THE ROLE OF INTRINSIC FEATURES IN THE JUDGMENT OF "UPRIGHT" ORIENTATION OF TWO-DIMENSIONAL FORMS: A DEVELOPMENTAL ANALYSIS

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Lauren Harris
Major professor

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ABSTRACT

THE ROLE OF INTRINSIC FEATURES IN THE JUDGMENT OF 'UPRIGHT' ORIENTATION OF TWO-DIMENSIONAL FORMS: A DEVELOPMENTAL ANALYSIS

By

M. Joseph Schaller

Considerable evidence shows that children and young adults can identify an 'upright' orientation of various two-dimensional non-representational forms (Ghent, 1961; Antonovsky & Ghent, 1964; Harris & Schaller, 1969; Harris & Schaller, 1970a; Harris & Schaller 1970b). The current study attempted to systematically investigate the role that intrinsic features of the forms might play in this judgment. In addition, the age range was extended through college age in order to investigate the apparent decline in strength of agreement among subjects in the older grades in previous studies. Eighty students counterbalanced for grade and sex (kdg., 2nd, 4th, 6th, college) were asked to orient each of 51 forms the way they judged it to be upright when projected by a slide apparatus which allowed each child to rotate the forms through the 360 deg. range.

In the past there has been some concern to identify the bases for such judgments. Braine (Ghent, 1961), in the original demonstration of the phenomenon, suggested that when the "focal point" of the form was at the bottom, the form was called up-side down. In another approach, Harris and Schaller (1970b) found, with kindergartners, that judgments of esthetic preference for an orientation produced much more variance between subjects

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than did instructions to put the forms in the upright orientation and they concluded that preference, while it might play a role in the judgment of the more ambiguous forms, could not account for the uniformity of judgment found previously on most forms.

Striking age changes were found for the upright judgments of several of the forms. However, these changes were not in the expected direction of a decline in agreement with age, but rather a switch in the orientation chosen as upright. The college students' choices agreed most strongly (followed by the kindergartners'). The apparent leveling off of agreement in the middle grades found previously probably represents a change from the 'child's' judgment in the kindergartners to the 'adult' judgment of the college students, with mixed judgments in the interim grades.

In addition to indicating the orientation most frequently chosen as upright for the forms, the study gives evidence that several of the selected features of the forms may be important in determining which way is 'up' for the forms. Most important was vertical symmetry. Stability, taper, light-dark gradient, main lines, polar axes, texture lines, texture gradient, weight, and "focal point" are also discussed. Some evidence is presented against the "focal point" hypothesis. Forms resembling Braine's, with "more focal" modifications, elicit orientations contrary to those of the original forms. Again there is evidence that letter-resemblance affects these judgments in a non-linear manner.

Implications for further research are discussed.

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By

M. Joseph Schaller

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Merrill Mitler, Terry Allen, and David Gilbert put me through a very rigorous example of what an oral defense is supposed to be.

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INTRODUCTION

There are a number of ways in which visual patterns can vary. Two variations of particular interest are variations of shape and orientation. "Shape" is used here to refer to the relations between the elements of a pattern which remain constant despite the orientation of the pattern. Some writers (viz., Howard & Templeton, 1966) have distinguished "shape" from "form" where "form," like retinal image, changes as the orientation changes, so that in their terminology ∧ and ∨ are the same "shape" but different "forms." The two terms will be used interchangeably in the present study in the sense of Howard and Templeton's "shape" (i.e., shape is not changed by changing orientation).[1]

It is well known that shape and orientation interact so that one affects the perception of the other. For example, one of the earliest studies, by Mach (1886), noted that a square looks like a diamond (i.e., longer vertically) when it is tilted to stand on a corner. (A number of such studies are reviewed by Howard and Templeton, 1966, especially Chapters 12 and 13.) Howard and Templeton (p. 294) distinguish two questions we may ask about these variations in the visual pattern: how do variations in orientation affect the perceived shape (in both their and our sense) of an object and how do variations in shape affect the perceived orientation?

