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ABSTRACT

In the first experiment, the development of the ability to copy alphabet letters by black males aged 3-9 (middle and low S.E.S.) was studied, using a newly-developed scoring system. In the second experiment, kindergarteners learned to associate letter names with six lower-case printed letters by the anticipation method. The addition of an active-kinesthetic training component led to performance inferior to that following purely visual or passive-kinesthetic training. The final two experiments, in which nursery school and kindergarten children were studied, compared tactile-kinesthetic training and visual discrimination training on the ability to reproduce and to discriminate letters and letter-like forms. Training effects were "specific," in that discrimination training aided performance on the discrimination posttest, and reproduction training performance. In addition, the effects of discrimination training were seen on untrained as well as trained forms, but reproduction training effects were limited to trained forms. The results of these experiments did not strongly support the claims that have been made for tactile-kinesthetic training techniques by designers of a variety of remedial programs in reading. (Author/CS)

FINAL REPORT

Project No. 1-0449

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TRAINING KINDERGARTEN CHILDREN IN TACTILE-KINESTHETIC SKILLS ASSUMED TO BE RELATED TO READING

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U. S. DEPARTMENT OF

HEALTH, EDUCATION, AND WELFARE

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PREFACE

During the course of this Project, Ellen Blumberg, Harriette Robbins, and Cheryl Sopko served as full-time research assistants. Each of them contributed substantially to all aspects of the research. The author is very appreciative of their generous assistance.

The author wishes to thank John S. deCani, Chairman of the Statistics Department of the Wharton School, for his help with the analysis of the data, and also all the pupils, teachers, and administrators in the Philadelphia Public Schools and Get Set Centers that cooperated.

In addition, several students participated in the Project, some with distinction. They were involved either as members of graduate courses in educational psychology or as paid assistants, or, in some cases, both. They were Bonnie Anderson, Caryn Askinas, Christine Bebel, Mark Blair, Elizabeth Ellis, Frank Fiammino, Roberta Genauer, Claudia Gilfoil, Pamela Reid, Kathy Resnick, Irving Sears, Arlene Weissman, and Anne Winkler.

The Development of the Ability to Copy Letters

Research into the ways in which sensory modalities develop and interact is essential to an understanding of how literacy skills are acquired. While there has been a substantial amount of work done on the visual and aural modalities, both of theoretical importance (Day and Beach, 1950; Dilley and Paivio, 1968; Schulz, 1969) and also of relevance to reading instruction (Katz and Deutsch, 1964; Williams, Blumberg and Williams, 1970; Williams, Williams and Blumberg, 1973), considerably less work has been done on the tactile-kinesthetic modality. Over the years, there has been interest in methods of instruction that rely heavily on tracing and copying (Fernald, 1943; Spalding and Spalding, 1957); and standardized tests of form-copying, such as the Bender-Gestalt (Koppitz, 1964) have long been used as predictors of reading readiness (e.g., Keough and Smith, 1968). But there has been little systematic research of a fundamental nature.

This lack of interest may reflect the current emphasis within psychology on psycholinguistics and cognition as well as the fact that technology has tended to make the "fine hand" obsolete. However, research in the area should not be neglected, for (at least) one reason: the perceptual-motor training involved in developing handwriting skill may also influence the development of the reading process itself.

The only contribution of a theoretical nature that extends current interest in basic research on reading to the topic of writing was made by Gibson and Yonas (1968), who described the "fundamental graphic act," i.e., the child's early scribbling and the tendency to explore visually the results of his scribbling. Gibson and Yonas stressed the importance of this activity for perceptual learning.

Goodnow and Levine (1973) have considered form-copying as a type of task that can be used to analyze patterned or rule-governed activity. Braine (1972) takes the same approach, arguing from data on children's judgments of orientation that there are processing strategies in the perception of two-dimensional forms and that these strategies may change as a function of development. However, neither of these investigators has attempted to consider the implications of her work for the acquisition of reading and writing skills.

There have been a few studies which have focused specifically on how the ability to copy forms changes with age. Birch and Lefford (1967), for example, looked at the ability of middle-class children, five to eleven years old, to copy triangles and diamonds. As would be expected, older children were more able to identify components of a figure and to combine and reorganize parts of the whole. Graham, Berman, and Ernhart (1960) traced developmental changes in the reproduction of eighteen simple forms in children from two-and-one-half to five years old. Their samples included boys and girls, black and white, who varied widely in intelligence (IQ's from 75 to 173). The data indicated that a child's performance did not reflect discrete stages of development; rather, there was gradual improvement in ability over the ages tested.

The above studies have concentrated on the ability to copy simple geometric forms. Indeed, even the educators who have been concerned about the relationship between visuo-motor skill and reading readiness have focused primarily on how children copy such forms rather than focusing more directly on how they copy letters of the alphabet.

Little research has been done on the manuscript style of handwriting that is taught to most pupils. Ames and Ilg (1951) described gross changes in writing behavior that occur between the ages of three and nine, including not only the development of the form-copying per se but also of general posture and patterns of hand activity. Coleman (1970) ranked the lower-case letters in the order of difficulty that kindergarteners demonstrated in learning to print them. Lewis and Lewis (1965) assessed the relative difficulty of reproducing each of the fifty-two letters and tabulated the incidence of various types of errors on each letter. Their subjects were middle-class first-graders. Most of the conclusions were based on data confounded in terms of instruction--i.e., letter-productions prior to instruction and after six months of instruction were analyzed together. Stennett, Smythe, Hardy and Wilson (1972) did a similar study of children from kindergarten to third grade. In all of these studies, letter-reproductions were evaluated by means of judges' subjective ratings; no well-specified scoring systems were used.

In recent years there has been a great deal of interest in learning efficiency as it relates to group differences. When learning proficiency is assessed in terms of performance on standardized achievement tests or intelligence tests, middle-class children are generally superior to disadvantaged children (Stodolsky and Lesser, 1967). While most of the evidence comes from such data, there is a small number of recent studies that deal with laboratory learning paradigms. These are important, because the tasks involved demand new learning and do not depend heavily on past learning. In contrast to the findings with intelligence and achievement tests, in these "new-learning" tasks disadvantaged children tend to perform as well as do middle-class children. For example, studies by Zigler and his associates (e.g., Zigler and Kanzer, 1962) have shown no difference in overall performance on a learning task between the two social classes, even though there were significant differences as a function of social class in terms of the effectiveness of various types of reinforcers (tangibles versus intangibles).

Rohwer, Lynch, Levin and Suzuki (1968) found no differences between children from high-strata and low-strata elementary schools on a paired-associates task. On the other hand, while Semler and Iscoe (1963), using a similar task, did not find a difference in eight-to ten-year-old children, high-strata white subjects did better at the five-and six-year-old level than low-strata black subjects. Williams, Williams, and Blumberg (1973) found that middle-class white children were significantly superior to lower-class white children on both aurally-presented and visually-presented paired-associates lists at the second-grade level; no socio-economic status differences appeared at the fourth- and sixth-grade levels. A second experiment replicated these findings for black children.

Practically all the work to date on the relationship of basic learning abilities and socio-economic status has been done in verbal learning; perceptual-motor skills have been neglected in this context. Most of the studies mentioned above, for example, focused on middle-class children; or, as in the case of Graham,et al., data from several types of children were collected but not differentiated.

There were two major purposes of the present experiment. The first was to trace the development of the ability to copy the letters of the alphabet over a wide age range (three to nine), using a newly-developed scoring system that is well specified and highly reliable. The second purpose was to compare the performance of children from two socio-economic levels on this basic perceptual-motor skill.

METHOD

Subjects

Subjects were 196 black males, all right-handed, enrolled in public schools, Get Set Centers, and private nursery schools in Philadelphia. At each age level (three to nine), fourteen children of low socio-economic status and fourteen of middle socio-economic status were tested.

Materials

Each upper-case and lower-case manuscript letter was printed individually on a 6" x 9" card. Letters were one to two inches tall.

Procedure

Four booklets, each containing a different random order of the fifty-two letters, were prepared. Subjects were assigned one of the four booklets randomly. Each letter was presented to the subject individually, and, with the standard in view, he was asked to copy it with a beginner's pencil on a sheet of paper the same size as the stimulus card. Ample time was allowed for completion of the task. There were two sessions with each child, held on consecutive days or with a maximum of one day intervening. Twenty-six letters were copied at each session.

Scoring

A scoring system was developed in which each letter was evaluated in terms of two general criteria, each weighted equally: first, the method of reproduction and second, the overall appearance. The maximum score for a letter is 6.0. A detailed description of the scoring system is presented later in this report.

The reliability of the scoring system was determined by randomly selecting five reproductions of each of six letters at each of the seven age levels. The letters E, f, g, k, N, and p were selected as representative of the entire alphabet. The thirty-five reproductions for each letter were scored independently by two people, and a Spearman rank correlation coefficient was computed for each letter separately. Correlations ranged from .96 to .99.

To assess the validity of the scoring system, the same set of reproductions were used. The thirty-five samples of each letter were ranked from 1 (best reproduction) to 35 (poorest reproduction), and these rankings were correlated with a set of scores obtained using the scoring system. Spearman rank correlation coefficients, corrected for tied observations, were calculated. Correlations ranged from .62 (E) to .86 (k).

A second, independent assessment of validity was done, using the same six letters (E, f, G, k, N, p). Eight reproductions of each letter were randomly selected from the three-year-old, four-year-old, and five-year-old subjects. Four judges ranked the twenty-four samples of each letter from best to poorest, and the mean of the four judges' rankings was correlated with a set of scores obtained using the scoring system. Spearman rank correlation coefficients, corrected for tied observations, were calculated. Correlations ranged from .75 (E) to .92 (k and p).

RESULTS

Mean reproduction scores (method and appearance subscores separated) as a function of age and socio-economic status are presented in Figure 1. An analysis of variance was computed on the total reproduction score (equally weighted on method and appearance). There were two factors: age, with seven levels (3-9), and socio-economic status, with two levels--low and middle. Similar analyses were also done on the method subscore and on the appearance subscore separately. Table 1 presents the results of these analyses. In all three analyses, both factors were significant. That is, performance increased with age; and performance was superior for middle-class subjects. There was also a significant interaction, such that the differences between the middle-class and lower-class subjects appeared only at ages three and four.

Table 2 presents the correlations between the method and the appearance subscores as a function of age and socio-economic status. There was a substantial positive correlation at the younger ages, but as age increased, the correlation decreased. At age nine, the correlations were negative, though neither reached significance.

FIGURE 1

Mean Reproduction Score by Age and

Socio-economic Status

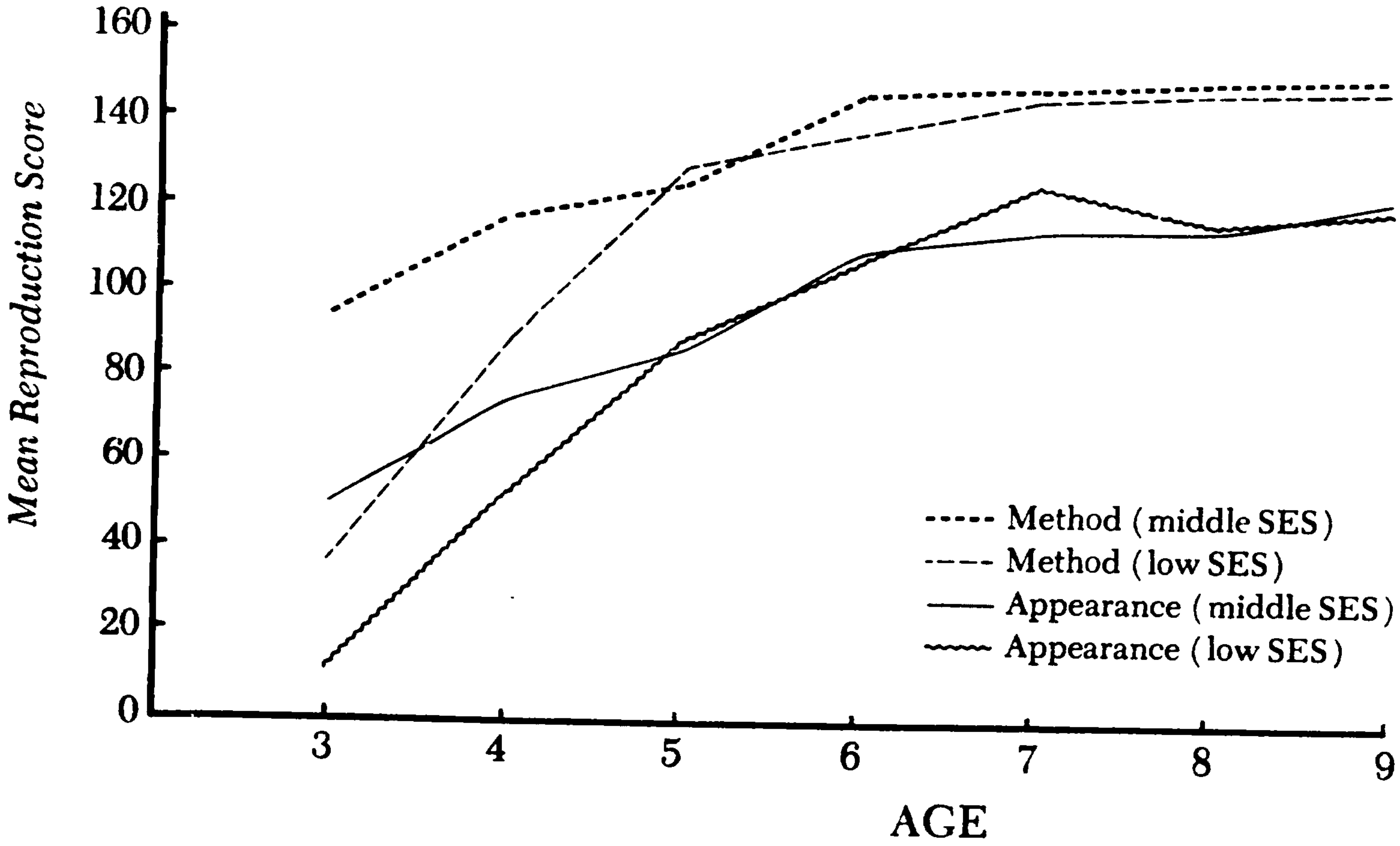

Mean Reproduction Score
160
140
120
100
80
60
40
20
0
3
4
5
6
7
8
9
AGE
Method (middle SES)
Method (low SES)
Appearance (middle SES)
Appearance (low SES)

TABLE 1

Analyses of Variance on the Re t Scores

	df	ms	F
(a) Total score:			
A (class)	1	24,399.33	34.12**
B (age)	6	118,281.87	165.44**
AB	6	10,052.20	14.06**
Error	182	714.92	
(b) Method score			
A (class)	1	9,711.96	27.88**
B (age)	6	26,486.15	76.03**
AB	6	3,360.83	9.64**
Error	182	348.33	
(c) Appearance score			
A (class)	1	3,320.64	17.81**
B (age)	6	33,059.97	177.36**
AB	6	1,832.84	9.83**
Error	182	186.39	

**$p < .001$

TABLE 2

Correlations Between Method and Appearance Subscores

	Socio-economic Status	
Age	Low	Middle
3	.90**	.95**
4	.91**	.74**
5	.66*	.54*
6	.07	.48
7	.42	.14
8	.32	.18
9	-.43	-.34

*$p < .05$; ** $p < .01$

DISCUSSION

The usefulness of the scoring system was demonstrated not only in terms of its high reliability and validity but also by the results of this developmental study. The data indicated clearly that the ability to copy alphabet letters increases with age, as would be expected. Moreover, the fact that the middle-class children performed significantly better than did the lower-class children, but only at the lowest age levels, corroborates previous findings (Williams, Williams and Blumberg, 1973). Thus the development of this basic tactile-kinesthetic skill is similar to the development of learning tasks involving the visual and aural modalities. The present data suggest that the task and also the method of scoring the data will be of value in further experimental work.

