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ABSTRACT

The study investigated the visual discrimination abilities of children who varied in their ability to recognize words. Measures of word recognition and intelligence were obtained in 87 first-, second-, and third-grade subjects. All subjects then performed a visual discrimination task which uses artificial graphemes as stimuli. The task required subjects to match a standard grapheme with an identical form. Errors on this task were classified into six categories. A two-way multivariate analysis of covariance (grade level X word recognition skill) was performed. In the analysis intelligence test scores were covaried. The main effect for grade was significant (p. is less than .0004), while neither word recognition skill nor the grade X word recognition skill interaction approached significance. Results provide information concerning the possible need for a re-evaluation of visual training practices in schools. (Author)

The Relation Between The Discrimination Of Letter-Like Forms And Word Recognition

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Running Head: Discrimination of Letter-Like Forms and Word Recognition

THE RELATION BETWEEN THE DISCRIMINATION OF LETTER-LIKE FORMS AND WORD RECOGNITION

Michael J. Ash and Pearl R. Buckland

Since the 1920's, investigators have explored the relation between visual perception and reading skill. This interest in visual perception has led to a proliferation of both visual perceptual tests and training programs. It is notable, however, that investigators have not been able to relate specific visual perceptual abilities to particular reading skills. Rather, they have been content to obtain significant correlations between total reading achievement and total perceptual score (Goins, 1958; Monroe, 1935; Olson, 1966). Relatively few studies have determined what specific kinds of visual skills are related to certain components of reading.

One example of such research is the efforts of Eleanor Gibson and her co-workers in identifying four factors that lead to the visual discriminability of alphabet letters. According to Gibson (1962), identifying graphemes and letters accurately involves a process of focusing on critical features or dimension of differences. In a study using letter-like forms, Gibson showed that normal children between four- and eight-years-old learn something which may make possible better discrimination of letters.

Briefly, Gibson analyzed the visual characteristics of actual letters (printed capitals, upper case) in terms of the number of strokes, straight versus curved lines, angles, open versus closed forms, etc. This analysis provided a set of characteristics or rules on the basis of which one could generate artificial graphemes that follow these rules. Twelve such artificial graphemes were constructed according to the same constraints which appear in printed capitals. From these standards, four types of transformations: line to curve or curve to line, rotations and reversals, perspective transformations, and topological or close and break transformations were constructed for each standard form. Subject's errors were classified according to the kind of transformation mistakenly matched with the standard.

Gibson found that, in general, errors decreased with age, but that more errors were made on some transformations than others. Specifically, perspective errors were greatest among four-year olds, and while decreasing slightly with age, they remained high across all grade levels. The other three transformations showed significant decreases in errors with age, so that eight-year olds made few errors of these kinds.

Thus, certain kinds of transformations in letters seem to become distinctive as children grow older, allowing them to discriminate among letter forms with increasing accuracy. Perspective transformations, on the other hand, are not distinctive, and must be colerated in order to discriminate letters which appear at different angles of sight.

Gibson concluded " . . . it is the distinctive features of grapheme patterns which are responded to in the discrimination of letter-like forms. The inprovement in such discrimination from four to eight (in normal children) is the result of learning to detect these invariants and becoming sensitive to them" (p. 904).

What has not been determined, however, is whether the kinds of discrimination skills described by Gibson are important for more complex reading requirements like word recognition. Vernon (1957), for example, has indicated that children who have reading problems show perceptual difficulty in their inability to recognize significant details, distinguish one letter from another and have confusion about the direction of letters and words. Frostig (1964) postulated that:

(a) children who could not recognize words often had disturbances in figure-ground perception, (b) children who had difficulty in recognizing a letter when written in different sizes or colors had poor form constancy, and (c) children who had rotations or reversals indicated difficulty in perceiving position in space.

But Gibson has shown that as children grow older they make fewer of these sorts of errors. Is this finding consonant with the expectations of reading experts? Perhaps it is, and hence the problem of this study was to investigate the visual discrimination abilities of children who varied in their ability to recognize letters and words. Word recognition skill was selected as the variable to be related to visual discrimination performance because it is a fundamental reading behavior that is not confounded with other, more cognitive reading skills. According to one learning expert, R. M. W. Travers (1973), "Most word characteristics involve letter characteristics, and hence learning to discriminate between words inevitably involves the characteristics that permit letter discrimination" (p. 104).

