computed and reported in Table 5. The values obtained are sufficiently high to engender confidence in the instrument, especially considering the fact that the population tested is a comparatively homogeneous one.

To summarize, the use of the UCLA instrument has demonstrated its usefulness in identifying a range of ability in visual discrimination with several population groupings. Additional work is now being done to develop the four subtests as measures of component elements of a broad visual discrimination ability.

Large pools of items are being administered over a broad population of children. The data will then be subjected to factor analysis to identify the most sensitive items and those which have minimum overlap. It is expected that a strong and reliable measure of visual discrimination, which can be used with young children from a wide range of socioeconomic backgrounds, will be developed. It is hoped that this type of measure, given as a routine test at the kindergarten or first grade level, will identify children who may be expected to demonstrate a wide variety of problems in dealing with the environment. Of major importance will be the potential ability to predict cases of incipient dyslexia, as well as other learning disorders, before they have become severe enough to be obvious to the classroom teacher.

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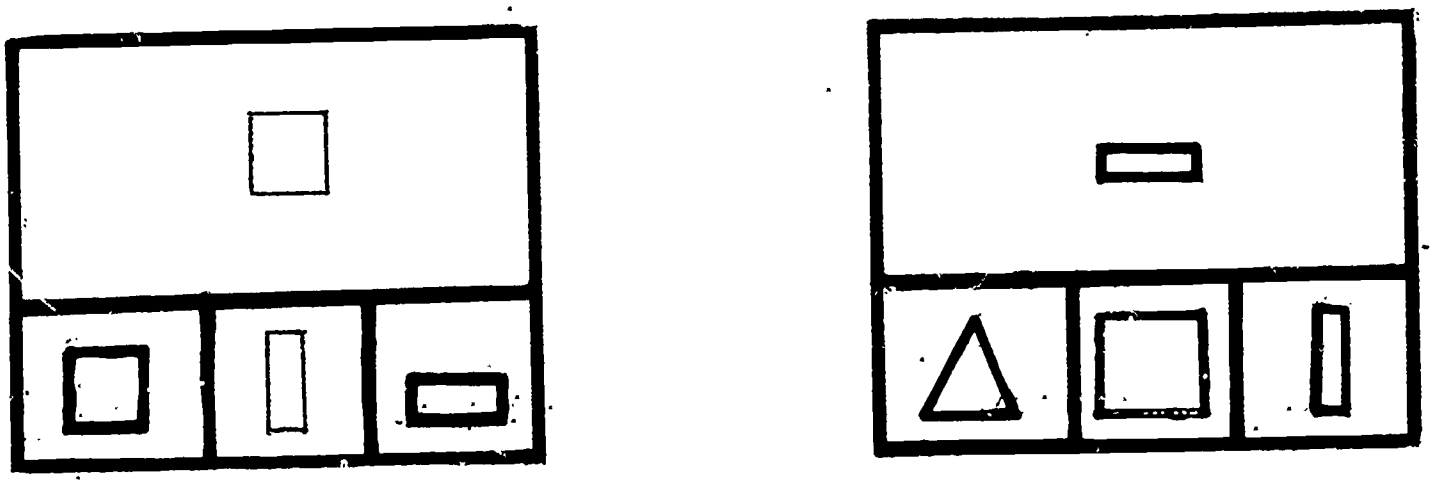
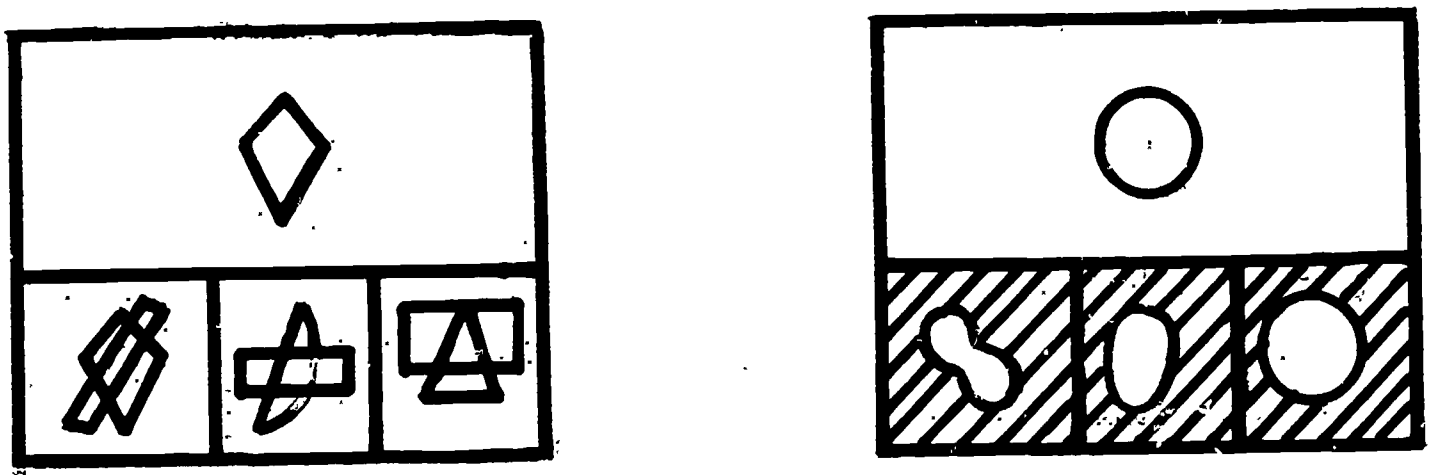