The finding that the correlations between method of reproduction and overall appearance are highly positive at early ages and decrease as age increases was unexpected. It would appear that as children get older, they become so adept at this copying task that they can produce a letter that resembles the standard even if they do not follow prescribed methods. However, before this point is reached, the method of reproduction is of greater importance. If a child follows prescribed procedures, the overall appearance of his reproductions will be closer to that of the letter standards. It would seem reasonable on the basis of these findings to investigate further the relationship between method of reproduction and quality of the final product, i.e., the overall appearance of the letter, in an instructional setting.

Using a tactile-kinesthetic method to learn letter names

The clinical literature abounds with recommendations for the use of "kinesthetic" or "tactile" techniques in reading instruction, as any textbook will indicate (Robeck and Wilson, 1974). Many of these techniques follow from the well-known Fernald method (Fernald and Keller, 1921; Fernald, 1943). One of Fernald's recommendations for remedial reading instruction consists of the following: The teacher writes a word as a demonstration. The child then traces the word with his finger and pronounces it at the same time. He repeats this procedure until he can read and write the word on his own.

One reason why such tactile-kinesthetic practice might be effective is that it might enhance labelling, or associative learning. Recent analyses of the processes involved in reading have stressed the development of grapheme-phoneme correspondences, which in many important ways can be understood in terms of the paired-associates learning paradigm (Samuels, 1968; Williams, 1968). Samuels (1973) has pointed out the complexity of this apparently simple paradigm. One of the several processes involved consists of visual discrimination, i.e., identifying and differentiating the visual stimuli (the graphemes). A likely way in which this visual identification occurs is through the mechanism proposed by Gibson (1962; 1970), i.e., the abstracting of the distinctive features of the forms, or, in other words, those dimensions of difference that distinguish the stimuli.

There are relatively few experimental studies of training in the tactile-kinesthetic modality, and the ones that exist do not lead to any conclusions as to the effectiveness of such training. Roberts and Coleman (1958), using a word-recognition task, found that visual presentation plus tracing was significantly more efficient than visual presentation alone for 12-year-old dyslexic boys. However, the same comparison for a normal group yielded no significant difference. Ofman and Shaevitz (1963), working with male disabled readers with a mean CA of 13-1/2 years, found both finger-tracing and eye-tracing, where the subject visually followed a moving point of light as it followed the outline of a nonsense trigram, significantly superior to simple visual presentation.

But in general, experiments do not indicate superiority for kinesthetic training: for example, Berman (1939), working with 9-year-old dyslexics, Kirk (1933), working with retardates whose mean CA was 10 and mean MA 7, and Mills (1956), working with children in grades 2 to 4. Otto (1961) found that second-graders learned a paired-associates list in fewer trials with tactile-kinesthetic "reinforcement," but visual reinforcement was more efficient with fourth-graders. There was no preference for any specific mode at the 6th grade level. Forster (1941), working with adults, found the addition of a tactile-kinesthetic component to training to be significantly inferior.

It would appear likely that the effectiveness of tactile-kinesthetic training would be greater at young ages. Piaget (Piaget and Inhelder, 1956; Flavell, 1963) sees tactile experience as a necessary prerequisite to perceptual and intellective development. Zaporozhets (1965; 1969) also emphasizes the role of motor activity in the development of perceptual processes especially in the early years. However, the results of studies on younger children, while fewer, are just as inconclusive. Levin, Watson and Feldman (1964) found that for first graders, tracing was effective as pretraining for associative learning, but only when the most salient cue, the initial grapheme, was traced. Ringler and Smith (1973), whose study involved a relatively extensive instructional treatment (7-1/2 hours), found no superiority on a word-recognition task for kinesthetic training, either for all their first-grade subjects or for those who had previously been characterized as "kinesthetic" learners. Using a kindergarten population, Jensen and King (1970) found no difference in word-recognition after training involving tracing, manipulative re-arranging of constituent letters, or matching-to-sample.

The present experiment, designed to investigate the effectiveness of the tactile-kinesthetic modality in associative learning, differs in several respects from the studies cited above. First, a younger population, kindergarten children, was studied, following the suggestions from previous data and developmental theory. Second, the task, while following the same paradigm, was simplified so that (a) it was appropriate for the younger subjects, and (b) it provided a meaningful task in terms of reading instruction: the children were required to label printed lower-case letters with their appropriate names. Third, a slightly difficult question in terms of kinesthetic training was asked, and the experimental treatments varied somewhat from previous studies.

Recommendations as to teaching techniques based on tactile-kinesthetic learning include copying as well as tracing; these are two quite different activities. One major difference between them is that copying involves more active participation on the part of the subject. No experiments have been noted that evaluate this particular training procedure, although very often one hears from classroom teachers that tracing per se does not assure that a child's attention will be focused effectively, because of the passive nature of the activity.

It must be concluded that the purely motoric aspect of the tactile-kinesthetic task cannot be responsible for its effectiveness. The Ofman and Shaevitz study suggests, rather, that its efficacy is due to the fact that it forces the child's attention to the critical features of the stimuli to be differentiated. This hypothesis has received some corroboration from findings in other experiments: while discriminative motor responses are significantly superior to labeling responses in preschoolers' learning of left-right distinctions (Jeffrey, 1958), the manual motor response can be supplanted by demonstrations that highlight the relevance of orientation (Koenigsberg, 1973).

The present experiment compares the following conditions:

(1) active kinesthetic training (AK), in which the child is asked to copy letter forms from a model (which is always available)

(2) passive kinesthetic training (PK), in which the child is asked to watch the experimenter trace the outline of letter forms
(3) no kinesthetic training (NK), in which the child simply looks at the letter forms.

A secondary purpose of the experiment was to compare the performance of middle-class and lower-class children on this task. Most of the work to date on the relationship of basic learning abilities and socio-economic status has been done in verbal learning (Rohwer, 1968; Williams, Williams and Blumberg, 1973), but no previous studies on the effects of tactile-kinesthetic learning have considered this issue.

Thus the design was a three by two factorial, with three levels of presentation-mode and two levels of socio-economic status

METHOD

Subjects.

Subjects were 108 black kindergarten children, half male and half female. Half the subjects were drawn from Philadelphia public schools whose population, based on scores on standardized aptitude and achievement tests and on educational level and occupational category of parents, could be classified as middle-strata. The other half were drawn from lower-strata schools.

However, at the kindergarten level itself, no standardized test scores were available. It was felt that pretest screening on the experimental task itself could serve as a useful indicator of the child's relative standing in his class; knowledge of letter names is generally considered a good predictor of reading achievement (Chall, 1967). Thus the subjects were those for whom difficulty in reading was likely.

Materials.

The stimuli consisted of six lower-case Roman letters 1.5 and 2.5 inches tall, printed on white 5 x 8 cards. The letters a, f, g, h, r, and y were chosen to minimize visual confusability as well as auditory confusability. Each subject in the AK group also used a 5 x 8 inch unlined writing tablet and a beginner's pencil.

Procedure.

The anticipation method was used. That is, a stimulus card was presented and the subject was given three seconds to name the letter shown. After each response, the experimenter said "Yes, good, it is an 'a,'" or "No, it's an 'a,'" thus providing reinforcement for correct responses, correction for errors, and equating the number of times the subject heard the name of the letter. Each subject was seen once for approximately twenty minutes. He was told that he was to play a game and that he would receive a prize (an animal sticker) at the end of the game.

A pretest was administered. Each of the six letters was presented individually, and the subject was asked to name it. If the child correctly named two or fewer letters, he was included in the experiment. Following the pretest, pretraining was given. Using a rapid drill pace, the experimenter repeated each letter name. The subject pronounced each one immediately afterward. The list of six names was randomized for each subject. The list was completed twice in this manner, in order to insure that the subject's responses would be correctly recognized during training.

Training.

Total training time was equated for all three treatment groups. The time required for training of each AK subject was used to determine the total training time for one subject in each of the other two groups. For the PK subject, this amount of time was divided by 18 (the number of stimulus presentations) so that each letter stimulus would have an equal exposure time. For the NK subject, additional training trials were presented until the specified amount of time had elapsed.

Group AK.

Three acquisition trials were given, each one consisting of a different random order of the six letters. A letter card was presented, and the subject's response was reinforced if correct, corrected if wrong, and provided by the experimenter if no response was made within the three-second time allotted. The subject was directed to repeat the correct letter-name after it was given by the experimenter, and then to copy the letter on a clean sheet of pad paper. After this first copy, the subject repeated the letter name, and copied the letter a second time. (The subject repeated each letter-name three times during the presentation of each item and the experimenter, four times.)

Group PK.

The same procedure was followed except that the experimenter traced the outline of each letter on the stimulus card while the subject watched. As in group AK, the subject pronounced each letter-name three times per item, and the experimenter, four times.

Group NK.

The same anticipation method, with three seconds allotted for a response, was used. The difference procedurally lay in the number of exposures to the stimuli, for additional trials (new random orders) were given until the total training time that had been specified by the Group AK subject had elapsed.

Posttest.

Immediately following the completion of training, all subjects were given the posttest, which was identical to the pretest.

RESULTS

In order to obtain 108 subjects who met the pretest criterion, it was necessary to pretest a total of 161 children. In the low-strata schools, 73 children were pretested and 19 excluded. In the middle-strata schools, 88 children were pretested and 34 excluded. The difference in proportion excluded was not significant ($\chi^2 = 2.873$, d.f. = 3). In addition, eight subjects were dropped from the sample because they were uncooperative. One subject was eliminated because, at the end of the letter-name pre-training, the experimenter could not evaluate his responses.

Preliminary analysis of the data indicated that males and females did not differ as a function of either treatment or social class, so in subsequent analyses the scores for both sexes were combined.

Correlations between pretest and posttest scores were computed for each of the six experimental groups. Pearson r's were significant in five cases. Table 3 presents these correlations.

Table 4 presents the analysis of covariance performed on the pretest scores, using the pretest score as the covariate. This analysis indicated that the main effect of training was significant ($F = 3.50$; d.f. = 2, 101; $p < .05$), the effect of S.E.S. was not significant, and the interaction of the two variables was not significant. Orthogonal comparisons indicated that there was no significant difference between the PK and NK groups ($F < 1$; d.f. = 1, 101). The AK group was significantly inferior to the other two groups ($F = 6.99$; d.f. = 1, 101; $p < .01$). Table 5 presents the adjusted posttest means.

DISCUSSION

The results indicate clearly that tactile-kinesthetic training did not lead to improved performance on the associative task. In fact, the active kinesthetic training group was significantly poorer than the other two training groups. It is possible that the added requirements in the AK task were in fact distracting to the subject rather than facilitating. This possibility was raised by Forster (1941), whose results were similar to those of the present study, and by Bee and Walker (1969), whose experiment evaluated tracing and copying in a paradigm different from the associative-learning paradigm.

While these findings, taken with those of previous studies, do not indicate that the Fernald method itself is not of value, it does suggest that perhaps the basis for the success of the method does not lie in the tactile-kinesthetic training itself. An analysis of the source of the effectiveness of the remedial educational program would require (a) the isolation of all possible task components that might be responsible for the

TABLE 3

Correlation Between Pretest and Posttest Score

	Training Condition		
	A.K.	P.K.	N.K.
Lower S.E.S.	.68**	.64**	.59**
Middle S.E.S.	.64**	.61**	.35

(d.f. in each case = 35; ** $p < .01$)

TABLE 4

Analysis of Covariance

	d.f.	m.s.	F
Training Group	2	5.44	3.50*
PK vs. NK	1	.003	<1
PK vs. (PK + NK)	1	10.88	6.99**
S.E.S.	1	3.59	2.31
Interaction	2	2.66	1.71
Error	101	1.56	

* $p < .05$; ** $p < .01$

TABLE 5

Adjusted Mean Posttest Score

	Training Condition			
	A.K.	P.K.	N.K.	Mean
Lower Class	1.17	2.20	2.38	1.91
Middle Class	1.40	1.70	1.55	1.55
Mean	1.28	1.95	1.96	1.73

effectiveness of the total program and, (b) the evaluation of each of them singly and perhaps in combination with certain others. An evaluation of the effectiveness of tactile-kinesthetic learning, on the other hand, should include an analysis of all the various ways in which this type of training might be utilized; the associative-learning paradigm is only one.

While the difference between the proportion of children that were screened out in the middle class and the lower class on the basis of the pretest was not significant, it was substantial enough to provoke speculation. The excluded proportion was larger in the middle class sample; this is in line with the higher level of achievement generally found in those schools. Were the middle-class subjects who actually participated in the experiment, then, more disabled in reading, relative to the other children with whom they would be compared? These children did show relatively less sensitivity to the various experimental conditions. (Again, this was a tendency in the data only.) Might this reflect the fact that these children see themselves as relative failures in their classrooms and thus exhibit lower levels of motivation for school tasks? The present data do not allow for conclusive answers to these questions.

Visual Discrimination vs Tactile-Kinesthetic Training

In Bee and Walker's (1969) study, four- and five-year-old children were given training consisting of pointing to detailed features of triangles and circles, which led to better drawings, but when tracing requirements were added, post-test drawings were worse than pre-test drawings. The results of the experiment, however, were equivocal, for the training was relatively brief, and the subjects who traced showed much fatigue.

Within regular kindergarten classes, Pryzwansky (1972) compared the effects of three widely-used perceptual motor training programs, two of which involved fine-motor exercises focusing on non-letter forms and one of which involved training in manuscript writing. While the program that had letters of the alphabet as its content significantly improved post-training scores, no effects were noted in tests of visual discrimination ability.