At least three questions can be answered by this study. First, what is the overall relation between grapheme discrimination skills and word recognition ability? Second, do qualitative differences in grapheme discrimination exist between children of varying word recognition skills, i.e., do they make the same kinds of errors? Third, do the relations between grapheme discrimination skills and word recognition ability vary with age?

METHOD

Subjects

The Wide Range Achievement Test (WRAT) Reading sub-test was administered to all first-, second-, and third-grade pupils in a middle-class Texas elementary school.

From this original group all pupils with WRAT standard scores between 70-130 (± 2.0 S.D.) were selected. At each grade level subjects were divided into three levels of word recognition ability: a high group consisting of subjects with WRAT reading standard scores of 110-129, an average group having scores from 90-109, and a low group with scores between 70-89.

Five males and five females were then selected randomly from each word recongition ability group at each grade level. Thus, 90 subjects were selected for participation in the study. Thirty first-graders, 30 second-graders, and 30 third-graders (due to the experimental error in administering the visual discrimination task, the final results were based on 28 first-graders, 29 second-graders, and 30 third-graders.)

Following their final selection of subjects, pupils were given the Otis-Lennon Mental Ability Test-Elementary Level I. Scores from this instrument were used as a covariate in the data analysis. Table 1 contains the summary data for all subjects for the variables age, WRAT scores, and IQ. Subjects were then asked to participate in the visual discrimination task identical to the one developed by Gibson.

Insert Table 1 about here

Procedure

The discrimination task required a subject to match a standard grapheme with an identical form, when the identical form was placed with a maximum of 12 transformations of the standard. The procedure faithfully replicated that used by Gibson et al., (1962) and a detailed description can be found there. Only a brief description follows.

Copies were made of the graphemes developed by Gibson, including both the standard forms and the four kinds of transformations: line to curve, rotation and reversals, perspective, and close and break. The graphemes were placed on 1½" squares of heavy white cardboard, and were displayed on black wooden boxes which were specially constructed for that purpose. Each display apparatus had an angled face, which had five equally spaced grooves in which the graphemes were placed.

The form to be matched was placed in the center of the top slot, and the remaining four rows were filled with standard graphemes and their transformations. One of these four rows contained transformations of the form to be matched, along with at least one copy of the standard. Three boards were available so that subjects could solve for all 12 standards with minimum waiting. Examples of the graphemes and some of their transformations are shown in Figure 1.

Insert Fig e 1 about here

To insure that all subjects fully understood the task (especially the younger ones) a demonstration was given with large-sized samples of actual letters, which included two reversals. Care was taken to insure that each subject understood that he was to determine if the forms were "equal" or "exactly alike." Following this preliminary pretraining, subjects were given a practice trial on a matrix board filled with real letters and E instructed the subject as follows:

"(Name of child), this is a game I'd like you to play. Your job in this game is to pick out shapes that look "exactly" the same. Now, (name) look at this board. See the letter alone at the top? Try to find all the ones that are just alike it in this row (E indicates row). When you find a letter that is exactly like the one at the top, take it from the board and give it to me."

(Subject then proceeded to make selections which were confirmed or corrected by E). Following the practice row, the main task began. Subject was instructed:

"Now, (name) we're going to play the same game with new kinds of letters. Remember, your job is to pick out all those letters in the row that are just exactly like the letter at the top of the board. Be sure to look at each letter in the row to see if it is like the one at the top of the board. Any questions? Now we'll begin."

Continuing to replicate the Gibson procedure, no time limit was set for the task and no correction of subject's responses were made after the task began. When subject withdrew a form from the board, the choice was scored either as correct or error. Errors were further classified as either an error of omission, i.e., failure to select a standard form, or a transformation error, in which case the type of error was recorded.

Results

A two-way multivariate analysis of covariance (grade x word recognition skill) was performed on six performance measures: the four kinds of transformation errors, omission errors (failure to select the standard), and the total number of errors of all kinds. Otis-Lennon Mental Ability Test-Elementary Level I scores were covaried in each analysis.

W. R. Skill. The main effect for reading skill was not significantly related to the error variables, $F\ (12,140) = 1.16\ p < .31$.

Grade. The multivariate analysis performed on the six criterion variables for the main effect grade yielded significant results, $F\ (12, 140) = 3.41$, $p < .0004$.