The distinction is not, however, so clear as Howard and Templeton imply. One can describe (correctly) the shape of an object only when he has available and uses analytical instruments which can give an objective description of the shape. Otherwise, one describes the "percieved" shape.

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The subject in a perceptual experiment, however well-equipped the experimenter may be, lacks the benefit of these instruments, so that to him it is a variation in perceived shape which affects the perceived orientation. This perceived orientation immediately affects the perceived shape, which affects the perceived orientation, and so on. The two considerations--the effects of shape and orientation--therefore are inextricably linked. In actual practice, one consequently can study neither the effect of shape on orientation nor the effect of orientation on shape; one can study only the interaction of perceived shape and perceived orientation. And researchers can---to sharpen Howard and Templeton's distinction---choose to approach this intertwined problem from one side or the other: by varying actual shape or actual orientation.

Most investigators, however, have treated these problems as separate and independent, and have given the question of their inter-relation limited attention and only haphazard experimental investigation (Howard & Templeton, 1966).

History

Interest in the relation between shape perception and the perception of orientation goes back many years. As early as 1899, Dearborn studied adults' ability to recognize previously seen inkblots whose orientations were changed in the recognition task. In general, recognition was more difficult when the forms were turned 90° right or left or were reversed right-left than when they were turned 180° or inverted upside-down.

Of greater influence and much greater developmental interest was the comment by Stern (1924), in his Psychology of Early Childhood, that young children were relatively less affected by the orientation of pictures than were adults. He wrote, "...there is one remarkable capability which the little chi

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little child possesses in far higher degree than do older children and adults, viz., independence of the position of the picture. It has often been observed that it seems to make little difference to small children whether a picture is put before them the right way or upside down. If a mother shows a book to several brothers and sisters at once, it frequently happens that the children crowd around the table, so that some see the picture either sideways or wrong way up, but that seems scarcely to interfere either with their understanding or enjoyment of it" (pp. 197-8, 1930). Stern summarized by saying that with the exception of individual differences, "The older the child, the less of this indifference to the position of the picture" (p. 198).

In 1925, Koffka, in his Growth of the Mind,paraphrased Stern's observation as follows: "...to a child a form is much more independent of its absolute spatial position [orientation] than it is to us adults.... Teachers who, at my request, have made observations upon this subject, have reported that certain children can read mirror-writing at first just as well as they can read ordinary writing; which shows the difference between children and adults, for an adult finds it no easy task to read mirror writing. Originally, then, a figure is in a high degree independent of its position, whereas for adults the absolute orientation of the figure is a very powerful factor" (1925, p. 293). Koffka later refers to this phenomenon in children as "the independence of figure and spatial position" (p. 293).

Stern's evidence appeared to come mainly from his observations of his own children. Despite the lack of other concrete evidence,his suggestion seems to have been taken very seriously, and the assumed independence of the form and its orientation in the young child, as contrasted with the strong dependence in the adult, has taken on the dimensions of

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a general belief. The difference between children and adults has been explained in traditional empiricist terms, that is, in terms of the vast differences between them in experience with objects. The adults have learned that objects commonly appear in one orientation and have probably developed habits (laid down neural pathways?) of perception which are disrupted when an object is presented in an abnormal orientation. The children, on the other hand, not yet having had this amount of experience, are no more likely to recognize a form in one orientation than in another because they are equally inexperienced with all orientations and because there were presumed to be no built-in bases for judging one orientation upright as opposed to another. (This latter assumption is now being seriously challenged; cf. Hubel & Wiesel, 1959, **and following.**)

Braine (Ghent, 1960) comments that, "Perhaps the idea that forms are equally identifiable in different orientations by young children has been accepted because it is commonly observed that children look at books, make drawings, or write letters in unconventional orientations. Such observations have been interpreted in the context of the Gestalt assumption that perception of form is unitary and primary; from this point of view, one would anticipate that the young child, who presumably has not developed strong visual habits, would recognize a form equally well in any position" (p. 249). Braine also suggests that on the basis of Hebbian theory one might predict a greater dependence on the orientation of a form in young children under some circumstances. (She has also supported this assertion; cf. Ghent & Bernstein, 1960).