The question can be reversed, of course. Does visual discrimination training enhance the ability to copy? Hirsch and Niedermeyer (1973) found that the addition of discrimination training to letter-formation training did not improve performance on a post-test requiring the ability to copy the letters used in training. Rand (1973) gave three- to five-year-olds visual analysis training on simple geometric figures, consisting of printing and counting sides and corners of figures, and discrimination training with feedback (i.e., placing transparent outlines of the standard figure over samples). This training did not help the child's ability to copy accurately.

In a slightly different type of experiment, Strayer and Ames (1972) found that four- and five-year-olds given perceptual training in using orientation as a discriminative stimulus significantly improved in copying performance, whether or not the specific aspects of the particular forms to be copied on the post-test were used in training. None of those different types of discrimination training led to improved copying in young learning-disabled children in a study by Axelrod (1974).

Considering all the studies cited above together, it appears that the effectiveness of either training method is limited to performance on tests involving similar procedures; it does not generalize to other tasks involving the same stimuli. The studies demonstrating this are those by Williams (1969); Rand (1972); and Hirsch and Niedermeyer (1973); none of the other studies conflicts with this finding, but they were more limited in their experimental conditions.

The studies are less clear as to whether the training effects transfer to novel stimuli content (forms and letters) not used in training. Hirsch and Niedmeyer's experiment did not include a test of this sort of transfer. Rand found that both discrimination training and reproduction training were effective in improving performance on both trained and untrained stimuli. It should be noted, however, that her reproduction training was of a different variety: she taught "drawing rules," which involved planning one's drawing by making dots at the corners of figures and then connecting the dots. Performance in this task did improve with training, but it did not transfer to more typical copying, where there was no such stimulus support. (One of Hirsch and Niedermeyer's experimental groups was trained with a similar technique, involving gradual withdrawal of the supportive dots; no improvement on a regular copying post-test was seen.) Koenigsberg's, Bee's, Williams', and Pryzwasky's studies were not designed to answer this question.

Many of the earlier studies that investigated the effectiveness of tactile-kinesthetic training did so in the context of rather complex situations. The effectiveness of such training was often evaluated on a measure such as word recognition or word retention, involving one or another variation of a paired-associates paradigm. For example, Ofman and Shaevitz (1963) compared tracing with visual presentation on a test of written recall of three-letter words. Jensen and King (1970) used a simple oral reading test of the words that had been used in training. Levin, Watson, and Feldman's (1964) criterion was the ease of learning to attach labels to "words" constructed from artificial graphemes after pre-training which either did nor did not involve tracing.

The results of a fairly large number of such studies do not indicate a strong superiority for tactile-kinesthetic training. Even if they did, it would be difficult to identify the specific mechanisms by which the effect occurred. For example, it might be a function of the amount of attention that is focused on the stimuli (Ofman and Shaevitz, 1963; Wiener and Goodnow, 1970) rather than the motor activity _per se_.

There have not been many experiments that ask a question that, while still complicated, is relatively straightforward, i.e., what is the effectiveness of such training on visual discrimination? Williams (1969), working with children who had just begun their kindergarten year, compared reproduction training, involving tracing and copying letter-like forms, with discrimination training of two types, (1) where the comparison stimuli were quite different from the standard, and (2) where they were transormations (rotations and reversals) of the standards.

Reasoning from Gibson's (1962) hypothesis that improvement of visual discrimination depends on learning the distinctive features of the forms to be discriminated, i.e., those dimensions of difference that distinguish the stimuli, Williams predicted that the second discrimination training condition would be superior to the first. The dependent measure was a set of matching-to-sample tasks involving the letter-like forms used in training and transformations of them, presented singly and in clusters. The results were as predicted. When subjects were kindergarten children who had had only a couple of months of school, the reproduction training group was only as effective as the simple discrimination training group, suggesting that if content in a discrimination training procedure were carefully chosen, it would force the _Ss_ to attend to more criterial attributes of the stimuli than would simple discrimination training but not as many as discrimination-of-transformations. A replication of the experiment done toward the end of the kindergarten year showed no differences among training groups.

Koenigsberg (1973) compared a variety of training procedures including tracing, aligning standards with comparison figures, and observing alignments. She tested achievement on matching tasks with both line figures and difficult-to-discriminate letters. Her results indicated that demonstrations of the relevance of orientation were sufficient to produce improved discrimination and that the various forms of sensori-motor training did not improve performance further.

The purpose of the present experiment is to determine the relative effectiveness of tactile-kinesthetic training (tracing and copying) and of visual discrimination training on (a) the ability to reproduce letter-like forms, and (b) visual discrimination. A further question to be answered is whether or not the effectiveness of such training generalizes to novel, untrained material of the same type as the stimuli used in training.

EXPERIMENT 3

METHOD

Subjects

Subjects were ninety black males enrolled in Get Set Centers and public kindergartens in Philadelphia, whose population, based on educational level and occupational category of parents, could be classified as disadvantaged (poverty) schools. There were thirty subjects from each age group, three-year-olds (i.e., between three years,two months and four years of age at the start of the experiment), four-year-olds (four years,two months to five years), and five-year-olds (five years,two months to six years).

Materials

Six upper-case letters were used. All subjects were trained on the letters T and E, and test included those letters plus F, L, C and Q, singly and in combination. Stimuli were presented on 5" x 8" cards. In addition, the Reproduction group used 5" x 8" unlined paper and beginner's pencils.

Design

The experiment was a 3x3x3 factorial, with ten subjects per cell. The age variable (3, 4, and 5-year-olds) and the training group variable (discrimination, reproduction, and control) were between-subject factors; the letter-group variable (letters used in training; similar transfer letters; and different transfer letters) was a within-subject factor.

Procedure

Each subject was seen three times. At the first session, the first twelve items of the Beery-Buktenica Test of Visual-Motor Integration (1967) were administered and scored according to the test manual. In addition, there was an Alphabet-Naming test, in which each of the twenty-six upper-case Roman letters was presented individually in random order and the subject's score was the number he named correctly.

At the second session, two pretests were administered and training was begun. In the reproduction pretest, the subject was asked to copy each of the six letters on unlined paper. The sample letter remained visible to the subject as he copied it. In the discrimination pretest, twelve simultaneous matching-to-sample items were presented. Four had single-letter standards, four had pair standards, and four had triad standards. All standards and alternatives consisted of combinations of T and E or of C and Q. Subjects were asked to underline, among four alternatives, the one identical to the standard. Half the subjects received the discrimination pretest first, and the other half, the reproduction pretest. One-third of the total amount of training followed.

At the third session, the final two-thirds of training was given, followed by two posttests. Both the reproduction and the discrimination posttests were identical to the pretests; half the subjects received one test first, and half the subjects, the other first.

A scoring system developed by Williams was used, in which each letter was evaluated on two general criteria, each weighted equally: first, the method of reproduction, assessed in terms of the number of lines drawn and the order and direction in which they were drawn; and second, the overall appearance, evaluated according to a series of criteria specified for each letter individually (accurate intersection, angularity, accurately proportioned curved segments, etc.). The total possible weighted score for a letter was 6.0, and thus, with six letters in a test, the best score possible for an individual subject was 36.00.

In order to determine the reliability of this scoring system, thirty pretest reproductions of each of the six letters (T, E, F, L, C, Q) were randomly selected, ten from each age group. These were scored independently by two people. A Spearman rank correlation coefficient was computed on the thirty scores for each letter separately; none of the correlations was below .95. Overall, the correlation for the method subscore was .98 and, for the appearance subscore, .96. (The judges had had prior experience in rating a preliminary sample.)

To determine the validity of the scoring system, the same 180 reproductions were used. Four judges were asked to rank the thirty samples of each letter from best to poorest, and the mean of the four rankings was correlated with the scores obtained using the scoring system. Spearman rank correlation coefficients, corrected for tied observations, were obtained. With the exception of the letter C, for which the correlation was .77, all correlations were .86 and above, the highest (L) being .95.

Training

Discrimination: Training items consisted of eighteen simultaneous matching-to-sample items, using T and E, with equal numbers of single, pair, and triad standards. The total time taken by each subject was noted and was used as the basis of equating training time among groups.

Reproduction: Subjects traced and copied the two training letters (T and E) alternately. The standards were displayed continuously. Each subject in this group was given the same amount of training as had been

TABLE 6

Mean Scores on Pretest Measures

Age	Letter-Naming Test (maximum = 26)	Beery Test (maximum = 12)	Discrimination Pretest (maximum = 12)	Reproduction Pretest (maximum = 36)
3	4.03	3.18	4.70	14.29
4	6.18	4.95	6.48	22.89
5	17.43	8.13	9.33	29.17

TABLE 7

Correlations Among Pretest Measures

Age 3	Discrimination	Reproduction	Beery	Letter-naming
Discrimination	X	.55**	.31*	.23
Reproduction		X	.49**	.73**
Beery			X	.20
Letter-naming				X
Age 4				
Discrimination	X	.34*	.19	.42**
Reproduction		X	.57**	.55**
Beery			X	.28
Letter-naming				X
Age 5				
Discrimination	X	.20	.26	.26
Reproduction		X	.50**	.10
Beery			X	.22
Letter-naming				X

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

TABLE 8

Experiment 3

Analysis of Covariance Table for the Discrimination Post-test

	df	ms	F
Between subjects:			
A (Age)	2	38.822	25.57**
B (Training Method)	2	10.956	7.22**
$B_2 - B_4$	1	0.284	< 1
$2B_1 - (B_2 + B_4)$	1	21.627	14.25**
AB	4	2.263	1.49
Error	80	1.518	
Within subjects:			
C (Letter type)	1	18.049	15.42**
AC	2	0.487	< 1
BC	2	2.814	2.40
ABC	4	3.609	3.08*
Error	80	1.170	

*p. $<$.05; **p. $<$.01

TABLE 9

Experiment 5

Adjusted Means on Discrimination Post-test

Age	Trained Letters: Discrimination Training	Trained Letters: Reproduction Training	Trained Letters: Control	Transfer Letters: Discrimination Training	Transfer Letters: Reproduction Training	Transfer Letters: Control	Mean
3	4.22	3.96	2.42	2.74	2.84	3.01	3.20
4	4.94	3.91	3.94	4.54	3.03	3.90	4.04
5	5.25	5.22	5.14	5.36	3.95	3.92	4.81
Mean:	4.80	4.36	3.83	4.21	3.27	3.61	4.02

(N = 10 per cell)

taken by a subject in the discrimination group. Instructions were given, such as: "Let's start this time at the top. Let's start here. Do this line first. See if you can make your lines come together like this. Look how long this line is; make yours like that."

Control: During a time period equal to that taken in training by a discrimination subject, each subject looked at a picture book that contained no printed words.

RESULTS

Description of the experimental sample

The mean scores on the Beery and the letter-naming tests, as well as on the discrimination and reproduction pretests, are presented in Table 6. As expected, all four scores increased with age. The most dramatic increase occurred between the ages of four and five on the letter-naming test. The Beery scores fell with age expectations according to standardization data on the Beery test.

Pearson product-moment correlations between each pair of tests are presented in Table 7. It would be expected that the most substantial correlations would be found between the Beery test and the reproduction pretest scores, since both of these tests are similar in intent and in scoring. Indeed, most of the correlations between tests are significant at ages three and four, including the correlation between the Beery test and the reproduction pretest, but the latter is the only correlation that remains significant at age five.

An analysis of covariance with age, training method, and type of letter as factors was performed on the scores on the discrimination post-test. Discrimination pretest score was the covariate.

Table 8 presents the results of the analysis, and Table 9 presents the adjusted means. Performance increased with age, and specific comparisons indicated that performance at each age was significantly different from that at the other ages.

The training variable was also significant. Orthogonal comparisons indicated that discrimination training was significantly different from the other two conditions ($F = 14.25$; $df = 1, 80$; $p < .01$), which did not differ ($F < 1$, $df = 1, 80$). Performance on the half of the post-test containing the letters that had been used in training was significantly superior to that on the other half of the post-test. None of the two-way interactions was significant, but the three-way interaction was significant at the .05 level.

TABLE 10

Experiment 3

Analysis of Covariance Table for Reproduction Post-test

	df	ms	F
Between subjects			
A (age)	2	85.010	21.780***
B (training method)	2	11.874	3.042
AB	4	5.853	1.499
Error	80	3.903	
Within subjects			
C (type of letter)	2	6.656	2.812
AC	4	6.267	2.648*
BC	4	3.567	1.507
ABC	8	0.796	0.336
Error	160	2.367	

* $p < .05$
*** $p < .001$

TABLE 11

Experiment 3

Adjusted Reproduction Post-test Means

	Discrimination Training			Reproduction Training			Control			
Age	T, E	F, L	C, Q	T, E	F, L	C, Q	T, E	F, L	C, Q	Mean
3	6.26	7.17	7.51	6.55	5.71	5.98	5.29	5.21	5.76	6.16
4	6.98	8.83	6.89	6.85	7.69	6.52	6.72	7.27	6.33	7.12
5	7.48	8.50	7.95	7.95	8.49	8.13	7.92	7.95	8.58	8.10
Mean:	6.90	8.16	7.78	7.12	7.30	6.88	6.64	6.81	6.89	7.12

A similar analysis of covariance, using pre-test score as the covariate, was done on the reproduction post-test scores. (See Tables 10 and 11.) Again, performance improved as age increased, with performance at each age level significantly different from performance at each other age level. There were no significant differences among training methods nor among the types of letters. Only one interaction was significant, that between age and training method. This interaction was due to a high score for the four-year-olds on the similar transfer letters (F and L).

DISCUSSION

The finding that discrimination training was significantly better than reproduction training on the discrimination test corroborates previous findings. In the present experiment, post-test performance on the trained letters was significantly superior to that on the untrained letters, suggesting that effects of training do not transfer beyond the specific content used in training. No firm conclusions can be drawn from the present data, however, because the training letters and the transfer letters had not been equated in difficulty prior to the experiment. (Over all ages, the mean pre-test score for T and E was 4.33, and for C and Q it was 3.90.) There is no logical reason for the three-way interaction, and in view of the fact that none of the simple interactions reached significance and that there was no <u>a priori</u> reason to expect a three-way interaction, it should be ignored.

Turning to the reproduction test, the main effect of training method did not prove to be significant in the present experiment. The most likely explanation for this result is that the experimental treatments were not designed effectively enough. It is felt that too little time was devoted to training. Because of this, the hypothesis that the differences between training methods would vary as a function of age can, of course, not be assessed effectively by this experiment.

The fact that the performance of the four-year-old subjects was particularly high on the similar transfer letters led to a significant age-by-training-method interaction. Again, there is no reason to expect such an effect, and without replication, does not warrant speculation.