W.R. Skill x Grade. The interaction effect WR skill x grade was not significantly related to the error variables, $F(24,278) = 1.39$, $p < 0.11$.

Table 2 is a summary of the multivariate analysis.

Insert Table 2 about here

The multivariate analysis of covariance also provided univariate tests of the two main effects and their interaction for all six criterion variables. However, only the main effect for grade was significant in the multivariate case, and since any significant univariate tests found within a nonsignificant multivariate analysis may be spurious, only the univariate tests for grade were examined. Four of the six univariate F-ratios were significant at the .05 level of confidence and beyond. Perspective transformation and omissions did not vary systematically with grade level. Table 3 is a summary of the univariate analyses for the grade main effect.

Insert Table 3 about here

Correlation between types of error and I.Q. Correlations were run between errors for each of the four kinds of transformations, omissions, total errors, and intelligence test scores, separately for each grade level and combined across grade levels. This resulted in four 7 x 7 correlation matrices. In general, the variables in the matrices were interrelated, with only a few nonsignificant. It is notable that the variables of omissions and I.Q. were consistently negatively correlated with the others, but it is not surprising that as I.Q. increased errors decreased, nor that as errors increased omissions decreased. Errors were a function of the absolute number of graphemes chosen, thus lowering the probability of omission errors. Tables 4 and 5 show these relations.

Insert Tables 4 and 5 about here

The magnitude of decrease in visual discrimination errors as grade increased is presented in Figure II. These curves represent mean combined errors for each of the four transformations across the three grade levels. Several items are of interest in Figure II. First, close and break errors, while significantly related to grade, represented only a small percentage of total errors. Second, the curve for rotations and reversals decreases sharply from grade one to grade two and then rises at grade three. Only a decrease from grade one to grade two was significant, however, ($t = 2.45$, $df = 54$, $P < .05$), the increase from second to third grade was not ($t = .75$, $df = 55$, $p > .05$). Third, line to curve errors decreased most consistently over grade level.

Insert Figure II about here

Discussion

The three questions posed earlier in this study were clearly answered, at least within the context of this investigation. The first question asked whether there was a relation between grapheme discrimination skills and word recognition. No relation was obtained between overall grapheme discrimination skills and word recognition. In other words, among the subjects in this study there were children who made high word recognition scores who displayed poor grapheme discrimination skills, and there were some poor readers who did very well in the grapheme discrimination task. There appeared no systematic relation between the two skills.

The second question was concerned with whether qualitative differences in grapheme discrimination exist between children with varying word recognition skills. The question was obviated by the obtained results. Since there was no relation between the variables of grapheme discrimination and word recognition skills, there were no qualitative differences to trace.

The third question, do the relations between grapheme discrimination skills and word recognition ability vary with age, was concerned with possible changes in the relations between the two main factors as age increased. For example, it might have been true that as children grow older the relation between grapheme discrimination and word recognition grows weaker. There was not, however, any obtained relation at any grade level. It should be noted, however, that as grade level increased grapheme discrimination errors generally decreased (except for perspective and omission errors), across all levels of word recognition ability.

The implications of this study are quite clear, especially for those people involved in beginning reading instruction. Visual discrimination skills of the type needed to discriminate between artifical graphemes do not seem essential for the word recognition aspect of reading. Apparently the time and expense currently devoted to visual training in the school should be re-evaluated especially if the purpose of such training is to enhance letter and word recognition abilities.

Such a conclusion is not, of course, in tune with the current Zeitgeist of educational practice. The assumption that visual discrimination abilities covary with academic achievement, in particular reading, has been based on research that typically has failed to control crucial variables. In a recent review of the literature relating visual perceptual abilities to school learning Larsen and Hammill (1974) discovered that in the vast majority of such studies IQ was inadequately controlled. When the data from the present study were analyzed without using IQ as a covariate, large significant relations were obtained between word recognition ability and visual discrimination skills.

However, when the results of IQ variation were controlled, no relation was obtained. This result carries with it some important implications for public school personnel who are engaged in the diagnosis of learning difficulties. The efficacy of placing children in special learning environments designed to improve alleged visual perceptual defecits is called to question. Given the outcomes of the Larsen and Hammill review and the present study, one can conclude that visual skills are not independently related to academic achievement, but rather are confounded with other more global measures like IQ. It would be inappropriate, however, to make decisions on the basis of IQ alone. What needs to be accomplished is an unraveling of the variables which comprise IQ scores. In fact, the epistemology of interpreting achievement difficulties, especially reading problems, as being largely based on perceptual processing handicaps may be contraproductive. Learning difficulties may be more closely related to cognitive variables than they are to perceptual abilities.