Another explanation of young children's apparent indifference to orientation would be that the children are indeed sensitive to the orientation, in that they can detect it, but that they choose to ignore it because it is an irrelevant dimension. Adults, more aware of the importance of orientation and having had a great amount of experience with familiar forms in one orientation, are more affected by disorientation. The former, in fact, was an interpretation made by Davidson in her studies (1934, 1935) of errors in the matching of letters and words by five- and six-year-old children. Davidson found more right-left reversal errors than up-down inversions or 180^{o} rotations. (Re-examination of her results shows more than twice as many right-left errors as up-down or 180^{o} errors.) When Davidson asked her subjects whether they were sure the reversals were the same as the original, they said they were sure, except for one or two children who said the two figures were the same but faced in opposite directions. To Davidson such comments indicated "that the child noted the difference in orientation of the letters but did not consider that this fact made them different" (1935, p. 464). Her data also indicated, though she did not make the explicit connection, that children indeed were 'sensitive' to orientation in that they had differing rates of error depending on the relative orientation of the letters with respect to one another.

Other evidence, often of a contradictory nature, was slowly gathered. Rice (1930) showed young children drawings of vertically-oriented diamond shapes, in one test, and spoons in another. She then tested their ability to pick out these shapes in various orientations from among others in an array. Below the age of five the children more often chose the shapes irrespective of their orientation. Rice concluded that she had found a turning point in the importance of orientation at five to six years of age, about the time, she noted, when children begin school. The study has been criticized on methodological grounds, however (Wohlwill, 1960; Howard & Templeton, 1966), and may show only differences in spontaneous verbalization or interpretation of the instructions.

A study by Newhall (1937) purported to show that recognition of realistic figures (chair, horse, boat, rabbit, child) was not affected by orientation for 3- to 5-year-old children. The children were able to pick the correct forms from a tray irrespective of their orientation. However, because Newhall did not include adults in his sample, we do not know whether adults might not have performed equally well with these simple forms.

Hunton (1955) showed that two- to seven-year-old children's responses to depictions of various scenes depended on the orientation of the scene, with fewer descriptions of action when the scenes were inverted. She also concluded, on the basis of her subjects' spontaneous remarks, that children as young as two years and ten months were able to recognize that the pictures were inverted.

Howard and Templeton (1966) have reviewed much of the early (and later) research in this area, but little of the early literature bears directly on the developmental aspects of the problem. Moreover,much of what research has been done (e.g., Gellerman, 1933; Ling, 1941; Tanaka, 1960) is difficult to interpret because of methodological criticisms similar to those made for Rice's (1930) study.

More recent evidence has begun to differentiate better some of the components of the interaction of shape and orientation which may have contributed to the conflicting results in early studies. For instance, a series of experiments by Goldstein and his colleagues (Brooks & Goldstein, 1963; Goldstein & Chance, 1964; Goldstein, 1965; Goldstein & Chance, 1965) have demonstrated that with pictures of faces, young children show much less disruption of recognition by up-side-down inversion than do adults. Presumably,the adults' greater exposure to faces has caused them to "overlearn" these visual patterns in their normal orientation