Overall, the results of this experiment indicated that the experimental situation, generally speaking, was appropriate for the assessment of the hypotheses. However, the need for certain specific modifications in the design was noted. First, the use of Roman upper-case led to limitations in conclusions that would not have been necessary had content equated in difficulty prior to the experiment been used. Second, the training methods did not prove effective in demonstrating any differences that might be present on a reproduction criterion test. The following experiment was designed to take into account these issues.

EXPERIMENT 4:

METHOD

Subjects

Subjects were forty black children enrolled in two day-care centers in Philadelphia. Half were male, and half, female. The families of the subjects met the Federal socio-economic criteria for participation in Get Set (Headstart) and Day Care centers; thus the subjects were homogeneous in relation to low socio-economic status. All subjects were between the ages of forty-eight and sixty-six months at the time of the experiment.

Materials

Six letter-like forms, adapted from Gibson, Gibson, Pick and Osser (1962) and previously used by Williams (1969), were used. Three of these forms were used as standards in training, and all six were used in testing. The set of three training forms and the set of three non-training forms had been found to be equal in difficulty in the previous research (Williams, 1969). Stimuli were presented manually, the 2.5" letters drawn on 4" x 6" cards.

Design

The experiment was a 4 x 2 x 2 factorial, with five subjects per cell. Within the training method variable, there was (a) reproduction training; (b) discrimination training; (c) combination training; and (d) no training. Sex was the second factor. The third factor was type of letter-form and was the only within-subject factor: (a) forms used in training, and (b) forms not used in training.

Procedure

Each subject was seen five times. At the first session, scheduled on the Thursday or Friday preceding the Monday on which the training was begun, pretests were administered. There were three fifteen-minute training sessions, one per day. If more than one session were missed (because of absence from school), the subject was dropped from the study. The fifth session, held on the day immediately following the final training session (i.e., on Thursday or Friday), was devoted to post-testing.

Pre-tests

Four tests were administered, including the Beery-Buktenica Test of Visual-Motor Integration (1967) for children from two to eight, and an alphabet-naming test, in which each of the twenty-six upper-case Roman letters was presented individually in random order and the subject's score was the number he named correctly. The third test was a reproduction pretest, in which the subject was asked to copy six items composed of the three letter-like forms to be used in training. Unlined paper was used. Each standard form remained visible to the subject as he copied it. Each of the first three items consisted of one of the forms presented individually; each of the next two items contained two of the three forms; and the last item presented a combination of all three forms. The fourth test was a discrimination pretest, consisting of eighteen simultaneous matching-to-standard items involving the three training letter-forms. Six items involved choosing a match to a standard consisting of a single form, where the (four) alternatives consisted of transformations (rotations and reversals) of that standard. Another six items consisted of a pair of letter-like forms as the standard; the four alternatives included (1) the correct choice, (2) the first form correct and the second, a transformation of the second form, (3) a transformation of the first form and the second form correct, and (4) the two correct forms but in reverse order. The last six items presented all three forms as the standard, and the four alternatives consisted of (1) the correct choice, (2) the first two forms correct and a transformation of the thrid, (3) a transformation of the first and the last two correct, and (4) all three forms correct but with their order reversed.

Placement of the correct alternative in the response array was balanced over all items. Pretests (and posttests) in all cases were administered by a different person than the one conducting the training sessions.

Training

Reproduction training consisted of copying the three letter-like forms. When errors were made, feedback was given by the experimenter as to correct method of drawing the letters (using the same criteria as built into the scoring system). Training items were the three standards used in the pretest. Each daily training session was divided into three five-minute sections. During the first five minutes, the subject copied singly-presented forms (cf. the first three items on the pretest). During the second section, he copied pairs of forms, and during the third section, he copied sequences of three forms. Within each section, the appropriate standards were presented in random order and were repeated until the five minute period had elapsed.

Discrimination training consisted of simultaneous matching-to-sample practice on the items that had appeared on the discrimination pretest. There were three five-minute segments, during which single-form items, pairs, and triples were presented, in that order. Throughout each five-minute portion of training, appropriate items were presented in random order. Feedback as to correct choice was given on all items.

Combination training consisted of both discrimination and reproduction training, identical in format and content to the other two groups. Only half as much time for each type of training was given; within each five-minute section of a session, the subject chose whether he wished to do the reproduction tasks (2-1/2 minutes) or the discrimination tasks (2-1/2 minutes) first. No training was given to the control group.

Posttest

The reproduction posttest consisted of two parts. The first part was identical to the reproduction pretest. The second part, consisting of another six items, was exactly the same in format but was constructed from three letter-like forms that had not been used in training and transformations of those forms.

The discrimination posttest consisted of two parts. The first was identical to the discrimination pretest, and the second part consisted of another eighteen items exactly the same in format to the pretest but including the same three letter-like forms and transformations of them used in the second part of the posttest.

RESULTS

Table 12 presents, for each treatment group, mean chronological age and mean scores on the letter-naming and the Beery tests, as well as on the discrimination and reproduction pretests. All four treatment groups were comparable in age ($F < 1.00$, df = 3, 32), alphabet-naming score ($F = 1.44$, df = 3, 32), the discrimination pretest ($F = 1.001$, df = 3, 32), and the reproduction pretest ($F = 1.40$, df = 3, 32), and there were no sex differences on any of these measures (all relevant Fs below 2.50, df = 1, 32). There were initial differences on the Beery test ($F = 4.53$, df = 3, 32, $p < .01$). A Neuman-Keuls test revealed that the reproduction group differed significantly from both the discrimination and control groups but not from the combination group.

Pearson product-moment correlations between pairs of the following variables: chronological age, the Beery test, the alphabet-naming test, and the discrimination and reproduction pretests, are presented in Table 13.

To test whether the pretest and the posttest were indeed independent of one another, the scores on these tests were correlated for both the discrimination and the reproduction tasks. The obtained correlations were .66 and .61, respectively.

Analysis of covariance, using pretest score as the covariate, was performed on the discrimination posttest. There was a significant difference in performance among the four training conditions. Table 14 presents the analysis of covariance. Specific comparisons indicated that discrimination training was superior to the other three training conditions ($F = 8.10$; df = 1, 31; $p < .01$), which did not differ among themselves ($F = 1.20$; df = 1, 31). Neither of the other main effects, sex and type of letter, was significant. None of the interactions was significant. Figure 2 presents the mean (adjusted) scores as a function of training condition and type of letter.

TABLE 12

Experiment 4

Mean Scores on the Pretest Measures

Training Condition		Age (mos.)	Alphabet-Naming Test	Berry Test	Discrimination Pretest	Reproduction Pretest
Reproduction	Male	60.40	13.60	5.00	8.20	21.90
	Female	57.00	4.80	3.60	4.80	22.53
Discrimination	Male	59.80	14.20	7.00	5.60	28.34
	Female	56.60	16.60	6.60	5.60	26.43
Combination	Male	59.60	12.80	6.40	7.40	27.70
	Female	59.80	21.00	7.80	8.60	34.84
Control	Male	58.60	17.00	5.60	6.60	29.50
	Female	54.00	8.60	5.00	6.20	25.64

TABLE 13

Experiment 4

Correlations Among Pretest Measures

	Discrimination Pretest	Reproduction Pretest	Beery	Letter-Naming	Age
Discrimination Pretest		.27	.24	.29	.24
Reproduction Pretest			.46*	.60*	-.11
Beery				.43*	.34*
Letter-Naming					.10
Age					

*p $<$ .05

TABLE 14

Experiment 4

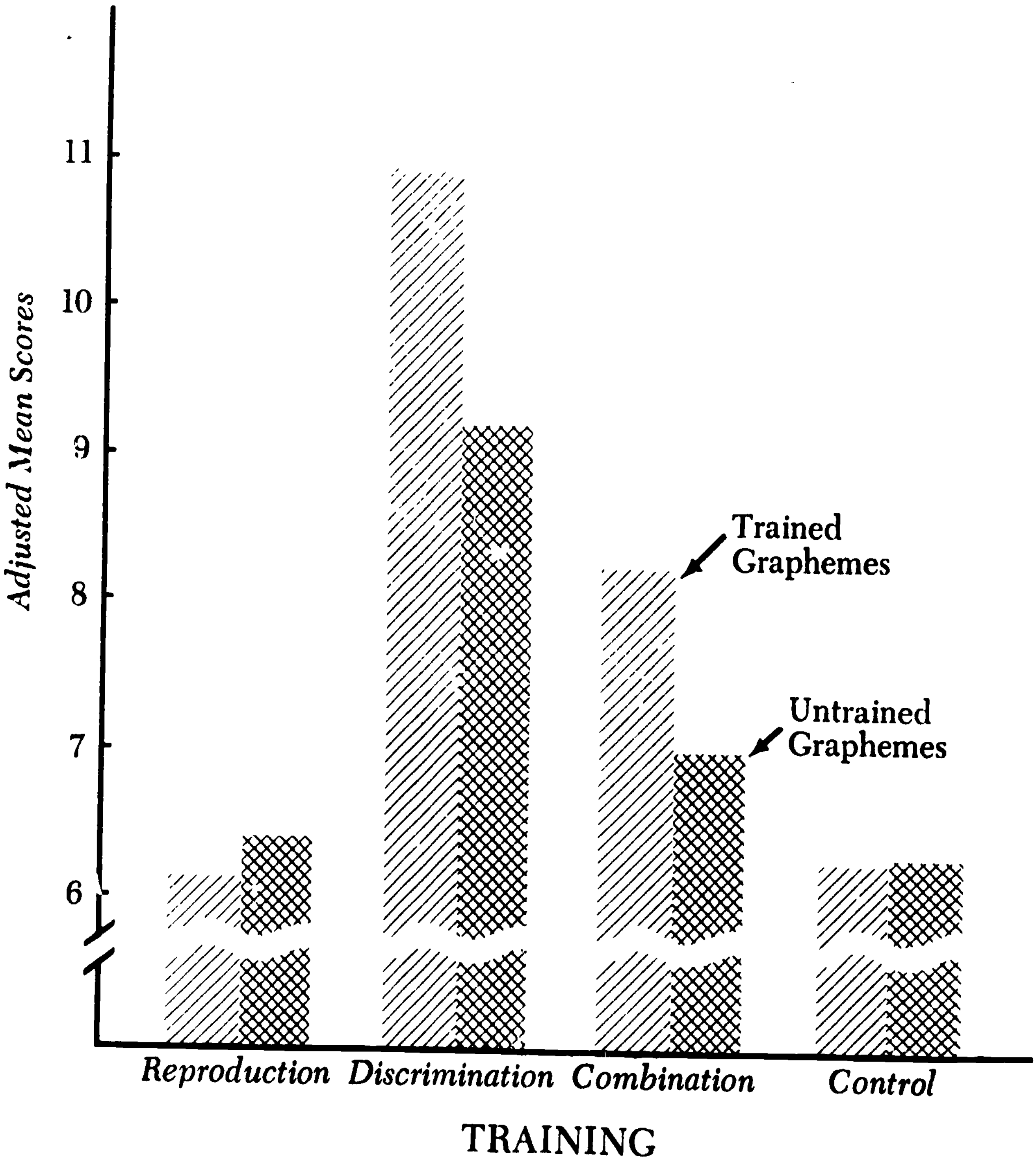
Analysis of Covariance on the Posttest Discrimination Scores

	df	ms	F
Between subjects			
A (Training Method)	3	63.821	3.10*
A_1-A_4	1	.001	<1
$(A_1+A_4)-2A_3$	1	24.778	1.20
$(A_1+A_3+A_4)-3A_2$	1	166.685	8.10**
B (Sex)	1	4.096	<1
AB	3	11.099	<1
Error	31	20.574	
Within subjects			
C (Type of letter-form)	1	8.450	1.98
AC	3	4.817	1.13
BC	1	1.384	<1
ABC	3	1.257	<1
Error	31	4.269	

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

FIGURE 2

Mean Discrimination Scores (Adjusted) as a Function of Training Method


Adjusted Mean Scores
11
10
9
8
7
6
Trained Graphemes
Untrained Graphemes
Reproduction
Discrimination
Combination
Control
TRAINING

Similar analyses were performed on the reproduction data, and the results are presented in Table 15 and Figure 3. Again, the main effect of training method was significant. Sex was not a significant factor, and the interaction between those two variables was not significant. The third factor, type of letter tested, was significant: performance on forms that had been used in training was superior to that on untrained forms. Only one interaction, between training method and type of letter, was significant. Partitioning the interaction sum of squares into orthogonal components revealed that all of the interaction was accounted for in the comparison of the Reproduction and the Combination training groups, on the one hand, with the Discrimination and Control groups on the other, on the two sections of the post-test ($F = 26.38$; $df = 1, 31$; $p < .001$). That is, on the trained forms only, Reproduction and Combination training did not differ from each other, but they were significantly superior to the other two training groups, which did not differ from each other.

DISCUSSION

The results indicated that effects of training were quite specific: that is, discrimination training improved performance on the discrimination test but not on the reproduction test, and reproduction training led to superior performance on the reproduction test and not on the discrimination test. The combination training was as effective as the reproduction training on the reproduction test, however, which suggests that either half as much reproduction training was as effective as the total amount that was given to the reproduction groups, or perhaps that the addition of some discrimination training enhances the effectiveness of reproduction training on a reproduction criterion.

The degree of "specificity" of the two tasks varied in another way as well. While the effects of the discrimination training were seen on both parts of the post-test, i.e., on the forms that had been used in training as well as on those that had not been used in training, the effect of reproduction training was present only on the trained forms; the training conditions did not differ in terms of performance on the untrained forms. Thus the "specificity" of reproduction training is even stronger than that of discrimination training.

Such findings are consonant with those of previous studies. The implications for instruction, especially for reading and writing, seem clear. One cannot rely on transfer from training on one task to another, even though both deal with the same content (alphabet letters). Rather, the perceptual learning involved in the development of the ability to differentiate between letters and the acquisition of the ability to copy letters must be considered in terms of optimal curriculum development as separate tasks.

Presumably, whatever is learned in the training of letter-discrimination--the ability to identify and contrast the distinctive features, according to Gibson (1970)--will transfer when the child is faced with novel letters. But the letter-formation training to be pursued in the development of good handwriting must focus on all the letters; improvement on novel, untrained forms cannot be expected.