Finally, one contribution of this study was to replicate and extend the previous research of Eleanor Gibson and co-workers. Her now classic study used subjects ranging in age from four to eight years, while the present work employed students from 6 to 9 years old. The results of this study followed quite closely the relations obtained by Gibson et al. (1962). All grapheme discrimination errors decreased from the first to third grade, and the relative difficulty of the grapheme transformations was very similar to those found by Gibson et al. Perspective transformations produced the greatest number of confusion errors, followed by line to curve errors, rotation and reversals, and finally close and break transformations showed the least errors.

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Footnote

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TABLE 1

Means and Ranges on I.Q., WRAT Scores, and Age Across Grade Level

	I.Q.		WRAT		Age	
	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range
First Grade	100.93	72-129	101.9	79-127	7.2	6.6-8.3
Second Grade	95.04	68-123	100.5	77-123	8.3	7.9-9.6
Third Grade	96.73	70-118	100.8	76-127	9.3	8.4-10.6

TABLE 2

Multivariate Analysis of Covariance for

Transformation Errors, Omissions, and Total Errors

Source	df	MS	F	p
Grade	12,140	N.A.*	3.41	.0004
Word Recognition Skill	12,140	N.A.*	1.16	.31
Grade x Word Recognition Skill	24,278	N.A.*	1.39	.11

* Not applicable to a multivariate analysis of covariance

TABLE 3

Summary Table on Six Univariate Analyses

of Variance for the Main Effect Grade

Types of Errors	df	MS	F	p
Line to Curve	2,86	202.99	8.67	.0007
Close & Break	2,86	8.36	6.75	.002
Perspective	2,86	159.67	2.51	.09
Rotations & Reversals	2,86	84.50	3.84	.02
Omissions	2,86	17.77	1.21	.30
Total Errors	2,86	1469.71	10.59	.0002

TABLE 4

Correlation Matrices for All Grade Levels
on Error Variables and I.Q.

Variables	1	2	3	4	5	6	7
				First Grade Ss N = 28			
1) Line to curve	1.00						
2) Close and break	.59***	1.00					
3) Perspective	.72***	.55**	1.00				
4) Rotations & Reversals	.69***	.61***	.51**	1.00			
5) Omissions	-.33	-.25	-.46**	-.27	1.00		
6) Total	.90***	.70***	.83***	.79***	-.20	1.00	
7) I.Q.	-.42*	-.37*	-.25	-.57**	-.31	-.54**	1.00
				Second Grade Ss N = 29			
1) Line to curve	1.00						
2) Close & break	-.06	1.00					
3) Perspective	.53**	.03	1.00				
4) Rotations & Reversals	.40*	.22	.44*	1.00			
5) Omissions	-.30	-.16	-.54**	.08	1.00		
6) Total	.78	.04	.87***	.66***	-.29	1.00	
7) I.Q.	-.39	-.15	-.30	-.55**	.21	.44*	1.00
				Third Grade Ss N = 30			
1) Line to curve	1.00						
2) Close & break	-.15	1.00					
3) Perspective	.42*	.18	1.00				
4) Rotations & Reversals	.18	-.06	.06	1.00			
5) Omissions	-.11	.08	-.57**	-.24	1.00		
6) Total	.66***	.12	.69***	.64***	-.26	1.00	
7) I.Q.	-.54**	-.03	-.28	-.37*	.15	-.53**	1.00

* p<.05
** p<.01
*** p<.001

TABLE 5

Correlation Matrix for All Ss

on Error Variables and I.Q.