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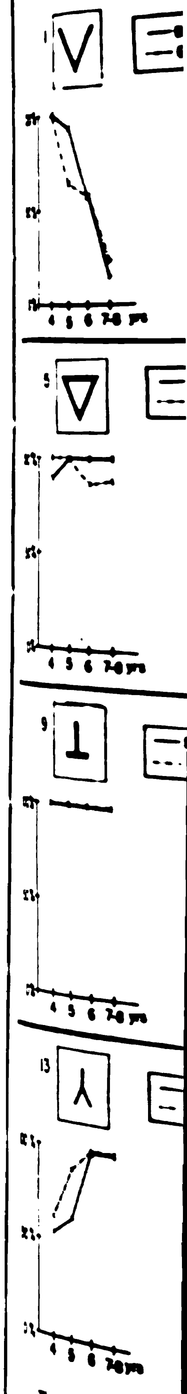
Another source of evidence comes from a series of studies by Lila Ghent Braine and her colleagues which has demonstrated consistent judgment of the up-side-down orientation of certain forms by preschoolers, with much less agreement among older children. It is this latter group of studies which provided the original impetus to the present research.

The Braine Studies

Braine (Ghent, 1960) reported presenting cartoon drawings of familiar objects to children, using a tachistoscope, in upright, 90^{o} tilted, or up-side-down orientations. Children from five to seven years old recognized as many forms in the disoriented positions as in the upright, but her three- to four-year-olds recognized more of the forms presented right-side-up.

The next paper in the series, entitled "Form and its orientation: a child's-eye view" (Ghent, 1961), described two studies of children's judgments of the orientations of certain geometric forms (which Braine called "nonrealistic" forms). The forms employed in her first study are reproduced in Figure 1. This figure depicts the percentage of boys and girls in age groups ranging from four to eight years (N = 78) who judged the form as up-side-down in the orientation shown. Contrary to the notion that young children are insensitive to orientation, Braine found striking agreement among subjects: for the four-year-olds, frequency of judgment of the form as up-side-down in the orientation depicted (in Figure 1) was greater than chance for 11 of the 16 forms. Indeed, for six of these forms the percent agreement was 95%. The older children's judgment agreed strongly for fewer forms and reversed in judgment for two--the  (#1) and the nearly closed  (#8). Thus it appeared that, at least insofar as sensitivity to orientation could be assumed to be reflected in



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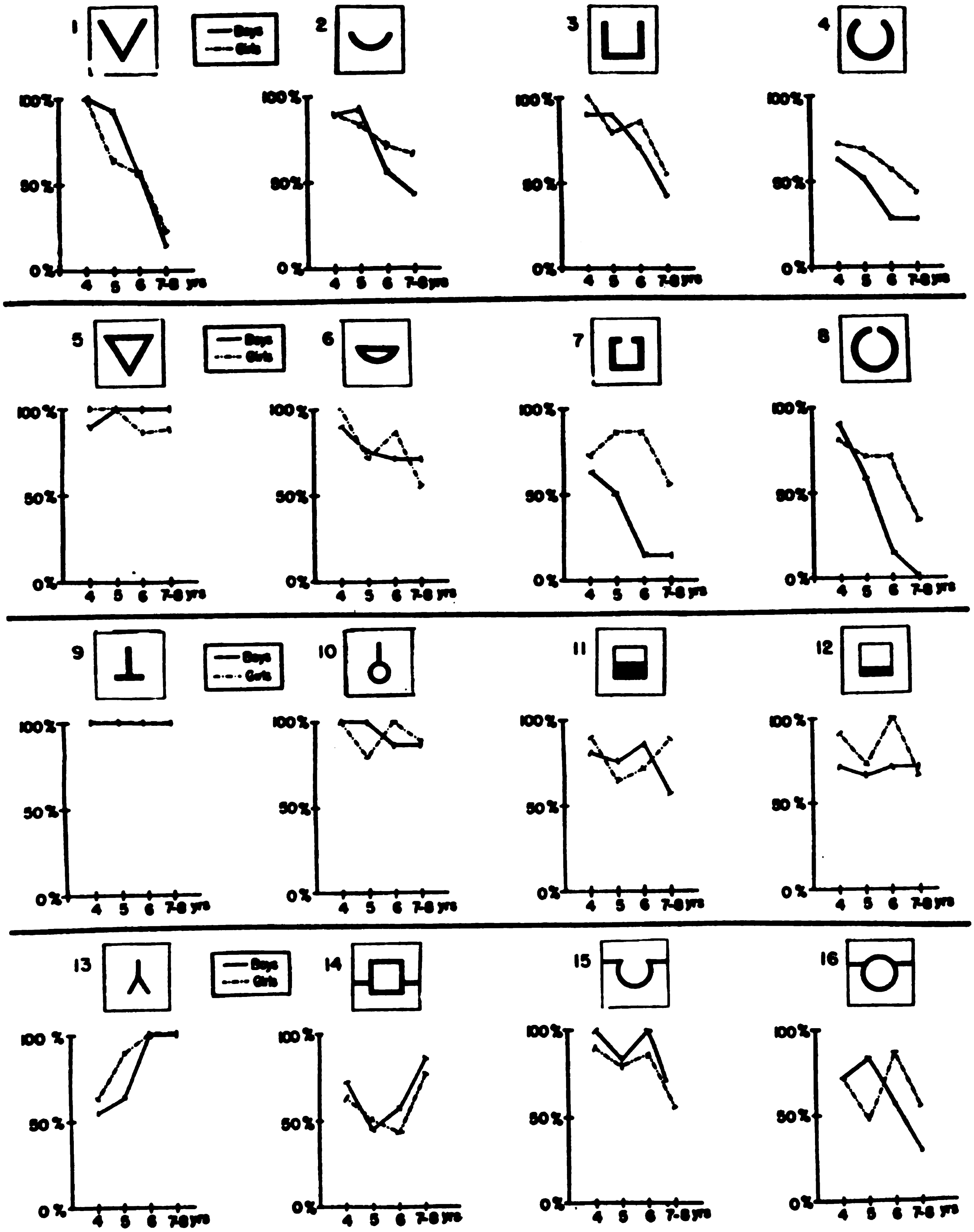