TABLE 15

Experiment 4

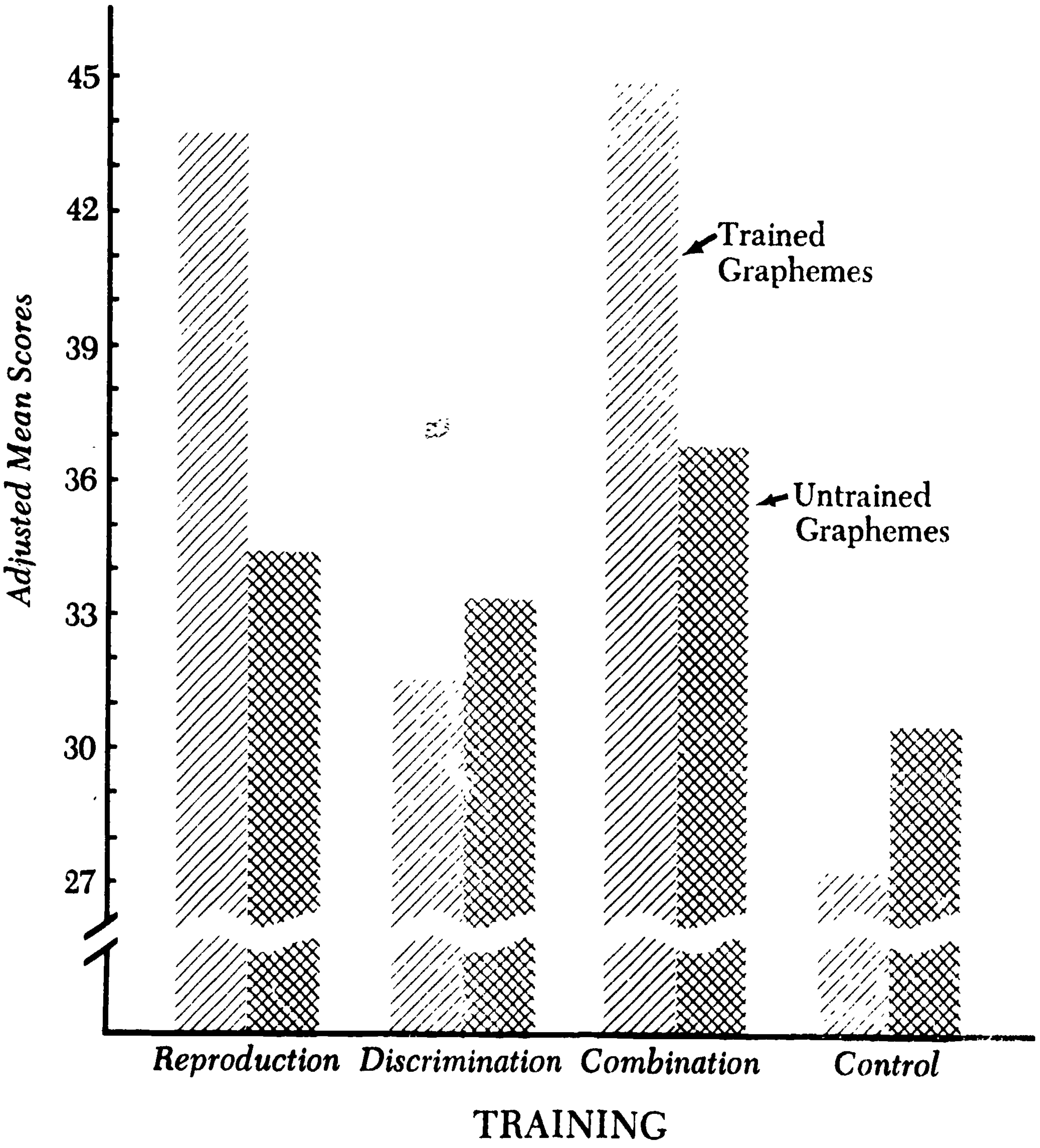
Analysis of Covariance on the Posttest Reproduction Scores

	df	ms	F
Between subjects			
A (Training Method)	3	641.751	7.11*
B (Sex)	1	7.711	<1
AB	3	49.515	<1
Error	31	90.245	
Within subjects			
C (Type of Letter)	1	200.343	7.98**
AC	3	233.603	8.905**
A_1, A_3 vs. C_1, C_2	1	3.451	<1
A_2, A_4 vs. C_1, C_2	1	4.900	<1
$A_1 + A_3$, $A_2 + A_4$ vs. C_1, C_2	1	662.458	26.38**
BC	1	4.012	<1
ABC	3	20.787	<1
Error	31	25.110	

$^*p < .05$; $^{**}p < .01$

FIGURE 3

Mean Reproduction Scores (Adjusted) as a Function of Training Method


Adjusted Mean Scores
45
42
39
36
33
30
27
Trained Graphemes
Untrained Graphemes
Reproduction
Discrimination
Combination
Control
TRAINING

CONCLUSIONS AND RECOMMENDATIONS

1. The system developed for scoring reproduction of alphabet letters proved reliable, valid, and useful in experimental work.

2. The development of basic tactile-kinesthetic skill is similar to the development of tasks involving the visual and aural modalities.

3. Active-kinesthetic training proved significantly inferior to purely visual and to passive-kinesthetic training in a paired-associates paradigm, indicating that the value of the tactile-kinesthetic presentation mode in remedial reading programs does not derive from its enhancement of associative learning.

4. Visual discrimination training led to superior performance on a discrimination test, while reproduction (tactile-kinesthetic) tracing led to superior performance on a reproduction test. Moreover, the effects of discrimination training were seen both on forms that had not been used in training and on forms that had been trained, but reproduction training effects were limited to the forms used in training. These findings suggest that tactile-kinesthetic training (and discrimination training, to some extent) is relatively specific in its effects.

5. The results of these experiments, while not conclusive, do not strongly support the claims that have been made for tactile-kinesthetic training techniques by designers of remedial programs in reading. This statement holds for the associative-learning paradigm, which most of the experiments to date have used, as well as for a perceptual-learning paradigm as used in Experiments 3 and 4. Unless further research leads to different conclusions, expectations for tracing, copying and other such instructional techniques should be tempered.

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APPENDIX

A Scoring System for Alphabet Letters

The system is based on two equally weighted divisions for scoring of letters: method of reproduction and appearance. The method of reproduction is further broken down into three categories--number of lines drawn, order of lines drawn, and direction of lines drawn. Each letter has a total possible raw score of 4.0 (1.0 for each method category and 1.0 for the appearance category) which, after weighting, yields a possible weighted score (referred to as TOTAL SCORE) of 6.0: that is, (1 x Method/Raw Score) + (3 x Appearance/Raw Score).

METHOD OF REPRODUCTION

For each letter there is a constant 1/n (where n is the optimal number of lines for that letter). Every score in the three Method categories should be a multiple of this constant for the specific letter. After category 1 (number of lines) is scored, all irrelevant lines or extra lines should be disregarded. That is, scoring for order and direction of lines should be based only on the lines which best fit the standard.

1. Number of lines: For each extra line drawn and/or each line missing, subtract 1/n from 1.00 to obtain score. Alternatively, each line drawn, from 1 to the optimum number, gives S 1/n credit. If the correct number of lines is drawn, the score will be n (1/n) = 1.0. For more than n lines drawn, give score of (-1/n) for each extra line drawn. Do not give negative scores; for scores below 0.0, give 0.0.

2. Order of lines: This is based only on those lines of best fit. The same lines should be used for this and category 3, direction of lines. If a curve is drawn where two lines are specified, consider it as two lines for these categories.

Credit as follows:

(a) 1/n points for line 1 drawn first (or for the lowest-numbered line of those lines of "best fit" in the event that more lines were drawn than the n of the standard)

(b) 1/n points for line 2 (or next highest) following line 1

(c) 1/n for line 3 (or third highest) following line 2

(d) etc., for all n lines (see examples below).

3. Direction of lines: The number of directions is not always equal to the number of lines in a figure. When, for example, a curve of more than 180 degrees is involved, the number of directions is increased by one, as in the case of the letter O, which has 1 line, 1 order, and two directions,

or in the case of the letter U, which has one line, one order, and three directions (downward vertical, horizontal across the bottom, and upward vertical on the right). Each line drawn in the correct direction receives credit of 1/n. Direction is determined in relation to the letter itself, and not in relation to its orientation on the page.

APPEARANCE

This category has a maximum score of 1.0 for each letter. Criteria are listed separately for each letter (see chart below). Give 1/n credit for each criterion satisfied.

General Criteria:

1. Proper orientation on page, i.e., no rotation in excess of 20 degrees
2. Distinct, continuous, relatively straight lines
3. Distinct, continuous, relatively smooth curves
4. Accurate intersections, no substantial gapping or overhanging
5. Angularity accurate within 10 degrees of specification
6. Accurately proportioned curved segments
7. Accurately proportioned line components
8. Accurate placement of midpoint intersections within 10 percent
9. No lateral reversal
10. No vertical rotation

All specifications are approximate:

(a) Angles may vary 10 degrees from the specification
(b) Midpoints may vary by 10 percent of the total length of a line
(c) Percentages may vary within 10 percent unless limits are otherwise stated.

GENERAL CRITERIA APPLICABLE TO EACH LETTER

	Orientation on page	Distinct Straight Lines	Distinct Smooth Curves	Intersections Accurate	Angulation Accurate	Proportional Curves	Proportional Lines	Midpoint Intersections	Lateral Reversal	Vertical Rotation
A	*	*		*	*		*	*		*
B	*	*	*	*	*	*		*	*	*
C	*		*			*			*	
D	*	*	*	*	*	*			*	
E	*	*		*	*		*	*	*	
F	*	*		*	*		*	*	*	*
G	*	*	*	*		*	*		*	*
H	*	*		*	*		*	*		
I	*	*		*	*		*	*		
J	*	*	*			*			*	*
K	*	*		*	*		*	*	*	
L	*	*		*	*		*		*	*
M	*	*		*	*		*	*		*

GENERAL CRITERIA APPLICABLE TO EACH LETTER

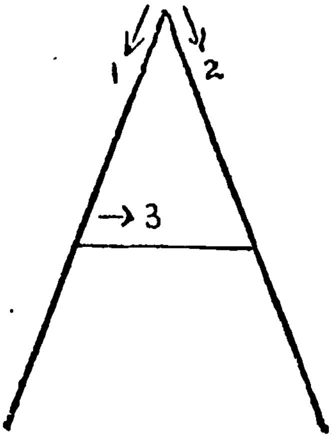
	Orientation on page	Distinct Straight Lines	Distinct Smooth Curves	Intersections Accurate	Angulation Accurate	Proportional Curves	Proportional Lines	Midpoint Intersections	Lateral Reversal	Vertical Rotation
N	*	*		*	*		*			*
O			*			*				
P	*	*	*	*	*	*		*	*	*
C	*	*	*	*		*	*		*	*
R	*	*	*	*	*	*		*	*	*
S	*		*			*			*	
T	*	*		*	*		*	*		*
U	*	*	*			*				*
V	*	*		*	*		*			*
W	*	*		*	*		*	*		*
X	*	*		*	*		*	*		
Y	*	*		*	*		*			*
Z	*	*		*	*		*		*	

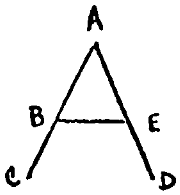
GENERAL CRITERIA APPLICABLE TO EACH LETTER

	Orientation on page	Distinct Straight Lines	Distinct Smooth Curves	Intersections Accurate	Angulation Accurate	Proportional Curves	Proportional Lines	Midpoint Inter-Sections	Lateral Reversal	Vertical Rotation
a	*	*	*	*	*	*	*		*	
b	*	*	*	*	*	*	*		*	*
c	*		*			*			*	
d	*	*	*	*	*	*	*		*	*
e	*	*	*	*		*			*	*
f	*	*	*	*	*	*	*	*	*	*
g	*	*	*	*	*	*	*		*	*
h	*	*	*	*	*	*	*	*	*	*
i	*	*					*		*	*
j	*	*	*			*	*		*	*
k	*	*		*	*		*		*	*
l	*	*								
m	*	*	*	*		*	*		*	*

GENERAL CRITERIA APPLICABLE TO EACH LETTER

	Orientation on page	Distinct Straight Lines	Distinct Smooth Curves	Intersections Accurate	Angulation Accurate	Proportional Curves	Proportional Lines	Midpoint Intersections	Lateral Reversal	Vertical Rotation
n	*	*	*	*		*	*		*	*
o			*			*				
p	*	*	*	*	*	*	*		*	*
q	*	*	*	*	*	*	*		*	*
r	*	*	*	*		*			*	*
s	*		*			*			*	
t	*	*		*	*		*	*		
u	*	*	*	*		*	*		*	*
v	*	*		*	*		*			*
w	*	*		*	*		*			*
x	*	*		*	*		*	*		
y	*	*		*	*		*	*	*	*
z	*	*		*	*		*		*	





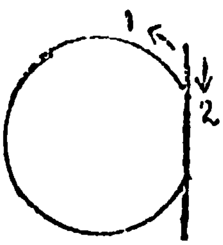
Method:

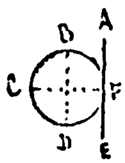
Number of lines: 3

Number of Directions: 3

Appearance:

1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging
4. The diagonals intersect to form an angle of 45 degrees. (Angle A = 45)
5. The diagonals are equal in length. (AC = AD)
6. The horizontal intersects the diagonals at their midpoints. (AB = BC; AE = ED)
7. No vertical rotation.





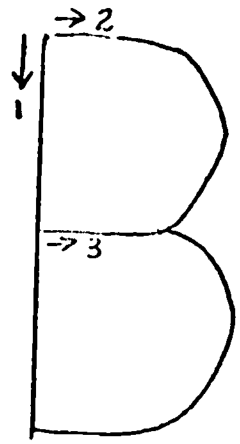
Method:

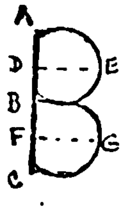
Number of lines: 2

Number of directions: 3

Appearance:

1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersections with no substantial gapping or overhanging.
6. The vertical cuts off no more than 15% of the completed curve.
5. A round or vertical oval shape, i.e., a horizontal diameter is 75%-100% of a vertical diameter. (CF = 75-100% BD)
7. The length of the vertic is equal to the length of a vertical diameter of the curve. (AE = BD)
8. No lateral reversal.

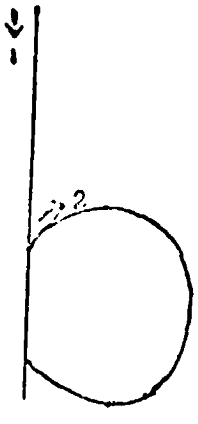


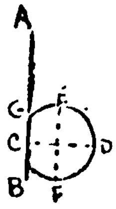


Method:
  Number of lines: 3
  Number of directions: 5

Appearance:

1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curves.
4. Accurate intersections with no substantial gapping or overhanging.
5. The curves are equal in size; the lower curve may be slightly larger. (BGC = AEB)
6. The distance between the vertical and the outermost point on a curve is 25%-75% of the length of the vertical. (DE = FG = 25-75% AC)
7. The curves intersect the vertical at its midpoint. (AB = BC)
8. No lateral reversal.
9. No vertical rotation.