FORM CONSTANCY



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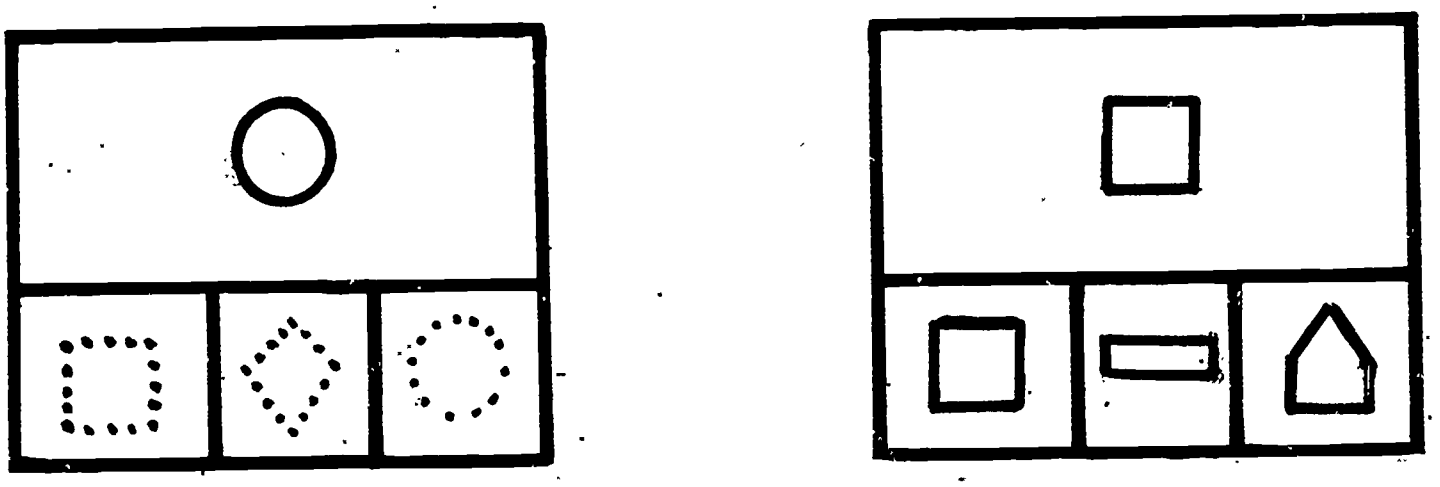
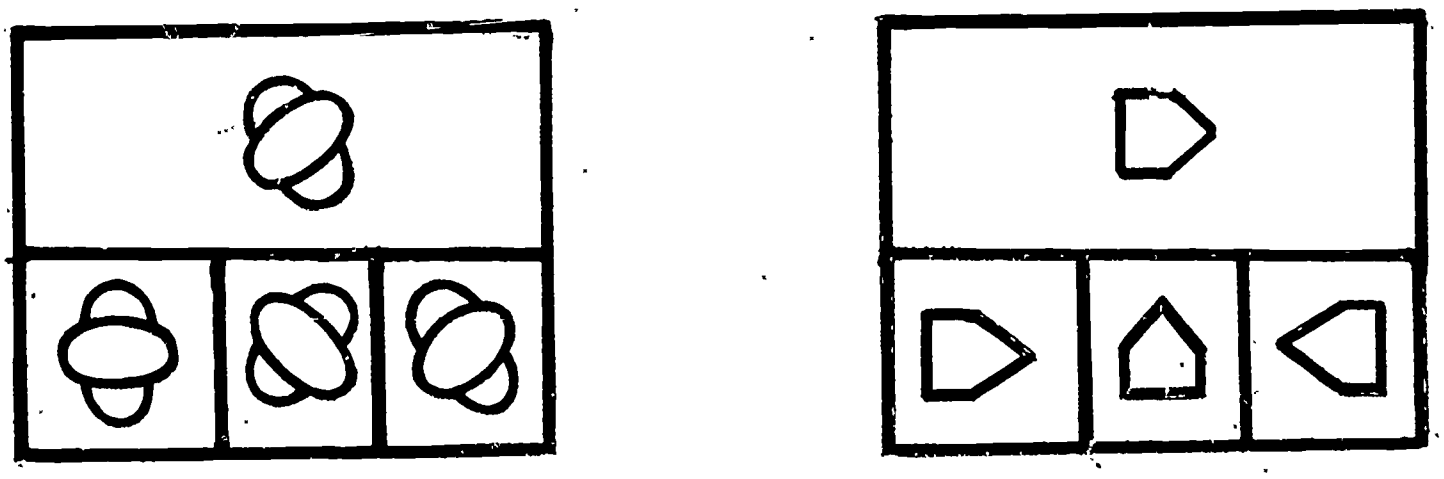


CLOSURE



POSITION IN SPACE

Figure 1. Sample Items for V.D.I.