Fig. 1. Percentage of Boys and Girls in Each Age-Group Choosing Card as Upside Down in the Orientation Shown.

Each card was 4 in. on a side and did not have the black border shown here.

Ghent (Braine) L., Form and its orientation: a child's-eye view. American Journal of Psychology, June, 1961, 74(2), 177-190.

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agreement of judgments of the up-side-down orientation of these figures, younger children were more "sensitive" than older children to orientation and that possibly this sensitivity was moderated, rather than strengthened, by experience.

Braine saw the most important problem raised by these findings to be that of "defining the characteristics of the cards selected as up-side-down" (Ghent, 1961, p. 181). She used a Hebbian "scanning mechanism" hypothesis as a possible explanation of the judgments. Using responses of her younger subjects as the basis for her analysis, she suggested that a form was judged up-side-down when the "focal portion was in the lower half of the card" (p. 181). Braine tentatively assumed that figures eliciting significant concordance of judgment had one portion that "caught the 'attention', or drew the eye,more readily than did other portions. The angle of the V, the point of intersection of the T, the rounded portion of the crescent, and so on, might be considered the focal portion of the particular form. When these portions of the figures were at the bottom, the cards were called up-side-down by the children" (p. 181).

Recognizing that her designation of "focal point" had been *post hoc*, Braine tested different four- and five-year-olds with new forms (Figures 2 & 3) for which she designated the focal points beforehand. These subjects' judgments supported her focal point hypothesis.

Braine and her associates then reported the same agreement with six preschool subjects for whom the figures were presented tachistoscopically at 1/25 sec. (Ghent, Bernstein, & Goldweber, 1960). It thus appeared that if a scanning mechanism was involved at all, it must be an internal type, which might have evolved from overt eye movments at an earlier age.