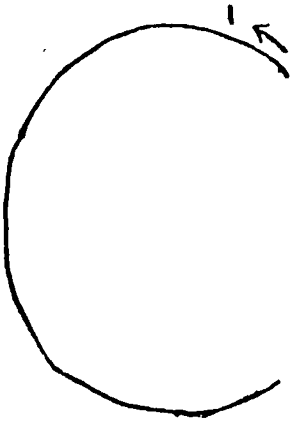


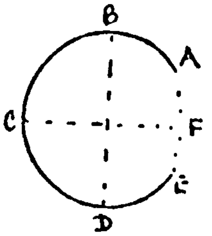


Method:
  Number of lines: 2
  Number of directions: 3

Appearance:

1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersections with no substantial gapping or overhanging.
6. The vertical cuts off no more than 15% of the completed curve.
5. A round or vertical oval shape, i.e., a horizontal diameter is 75%-100% of a vertical diameter. (CD = 75-100% EF)
7. The length of the vertical is twice the length of a vertical diameter of the curve. (AB = 2 EF)
8. No lateral reversal.
9. No vertical rotation.

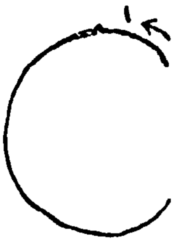


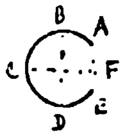


Method:
Number of lines: 1
Number of directions: 2

Appearance:

1. Proper orientation on the page.
2. Distinct, continuous, relatively smooth curve.
3. A round or vertical oval shape, i.e., a horizontal diameter is 75%-100% of a vertical diameter. (CF = 75-100% BD)
4. The open segment is 20%-40% of the total circumference.
5. The open segment (AE) includes equal portions of the upper right and lower right quadrants, i.e., no lateral reversal.

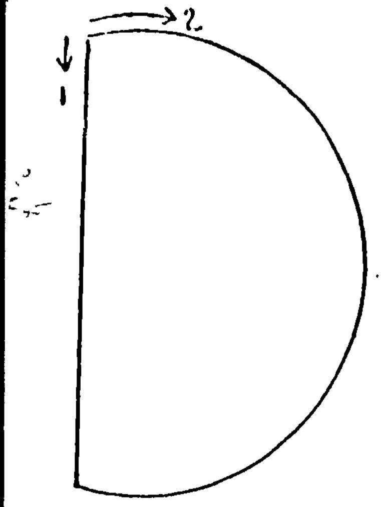


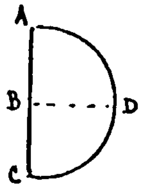


Method:
Number of lines: 1
Number of directions: 2

Appearance:

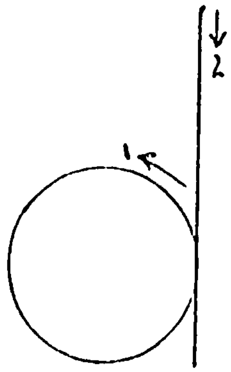
1. Proper orientation on the page.
2. Distinct, continuous, relatively smooth curve.
3. A round or vertical oval shape, i.e., a horizontal diameter is 75%-100% of a vertical diameter. (CF = 75-100% BD)
4. The open segment (AE) is 20%-40% of the total circumference.
5. The open segment (AE) includes equal portions of the upper right and lower right quadrants, i.e., no lateral reversal.

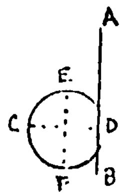




Method:
  Number of lines: 2
  Number of directions: 2

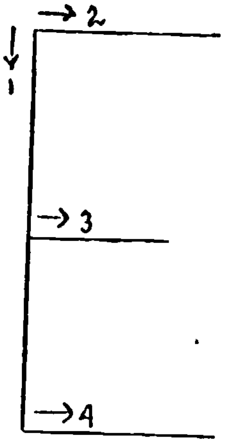
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersections with no substantial gapping or overhanging.
5. The distance between the vertical and the outermost point on the curve is 25%-75% of the length of the vertical. (BD = 25-75% AC)
6. No lateral reversal.

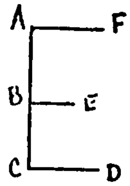




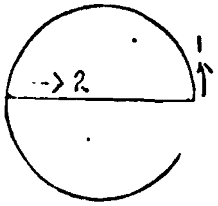
Method:
  Number of lines: 2
  Number of directions: 3

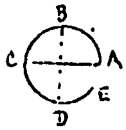
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersections with no substantial gapping or overhanging.
5. The vertical is tangent to the curve and perpendicular to a horizontal baseline.
6. The vertical cuts off no more than 15% of the completed curve.
   vertical diameter. (CD = 75-100% EF)
7. The length of the vertical is twice the length of a vertical diameter of the curve. (AB = 2 EF)
8. No lateral reversal.
9. No vertical rotation.



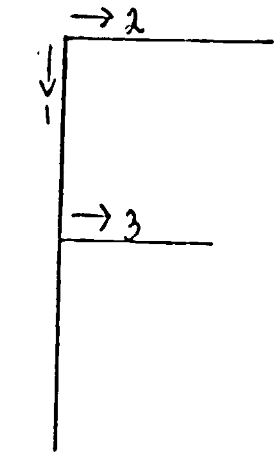


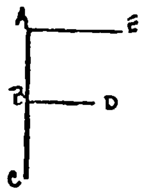
Method:
  Number of lines: 4
  Number of directions: 4
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging.
4. The horizontals are perpendicular to the vertical. (Angle A = Angle C = Angle ABE = 90°)
5. The outermost horizontals are equal in length. (AF = CD)
6. The outermost horizontals are 50% - 100% of the length of the vertical. (AF = CD = 50-100% AC)
7. The center horizontal is 50% - 100% of the length of the outer horizontals. (BE = 50%-100% AF)
8. The center horizontal is located at the midpoint of the vertical. (AB = BC)
9. No lateral reversal.





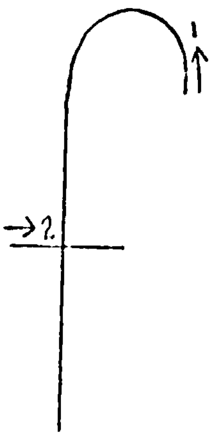
Method:
  Number of lines: 2
  Number of directions: 3
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersections with no substantial gapping or overhanging.
5. A round or vertical oval shape, i.e., a horizontal diameter is 75% - 100% of a vertical diameter. (CA = 75-100% BD)
6. The open segment (EA) is 5% - 10% of the total circumference.
7. The horizontal (CA) is a bisector of the curve.
8. No lateral reversal.
9. No vertical rotation.

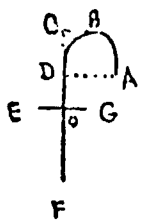




Method:
  Number of lines: 3
  Number of directions: 3

Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging.
4. The horizontals are perpendicular to the vertical. (Angle A = Angle ABD = 90°)
5. The upper horizontal is 50% - 100% of the length of the vertical. (AE = 50-100% AC)
6. The lower horizontal is 50% - 100% of the length of the upper horizontal. (BD = 50%-100% AE)
7. The lower horizontal is located at the midpoint of the vertical. (AB = BC)
8. No lateral reversal.
9. No vertical rotation.





Method:
  Number of lines: 2
  Number of directions: 2

Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersection with no substantial gapping or overhanging.
5. The horizontal is perpendicular to the vertical. (Angle COG = 90)
6. The distance between the vertical and the outermost point on the curve is 25% - 50% of the length of the vertical. (DA = 25% - 50% CF)
7. The curved segment extends through 25% of the length of the vertical. (CD = 25% CDF)
8. The horizontal is 33-50% of the length of the vertical. (EG = 33-50% CF)
9. The horizontal and vertical intersect at their midpoints. (EO = OG; CO = OF)
10. No lateral reversal.
11. No vertical rotation.

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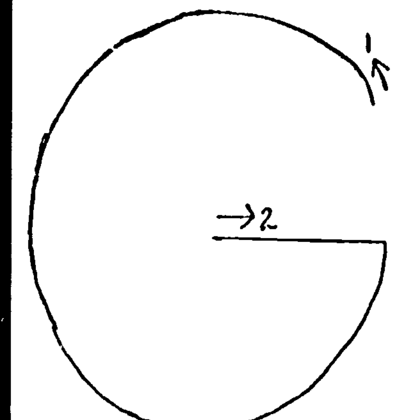
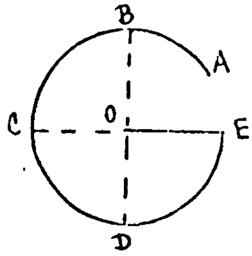
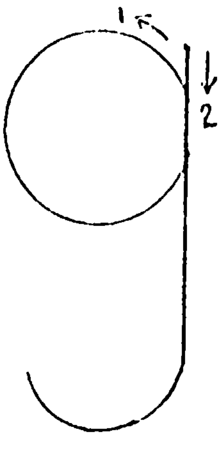


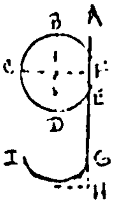


Method:
  Number of lines: 2
  Number of directions: 3

Appearance:

1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersection with no substantial gapping or overhanging.
5. A round or vertical oval shape, i.e., a horizontal diameter is 75% - 100% of a vertical diameter. (CE = 75-100% BD)
6. The open segment (AE) is an arc of 45 degrees.
7. The horizontal is a radian of the curve. (OE = 50% CO.E)
8. The open segment is located in the upper right quadrant, i.e., no lateral reversal.
9. No vertical rotation.



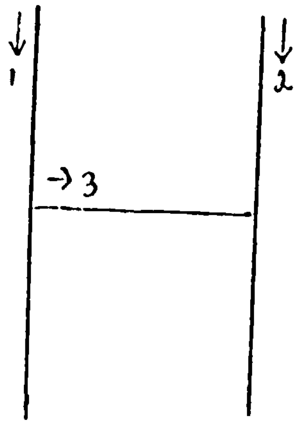


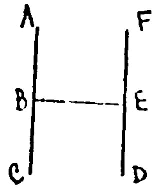
Method:
  Number of lines: 2
  Number of directions: 3

Appearance:

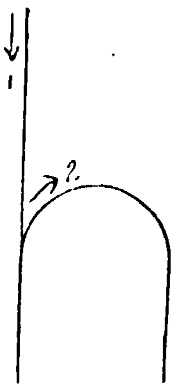
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curves.
4. Accurate intersections with no substantial gapping or overhanging.
6. The vertical cuts off no more than 15% of the completed curve.
5. A round or vertical oval shape, i.e., a horizontal diameter is 75% - 100% of a vertical diameter. (CF = 75-100% BD)
7. The distance between the vertical and the outermost point on its curved segment is 50% of the length of the vertical. (IG = 50% A
8. The curved segment of the vertical extends through 25% of the length of the vertical. (GH = 25% AH)
9. The length of the vertical is twice the length of a vertical diameter of the curve. (AH = 2.
10. No lateral reversal.
11. No vertical rotation.

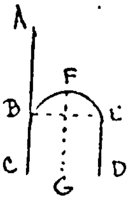
Method:
Number of lines: 3
Number of directions: 3
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging.
4. The horizontal is perpendicular to the verticals. (Angle ABE = Angle FEB = 90)
5. The horizontal is 50% - 100% of the length of the verticals. (BE = 50% AC)
6. The verticals are equal in length. (AC = FD)
7. The horizontal intersects the verticals at their midpoints. (AB = BC = FE = ED)

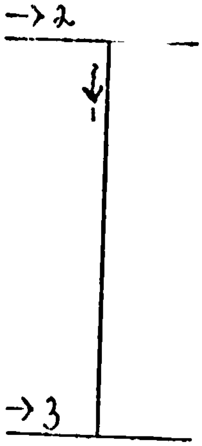




Method:
Number of lines: 2
Number of directions: 3
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersection with no substantial gapping or overhanging.
5. The distance between the vertical and the outermost point on the curved segment is 50% of the length of the left vertical. (FG = 50% ABC)
6. The curved segment extends through 50% of the length of the left vertical. (FG = 50% AC
7. The right vertical segment is parallel to the left vertical. (ED ABC)
8. No lateral reversal.
9. No vertical rotation.

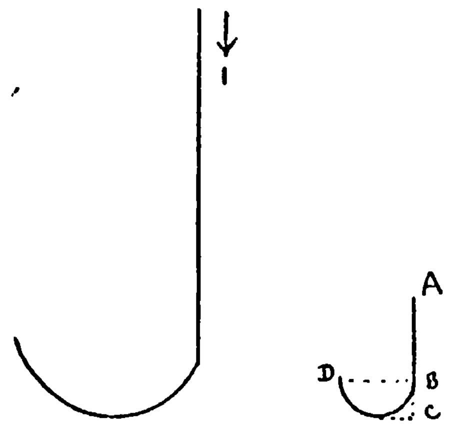




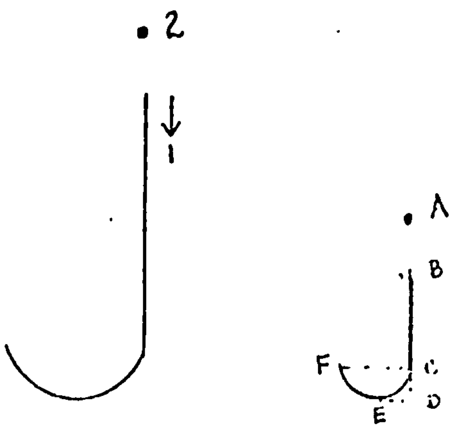


Method:
  Number of lines: 3
  Number of directions: 3
Appearance:
  1. Proper orientation on the page.
  2. Distinct, continuous, relatively straight lines.
  3. Accurate intersections with no substantial gapping or overhanging.
  4. The horizontals are perpendicular to the vertical. (Angle ABE = Angle DEB = 90)
  5. The horizontals are 50% of the length of the vertical. (AC = 50% BE; DF = 50% BE)
  6. The horizontals intersect the vertical at their midpoints.(AB = BC; DE = EF)

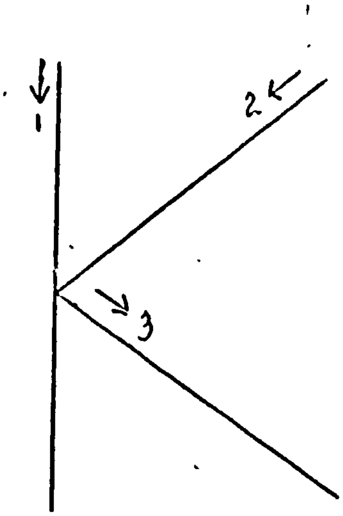
Method:
  Number of lines: 2
  Number of directions: 1
Appearance:
  1. Proper orientation on the page.
  2. Distinct, continuous, relatively straight line.
  3. Distinct placement of dot.
  4. The dot is placed directly above the vertical at a distance of 25% - 50% of the length of the vertical. (AB = 25-50% BC)
  5. No vertical rotation.