Scores on VDI by Ethnic Group, Age, Sex, and Socioeconomic Status

	N	THREE YRS. OLD		N	FOUR YRS. OLD		N	FIVE YRS. OLD		N	TOTAL YRS. OLD	
		M	SD		M	SD		M	SD		M	SD
High Negro Boys	10	27.2	4.8	6	30.5	5.7	5	33.8	5.8	22	29.1	6.2
High Negro Girls	7	25.4	3.5	7	33.0	4.0	4	37.8	7.3	17	30.6	6.5
Low Negro Boys	9	28.9	7.5	27	28.7	5.0	39	29.6	8.8	75	29.2	7.4
Low Negro Girls	22	24.0	9.4	28	28.1	4.4	35	31.5	9.3	85	28.5	8.5
Total Negro Boys	19	28.0	6.1	34	28.8	5.4	44	30.1	8.6	97	29.2	7.1
Total Negro Girls	29	24.3	8.4	34	28.8	4.4	39	32.1	9.2	102	28.8	8.2
Total Negro	48	25.8	7.6	68	28.8	4.9	83	31.0	8.9	199	29.0	7.7
High Cauc. Boys	12	28.5	6.7	17	33.7	7.0	2	37.0	5.7	31	31.9	7.2
High Cauc. Girls	15	28.7	5.2	18	39.0	5.8	6	36.2	9.3	39	34.6	7.8
Low Cauc. Boys	1	24.0	0.	7	34.3	6.3	3	41.0	7.8	11	35.2	7.7
Low Cauc. Girls	1	28.0	0.	4	32.5	7.4	6	31.7	11.7	11	31.6	9.3
Total Cauc. Boys	13	28.2	6.5	24	33.8	6.6	5	31.4	6.6	42	32.7	7.4
Total Cauc. Girls	16	28.6	5.1	22	37.8	6.5	12	33.9	10.3	50	33.9	8.1
Total Cauc.	29	28.4	5.7	46	35.7	6.8	17	35.5	9.5	92	33.3	7.8
Total High Negro	17	26.5	4.3	13	30.1	5.7	9	35.6	6.4	39	29.8	6.3
Total Low Negro	31	25.4	9.0	55	28.4	4.7	74	30.5	9.0	160	28.8	8.0
Total High Cauc.	27	28.6	5.8	35	36.4	6.9	8	36.4	8.2	70	33.4	7.6
Total Low Cauc.	2	26.0	2.8	11	33.6	6.4	9	34.8	11.0	22	33.4	8.5
Total High SES	44	27.8	5.3	48	34.7	7.1	17	35.9	7.1	109	32.1	1.3
Total Low SES	33	25.5	8.8	66	29.3	5.3	83	31.0	9.3	182	29.4	8.2
Total	77	26.8	7.0	114	31.6	6.7	100	31.8	9.1	291	30.4	7.9

Table 2

Analysis of Variance (Race x Sex x Age)

Source	df	MS	F
Race (A)	1	1253.3	23.8**
Sex (B)	1	9.0	.17
Age (C)	2	778.6	14.8**
A x B	1	0.31	.01
A x C	2	127.5	2.4
B x C	2	96.45	1.8
A x B x C	2	158.2	3.0
$Error_W$	279	52.6	

** $p < .01$

Table 3

Analysis of Variance (Race x SES x Age)

Source	df	MS	F
Race (A)	1	310.7	5.8*
SES (B)	1	179.9	3.4
Age (C)	2	484.3	9.09**
A x B	1	0.5	.01
A x C	2	62.8	1.2
B x C	2	6.1	.11
A x B x C	2	21.31	.40
$Error_w$	279	53.3	

* $p < .05$

** $p < .01$

Table 4

Correlations on UCLA Visual Discrimination Inventory with Goodenough Draw-a-Man Test and Peabody Picture Vocabulary Test by Race and SES

Group	N	VDI		DAM			PPVT		
		M	SD	M	SD	r	M	SD	r
Negro	78	27.7	6.7	48.2	10.6	.21	41.7	10.9	.25
Caucasian	83	33.2	7.4	51.5	14.5	.58	59.6	14.2	.55
High SES	70	33.4	7.6	51.3	14.9	.68	61.4	14.6	.59
Low SES	91	28.4	6.9	48.9	11.0	.19	42.8	10.7	.28

Table 5

Total and Subtest Reliabilities Based on Population of 112 Children from Low Socioeconomic Group Only (Combined Race and Age)

Test and Subtests by Forms	N	M	SD	K-R 20[1]
Total Test (52 Items)				
Form A	36	30.1	8.8	.90
Form B	38	32.1	9.2	.92
Form C	38	31.0	8.4	.90
Figure-Ground (13 Items)				
Form A	36	8.9	3.4	.88
Form B	38	9.3	2.3	.71
Form C	38	8.0	3.0	.85
Form-Constancy (13 Items)				
Form A	36	7.5	2.6	.71
Form B	38	8.0	2.5	.71
Form C	38	7.6	2.4	.62
Closure (13 Items)				
Form A	36	6.8	2.3	.69
Form B	38	7.9	2.8	.82
Form C	38	6.7	2.4	.77
Position-in-Space (13 Items)				
Form A	36	6.9	2.4	.64
Form B	38	6.7	2.9	.85
Form C	38	7.7	2.9	.86

[1]Horst's revision.