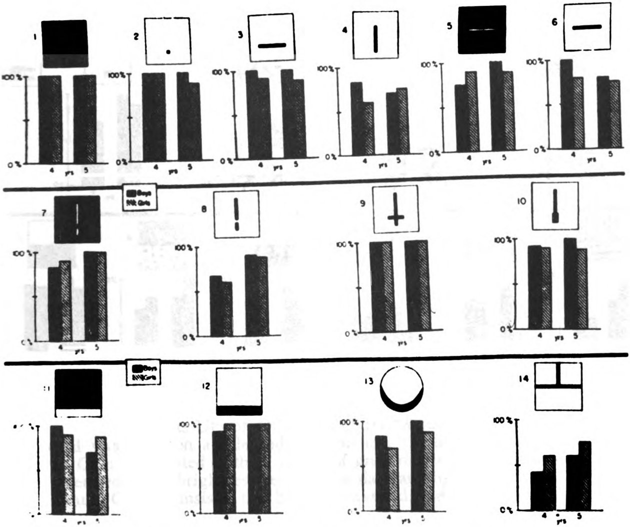

FIG. 2. PERCENTAGE OF BOYS AND GIRLS IN EACH AGE-GROUP CHOOSING CARD AS UPSIDE DOWN IN THE ORIENTATION SHOWN.
With the exception of Card 13, each card was 4 in. on a side and did not have the black border shown here.

Ghent (Braine) L., Form and its orientation: A child's-eye view. American Journal of Psychology, June, 1961, 74(2), 177-190.

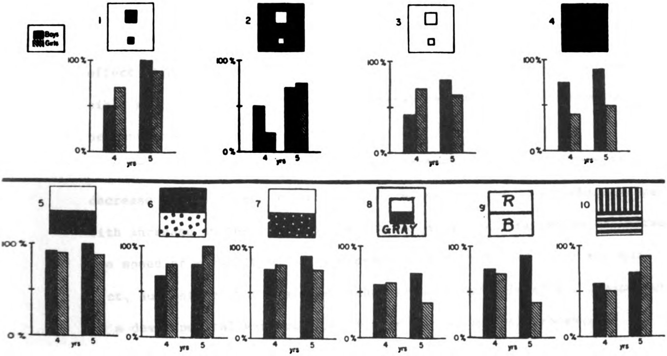

FIG. 3. PERCENTAGE OF BOYS AND GIRLS IN EACH AGE-GROUP CHOOSING CARD AS UPSIDE DOWN IN ORIENTATION SHOWN

Each card was 4 in. on a side and did not have the black border shown here. Card 8 consisted of three shades of gray, the background being intermediate in brightness between the dark and light portions of the figure. Card 9 consisted of a bright orange-red, and a dark royal blue.

Ghent (Braine) L., Form and its orientation: A child's-eye view. American Journal of Psychology, June, 1961, 74(2), 177-190.

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Ghent and Bernstein (1961) tested preschoolers with the figures presented tachistoscopically in both the right-side-up and up-side-down orientations. They found better recognition of the figures in the right-side-up orientation than in the up-side-down orientation.

Further support for the idea that the consistency of judgments represented the effect of some basic perceptual mechanism came from a study by Antonovsky and Ghent (1964). The study confirmed the results of Braine's (Ghent, 1961) earlier study, with Iranian four- and five-year-olds rather than American children. This finding suggested that the effect might be independent of cultural training and might very possibly give important clues to the general course of the development of perception.

Turning to a different approach, Braine (Ghent, 1964) then found a decrease in the effect of orientation on recognition in a tachistoscope with increase in the speed with which subjects could recognize the forms. The speed of recognition was independent of both MA and CA of the subject, suggesting that whatever mechanism underlay this effect again might be a developmental variable specific to the perceptual process.

In still another study (Braine, 1965) again with tachistoscopic presentation, Braine found evidence for a change at about four to four-and-a-half years in the direction of the "internal scanning mechanism." Figures with distinguishing features in one end were presented in two orientations. Older children discriminated the figures better with the distinguishing feature at the top and the designated "focal point" at the bottom. Younger children performed better in the reverse situation, with the focal point at the top.