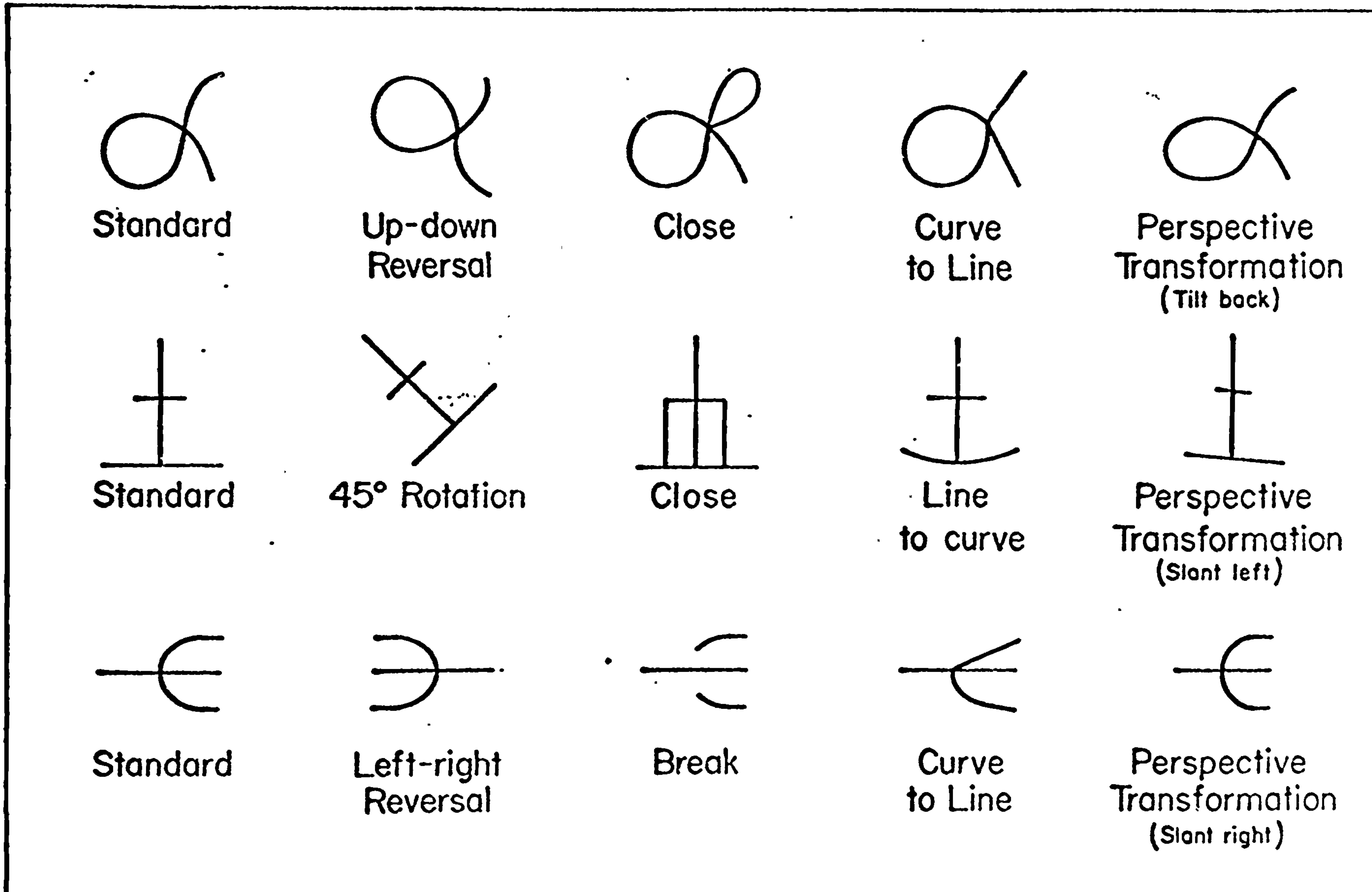
	Combined Grade Levels N = 87						
	1	2	3	4	5	6	7
1) Line to curve	1.00						
2) Close and break	.49	1.00					
3) Perspective	.61***	.39***	1.00				
4) Rotations & Reversals	.44***	.38***	.29**	1.00			
5) Omissions	-.22*	-.12	-.47***	-.19	1.00		
6) Total	.85***	.57***	.79***	.66***	-.17	1.00	
7) I.Q.	-.34**	-.15	-.26*	-.38**	-.01	-.41***	1.00