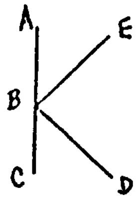


Method:
  Number of lines: 1
  Number of directions: 1
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curve.
4. The curved segment extends through 25% of the length of the vertical. (BC = 25% ABC)
5. The distance between the vertical and the outermost point on the curve is 50% of the length of the vertical. (DB = 50% ABC)
6. No lateral reversal.
7. No vertical rotation.

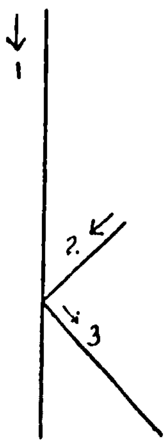


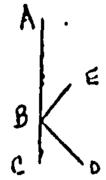
Method:
  Number of lines: 2
  Number of directions: 1
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curve.
4. Distinct placement of dot.
5. The curved segment extends through 25% of the length of the vertical. (CD = 25% BCD)
6. The distance between the vertical and the outermost point on the curved segment is 25% - 50% of the length of the vertical. (FC = 25-50% BCD)
7. The dot is placed directly above the vertical at a distance of 25% - 50% of the length of the vertical. (AB = 25-50% BCD)
8. No lateral reversal.
9. No vertical rotation.



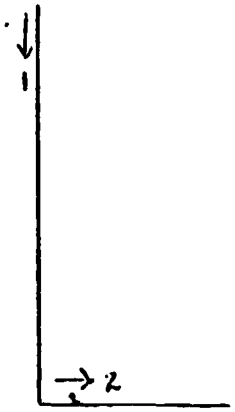


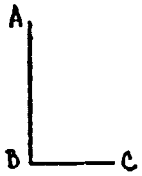
Method:
  Number of lines: 3
  Number of directions: 3
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging.
4. The diagonals form an angle of 75 degrees. (Angle EBD = 75)
5. The angles formed by the vertical and adjacent diagonal are equal. (Angle ABE = Angle CBD)
6. The diagonals are equal in length.
7. The diagonals are 50% - 100% of the length of the vertical. (EB = 50-100% ABC = BD)
8. The diagonals intersect the vertical at its midpoint. (AB = BC)
9. No lateral reversal.





Method:
  Number of lines: 3
  Number of directions: 3
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging.
4. The diagonals intersect to form an angle of 90 degrees. (Angle EBD = 90)
5. The angles formed by the vertical and adjacent diagonal are equal. (Angle ABE = Angle CBD)
6. The diagonals are 25% - 33% of the length of the vertical. (EB = BD = 25-33% ABC)
7. The diagonals intersect the vertical at a point 25% from the base of the vertical. (BC = 25% ABC)
8. No lateral reversal.
9. No vertical rotation.



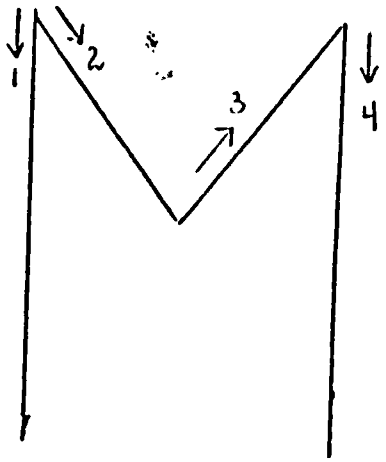


Method:
Number of lines: 2
Number of directions: 2

Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersection with no substantial gapping or overhanging.
4. The horizontal is perpendicular to the vertical. (Angle B = 90)
5. The horizontal is 50% - 100% of the length of the vertical. (BC = 50-100% AB)
6. No lateral reversal.
7. No vertical rotation.

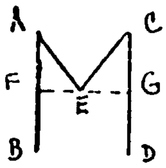
Method:
Number of lines: 1
Number of directions: 1

Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.

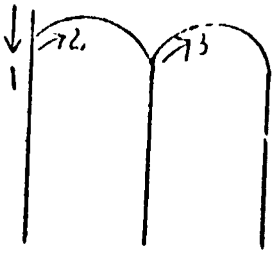


Method:
  Number of lines: 4
  Number of directions: 4

Appearance:

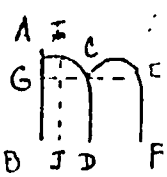


1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging.
4. The diagonals form angles of 40 degrees with their adjacent verticals. (Angle A = Angle C = 40)
5. The verticals are equal in length. (AB = CD)
6. The diagonals are equal in length. (AE = CE)
7. The diagonals intersect at a point midway between the verticals at the height of their midpoints. (FE = EG; AF = FB; CG = GD)
8. No vertical rotation.

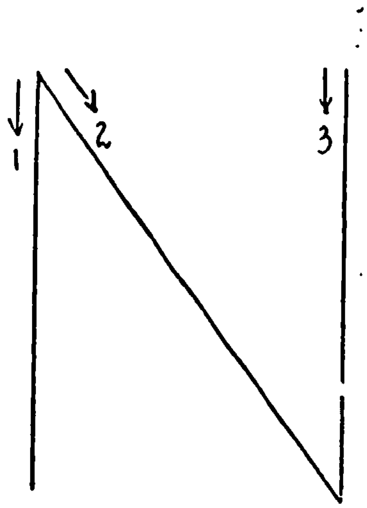


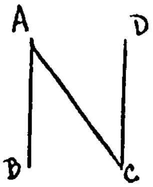
Method:
  Number of lines: 3
  Number of directions: 5

Appearance:



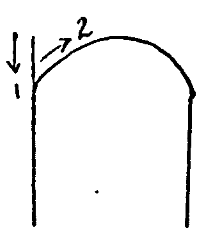
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Distinct, continuous, relatively smooth curves.
4. Accurate intersections with no substantial gapping or overhanging.
5. The curved segments are equal in size.
6. The curved segments extend through 100% of the length of the left vertical. (IJ = AB)
7. The distance between the left vertical and the outermost point on the right vertical segment is 150% of the length of the left vertical. (GH = 150% AB)
8. The vertical segments of the curves are parallel to the left vertical.
9. No lateral reversal.
10. No vertical rotation.

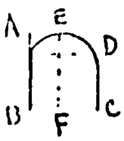




Method:
  Number of lines: 3
  Number of directions: 3

Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging.
4. The diagonal forms an angle of 40 degrees with each adjacent vertical. (Angle A = Angle C = 40)
5. The verticals are equal in length. (AB = DC)
6. No lateral reversal.





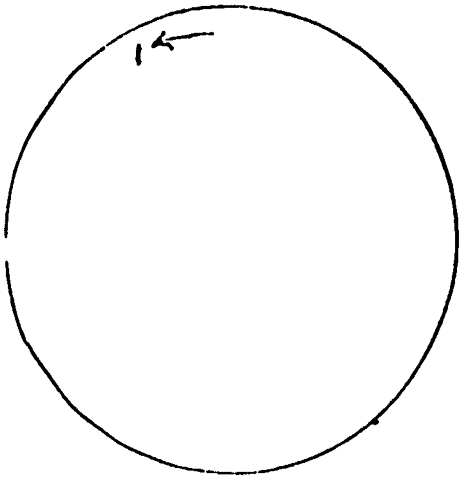
Method:
  Number of lines: 2
  Number of directions: 3

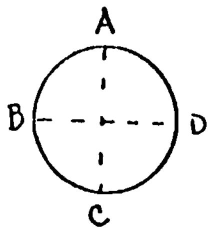
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersection with no substantial gapping or overhanging.
5. The curved segment extends through 100% of the length of the vertical. (EF = AB)
6. The distance between the vertical and the outermost point of the right vertical segment is 100% of the length of the vertical. (AD = AB)
7. The right vertical segment is parallel to the left vertical. (AB DC)
8. No lateral reversal.
9. No vertical rotation.

Method:
Number of lines: 1
Number of directions: 2

Appearance:

1. Distinct, continuous, relatively smooth curve.
2. A round or vertical oval shape, i.e., a horizontal diameter is 75% - 100% of a vertical diameter. (BD = 75-100% AC)

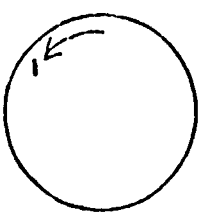


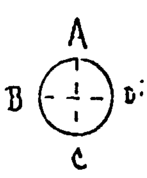


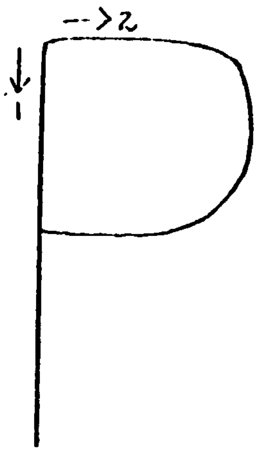
Method:
Number of lines: 1
Number of directions: 2

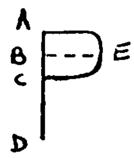
Appearance:

1. Distinct, continuous, relatively smooth curve.
2. A round or vertical oval shape, i.e., a horizontal diameter is 75% - 100% of a vertical diameter. (BD = 75-100% AC)

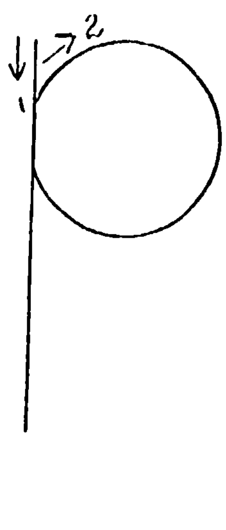


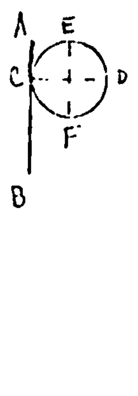




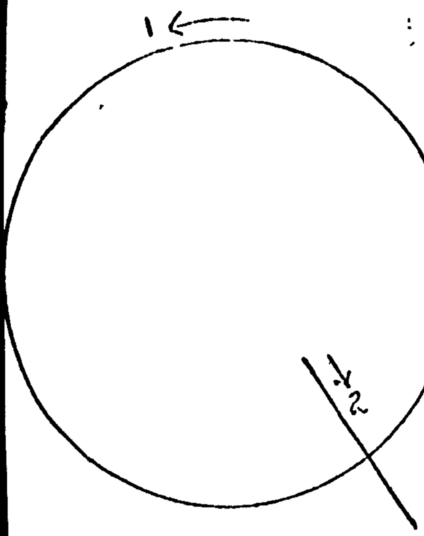


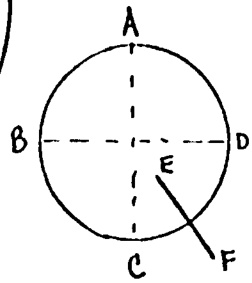
Method:
  Number of lines: 2
  Number of directions: 3
Appearance:
  1. Proper orientation on the page.
  2. Distinct, continuous, relatively straight line.
  3. Distinct, continuous, relatively smooth curve.
  4. Accurate intersections with no substantial gapping or overhanging.
  5. The distance between the vertical and the outermost point on the curve is 25% - 75% of the length of the vertical. (BE = 25-75% AD)
  6. The lower segment of the curve intersects the vertical at its midpoint. (AC = CD)
  7. No lateral reversal.
  8. No vertical rotation.





Method:
  Number of lines: 2
  Number of directions: 3
Appearance:
  1. Proper orientation on the page.
  2.. Distinct, continuous, relatively straight line.
  3. Distinct, continuous, relatively smooth curve.
  4. Accurate intersections with no substantial gapping or overhanging.
  6. The vertical cuts off no more than 15% of the completed curve.
  5. A round or vertical oval shape, i.e., a horizontal diameter is 75% - 100% of a vertical diameter. (CD = 75-100% EF)
  7. The length of the vertical is twice the length of a vertical diameter of the curve. (AB = 2 EF)
  8. No lateral reversal.
  9, No vertical rotation.

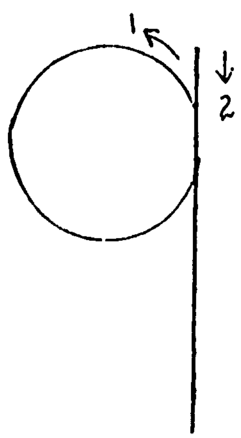


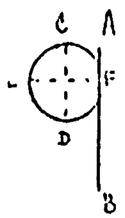


Method:
  Number of lines: 2
  Number of directions: 3

Appearance:

1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curve.
4. A round or vertical oval shape, i.e., a horizontal diameter is 75% - 100% of a vertical diameter. (BD = 75-100% AC)
5. The diagonal is 25% - 50 % of the length of a vertical diameter. (EF = 25-50% AC)
6. The diagonal is located in the lower right quadrant, i.e., no lateral reversal or vertical rotation.

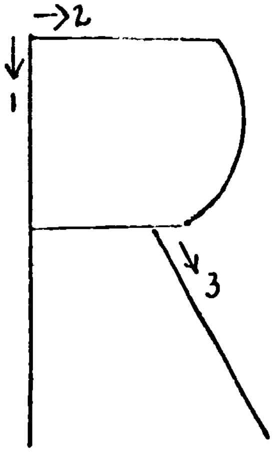




Method:
  Number of lines: 2
  Number of directions: 3

Appearance:

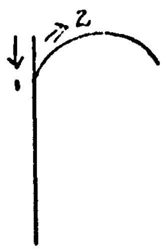
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersections with no substantial gapping or overhanging.
6. The vertical cuts off no more than 15% of the completed curve.
5. A round or vertical oval shape, i.e., a horizontal diameter is 75% - 100% of a vertical diameter. (EF = 75-100% CD)
7. The length of the vertical is twice the length of a vertical diameter of the curve. (AB = 2CD)
8. No lateral reversal.
9. No vertical rotation.

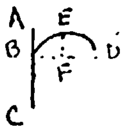


Method:
  Number of lines: 3
  Number of directions: 4

Appearance:

1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersections with no substantial gapping or overhanging.
5. The interior angle formed by the diagonal and the lower segment of the curve is 120 degrees. (Angle BDE = 120)
6. The distance between the vertical and the outermost point on the curve is 25% - 75% of the length of the vertical. (FG = 25-75% ABC)
7. The diagonal and the vertical are extended downward to the same horizontal plane.
8. The lower segment of the curve intersects the vertical at its midpoint. (AB = BC)
9. No lateral reversal.
10. No vertical rotation.