As a result of these studies, it was difficult to accept the early view that children are "insensitive" to the orientation of forms; in fact, the r

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fact, the recent studies suggested that young children in some ways were more responsive to certain aspects of the orientation of forms than adults were. To summarize and define more precisely the differing "sensitivities" of adults and children, we note that: 1. children are able, as are adults, to detect differences in orientation of the same form (Wohlwill & Weiner, 1964), though their performance may be poorer than that of adults (no one seems to have made the direct comparison); 2. children, however, seem on occasion to ignore or to disregard or to not comment on differences in orientation of the same form; adults more often attend to, regard as important, and comment on these differences; 3. recognition appears to be less affected for faces in young children than in adults, but more affected for familiar forms in young children than in older children; it is difficult to see how one could use experience as the basis of explanation of both findings despite Goldstein's (1965) and Braine's (Ghent, 1960) separate attempts; 4. young children (pre-schoolers and kindergartners) show greater agreement of choice of the upright orientation of some forms than older children (up to eight years); these judgments appear to be based on factors intrinsic to the form and may reflect build-in bases of perception.

It is clear that there are several different factors operating in the perception of form and orientation (e.g., ability, attention, interpretation, experience, and possibly esthetic preference or innate predispositions) and it is possible that much of the apparent inconsistency noted in previous years has been the result of looking at different aspects of the perceptual process.

The main concern in the current investigation is with the basis of perceptual process and its development. The paper which speaks most closely to this interest is Braine's 1961 "Form and its orientation..."

study, to which we return now in more detail.

Pilot Studies

As we have pointed out before (Harris & Schaller, 1970a), two features of Braine's method caused concern. First, Braine used what shall be called a "binary-vertical forced-choice procedure" to obtain her judgments of orientation. Her subjects saw two cards at a time, depicting the same form, one rotated 180° with respect to the other. An example is shown in Figure 4. In both orientations, moreover, the form was fixed vertically, meaning that it was symmetrical along its vertical axis but not along its horizontal axis. The subjects therefore were not shown the forms oriented either "horizontally" (i.e., symmetrical along their horizontal axes but not along their vertical axes) or "obliquely" (oriented so that the axis of symmetry lay neither vertically nor horizontally). Consequently the subjects had no chance to judge any of these orientations as the up-side-down orientation. Even if subjects were allowed to choose from additional orientations, the placement of the forms on square cards (though the block border shown in Figure 1 was absent in Braine's procedure) might have produced a "frame" effect, thereby influencing orientation judgments.[2] In other words, there are at least two kinds of cues which potentially can affect the perceived orientation or identification of a figure: (1) cues within the figure itself (what Howard & Templeton, 1966, have called "intrinsic factors") such as axes of symmetry, taper, texture, and light gradients, and Braine's "focal point" and (2) cues from without the figure (i.e., "frame" cues). Braine's procedures might have confounded these two factors. In addition, it is possible that the particular responses made by her subjects also were affected to some degree by frame cues.