* p<.05
** p<.01
*** p<.001

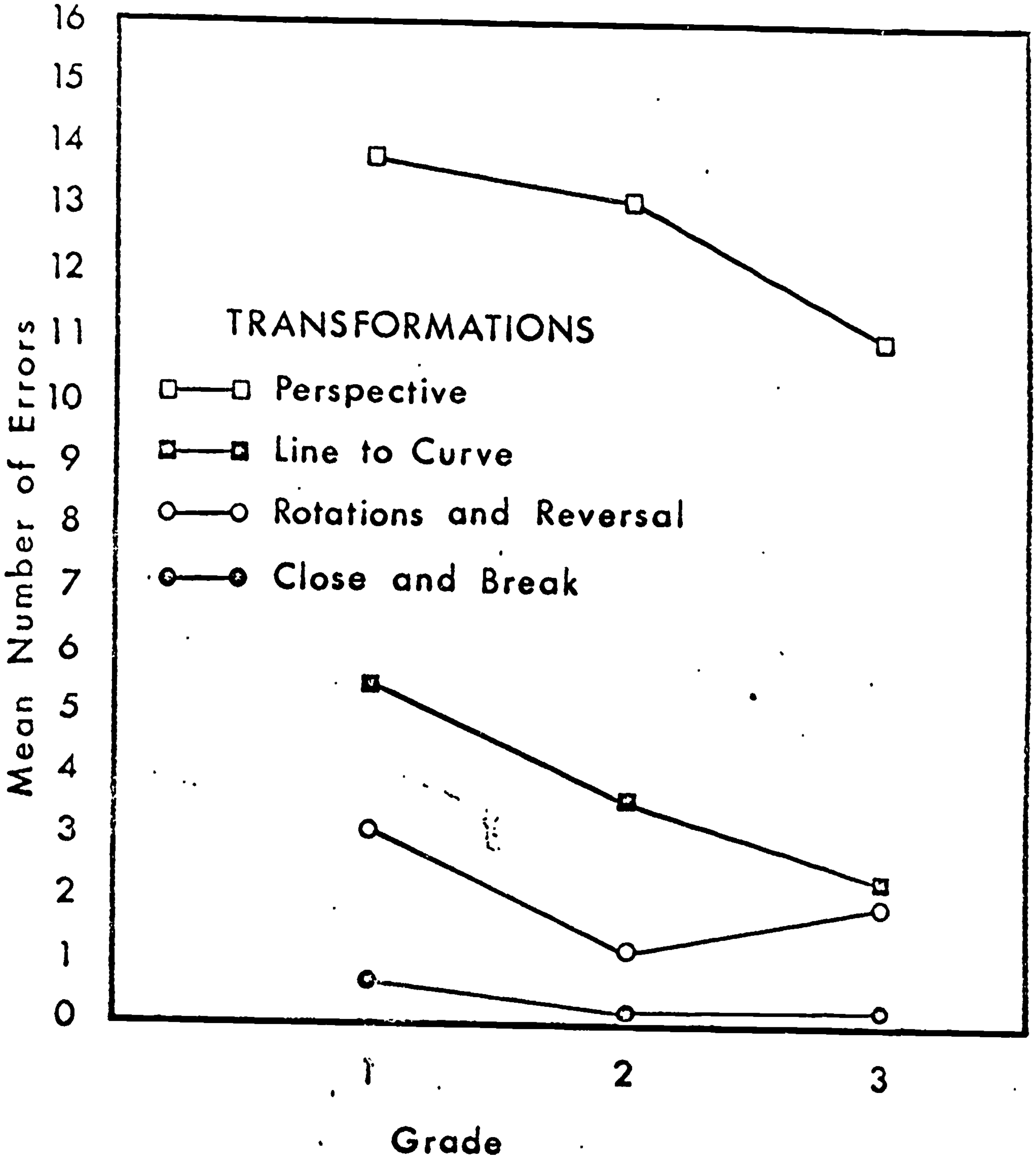
Figure Captions

Figure 1 - Examples of letter-like graphemes illustrating different types of transformations.

Figure 2 - Decreases in mean visual discrimination errors as a function of grade.



Standard
Up-down Reversal
Close
Curve to Line
Perspective Transformation (Tilt back)
Standard
45° Rotation
Close
Line to curve
Perspective Transformation (Slant left)
Standard
Left-right Reversal
Break
Curve to Line
Perspective Transformation (Slant right)


Mean Number of Errors
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TRANSFORMATIONS
Perspective
Line to Curve
Rotations and Reversal
Close and Break
1
2
3
Grade