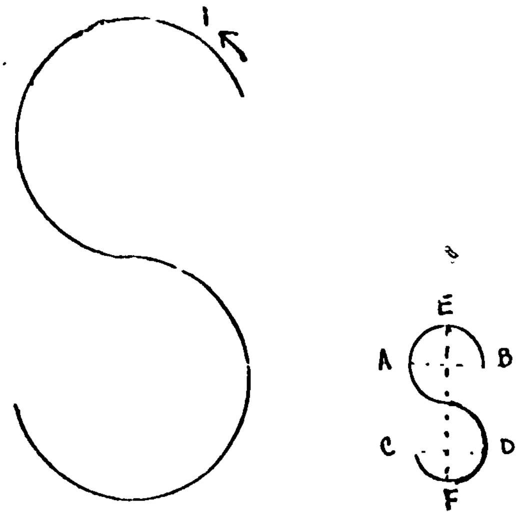




Method:
  Number of lines: 2
  Number of directions: 2

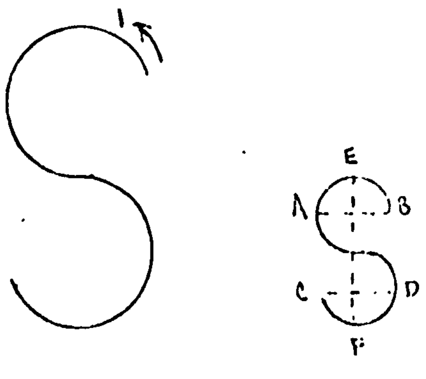
Appearance:

1. Proper orientation on the page.
2. Distinct, continuous, relatively straight line.
3. Distinct, contiguous, relatively smooth curve.
4. Accurate intersection with no substantial gapping or overhanging.
5. The curved segment extends through 25% of the length of the vertical. (EF = 25% AC)
6. The distance from the vertical to the outermost point on the curve is 75% of the length of the vertical. (ED = 75% AC)
7. The point of intersection is 20% from the top of the vertical. (AB = 20% ABC)
8. No lateral reversal.
9. No vertical rotation.



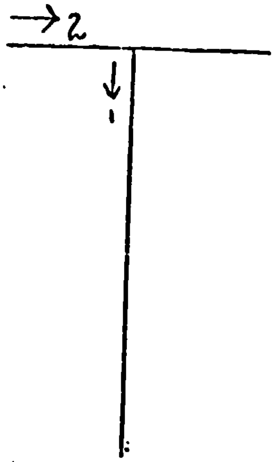
Method:
Number of lines: 1
Number of directions: 3

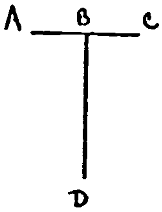
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively smooth curve.
3. The upper and lower segments of the curve are equal in size. (AB = CD; EF = FG)
4. The letter width is 50% of the vertical height. (AB = 50% EFG)
5. No lateral reversal.



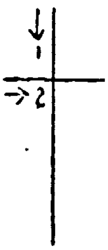
Method:
Number of lines: 1
Number of directions: 3

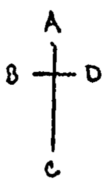
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively smooth curve.
3. The upper and lower segments of the curve are equal in size. (AB = CD; EF = FG)
4. The letter width is 50% of the vertical height. (AB = 50% EFG)
5. No lateral reversal.



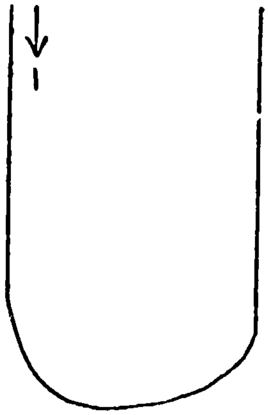


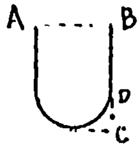
Method:
  Number of lines: 2
  Number of directions: 2
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersection with no substantial gapping or overhanging.
4. The horizontal is perpendicular to the vertical. (Angle ABD = 90)
5. The horizontal is 50% - 100% of the length of the vertical. (AC = 50-100% BD)
6. The intersection of the horizontal and the vertical is located at the midpoint of the horizontal. (AB = BC)
7. No vertical rotation.





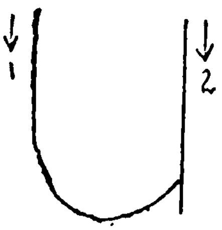
Method:
  Number of lines: 2
  Number of directions: 2
Appearance:
1. Proper orientation on the page.
2. Dis tinct, continuous, relatively straight lines.
3. The horizontal is perpendicular to the vertical. (Angle AEB = Angle DEC = 90)
4. The horizontal is 50% of thelength of the vertical. (BED = 50% AEC)
5. The horizontal intersects the vertical at a point 33% from the top of the vertical. (AE = 33% AEC)
6. The horizontal is intersected at its midpoint. (BE = ED)
7. No vertical rotation.

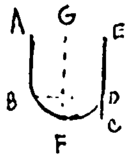




Method:
  Number of lines: 1
  Number of directions: 3

Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Distinct, continuous, relatively smooth curve.
4. The curve extends through 25% of the total vertical length. (DC = 25% BDC)
5. The vertical segments are equal in length.
6. The horizontal distance between the vertical segments is 50% - 100% of the length of the verticals. (AB = 50-100% BC)
7. No vertical rotation.

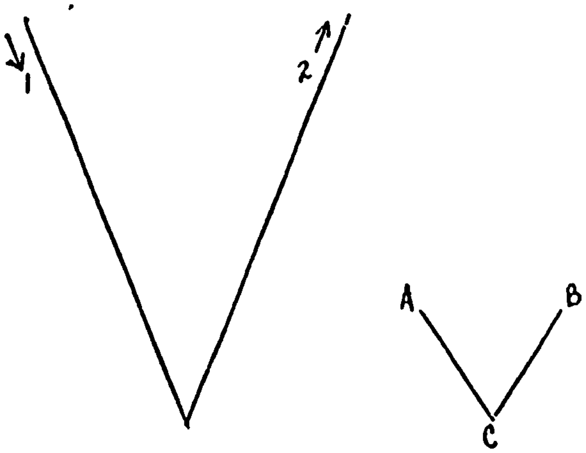




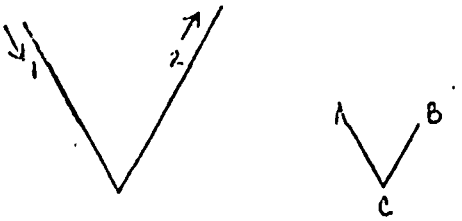
Method:
  Number of lines: 2
  Number of directions: 3

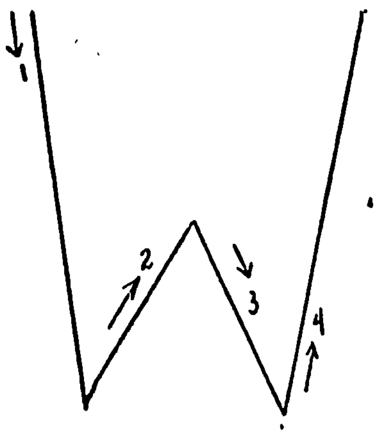
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Distinct, continuous, relatively smooth curve.
4. Accurate intersection with no substantial gapping or overhanging.
5. The curved segment extends through 100% of the length of the right vertical. (FG = EC)
6. The distance between the vertical and the outermost point on the left vertical segment is 100% of the length of the vertical. (ED = EC)
7. The left vertical segment is parallel to the right vertical. (AB EC)
8. No lateral reversal.
9. No vertical rotation.

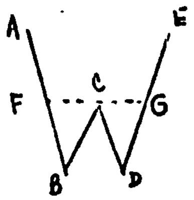
Method:
  Number of lines: 2
  Number of directions: 2
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersection with no substantial gapping or overhanging.
4. The diagonals intersect to form an angle of 45 degrees. (Angle C = 45)
5. The diagonals are equal in length. (AC = BC)
6. No vertical rotation.



Method:
  Number of lines: 2
  Number of directions: 2
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersection with no substantial gapping or overhanging.
4. The diagonals intersect to form an angle of 45 degrees. (Angle C = 45)
5. The diagonals are equal in length. (AC = BC)
6. No vertical rotation.

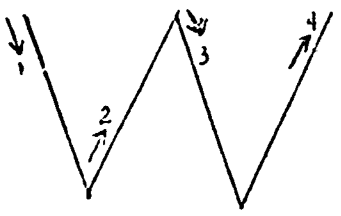






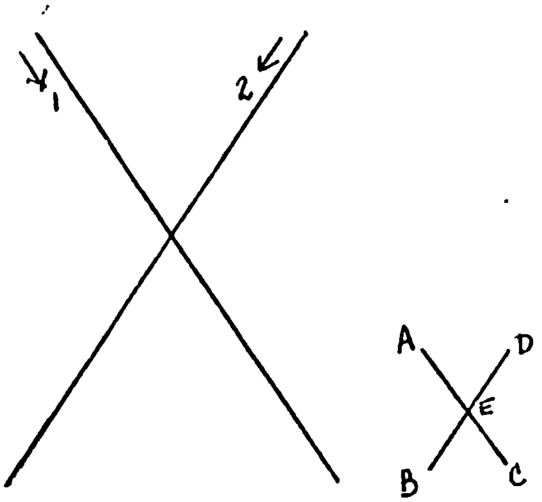
Method:
Number of lines: 4
Number of directions: 4

Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging.
4. The outer diagonals form angles of 40 degrees with adjacent inner diagonals. (Angle B = Angle D = 40)
5. The inner diagonals intersect to form an angle of 50 degrees. (Angle C = 50)
6. The outer diagonals are equal in length. (AB = ED)
7. The inner diagonals are equal in length. (BC = DC)
8. The inner diagonals intersect at a point midway between the outer diagonals at the height of their midpoints. (AF = FB; EG = DG)
9. No vertical rotation.



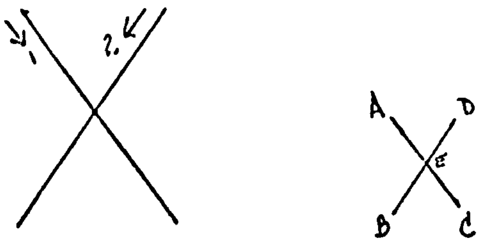
Method:
Number of lines: 4
Number of directions: 4

Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging.
4. The outer diagonals form angle of 40 degrees with adjacent inner diagonals. (Angle B = Angle D = 40)
5. The inner diagonals intersect to form an angle of 50 degrees. (Angle C = 50)
6. All diagonals are equal in length. (AB = BC = CD = DE)
7. No vertical rotation.



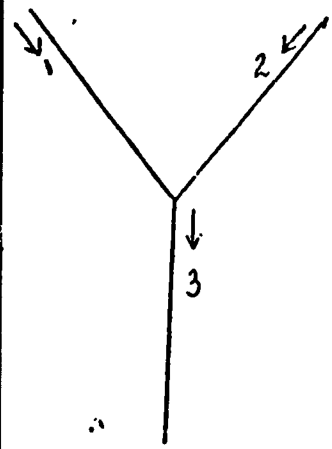
Method:
Number of lines: 2
Number of directions: 2

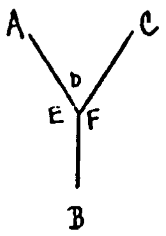
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. The diagonals intersect to form vertical angles of 70 degrees. (Angle AED = Angle BEC = 70)
4. The diagonals are equal in length. (AC = BD)
5. The diagonals intersect at their midpoints. (AE = EC; BE = ED)



Method:
Number of lines: 2
Number of directions: 2

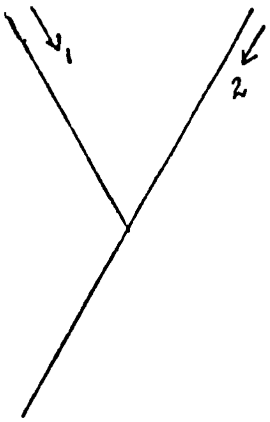
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. The diagonals intersect to form vertical angles of 70 degrees. (Angle AED = Angle BEC = 70)
4. The diagonals are equal in length. (AC = BD)
5. The diagonals intersect at their midpoints. (AE = EC; BE = ED)

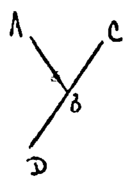




Method:
  Number of lines: 3
  Number of directions: 3

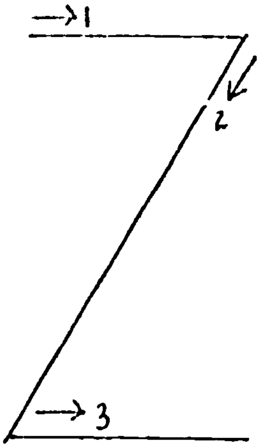
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersection with no substantial gapping or overhanging.
4. The diagonals intersect to form an angle of 80 degrees. (Angle D = 80)
5. The vertical forms an angle of 140 degrees with each adjacent diagonal. (Angle E = Angle F = 140)
6. The vertical and the diagonals are equal in length.
7. No vertical rotation.

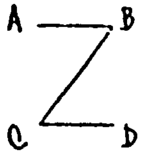




Method:
  Number of lines: 2
  Number of directions: 2

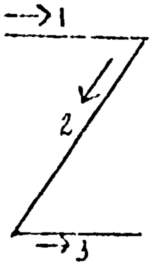
Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersection with no substantial gapping or overhanging.
4. The diagonals intersect to form an angle of 65 degrees. (Angle ABC = 65)
5. The left diagonal is 50% of the length of the right diagonal. (AB = 50% CBD)
6. The left diagonal intersects the right diagonal at its midpoint. (CB = DB)
7. No lateral reversal.
8. No vertical rotation.

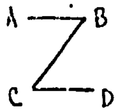




Method:
  Number of lines: 3
  Number of directions: 3

Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging.
4. The diagonal forms an angle of 60 degrees with each adjacent horizontal. (Angle B = Angle C = 60)
5. The horizontals are 50% of the length of the diagonal. (AB = CD = 50% BC)
6. No lateral reversal.





Method:
  Number of lines: 3
  Number of directions: 3

Appearance:
1. Proper orientation on the page.
2. Distinct, continuous, relatively straight lines.
3. Accurate intersections with no substantial gapping or overhanging.
4. The diagonal forms an angle of 60 degrees with each adjacent horizontal. (Angle B = Angle C = 60)
5. The horizontals are 66% of the length of the diagonal. (AB = CD = 66% BC)
6. No lateral reversal.