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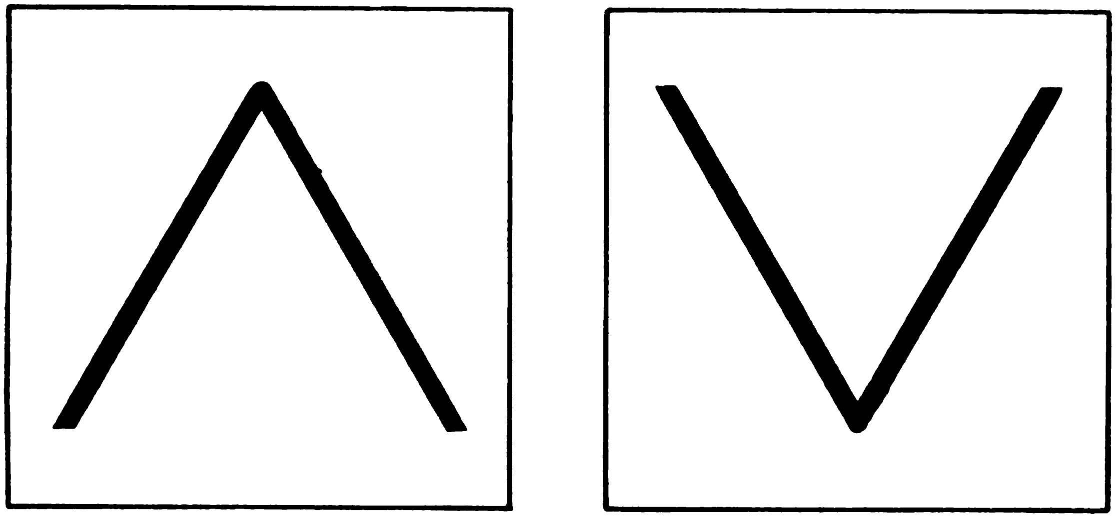

Figure 4. Example of a form in the two 'vertical' orientations (as used in the binary forced-choice procedure of Ghent, 1961). The axis of symmetry is vertically aligned (that is, in each orientation the left and right sides are mirror-images). The form is approximately actual size, both for the Ghent study and the Harris and Schaller (1970a) study. The forms in the current study were slightly larger when projected.

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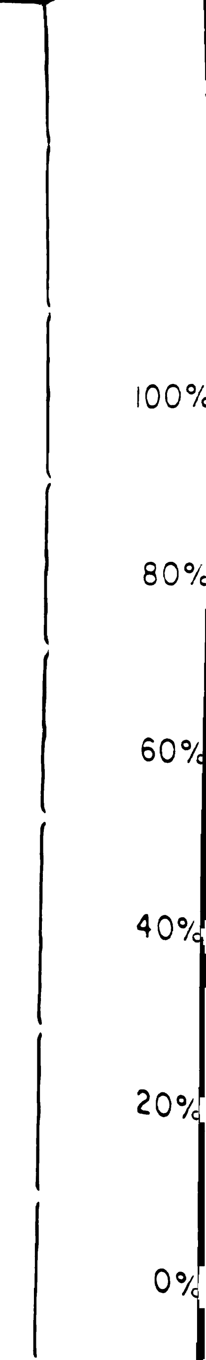
therefore were presented in a specially designed apparatus. This apparatus consisted of a 60 cm X 79 cm Masonite board covered with coats of white paint sufficient to eliminate all perceivable grain. In the center of this board a 9 cm diameter circle was cut, through which the forms could be viewed. The forms were inserted into a plexiglass holder mounted on a turntable which was attached to the board behind the window. The effect therefore was to eliminate or at least substantially reduce any frame-of-reference cues which otherwise could affect the subject's judgment of a form's upright orientation. The subject rotated the form directly by moving any part of the plexiglass container that showed through the circular window (roughly as one might rotate a phonograph record with one's fingers, except that the turntable was presented in nearly vertical orientation). The turntable was so adjusted as to permit easy rotation. The apparatus thus eliminated all constraints on the subject's range of judgments.

Our second concern was with Braine's instructions. Her subjects did not make direct choices of the upright forms: they were asked to pick that form in each set which was "up-side-down or wrong" rather than that form which was upright. Then, from their choice of the "up-side-down, wrong" form, Braine inferred that they would judge the other form (the 180^{o} rotation) to be right-side-up. But are "up-side-down" instructions in fact the empirical converse of "right-side-up" instructions? To answer this question, we compared the two kinds of instructions directly.

Results indicated that the use of the binary-forced-choice procedure would indeed significantly constrain subjects' choices for the figures considered as a group. Figure 5 shows the distributions of judgments for all figures and grade groups (Kdg., 2nd, and 4th grades) taken together, with Categories 3, 4, and 5 representing non-vertical orientations.



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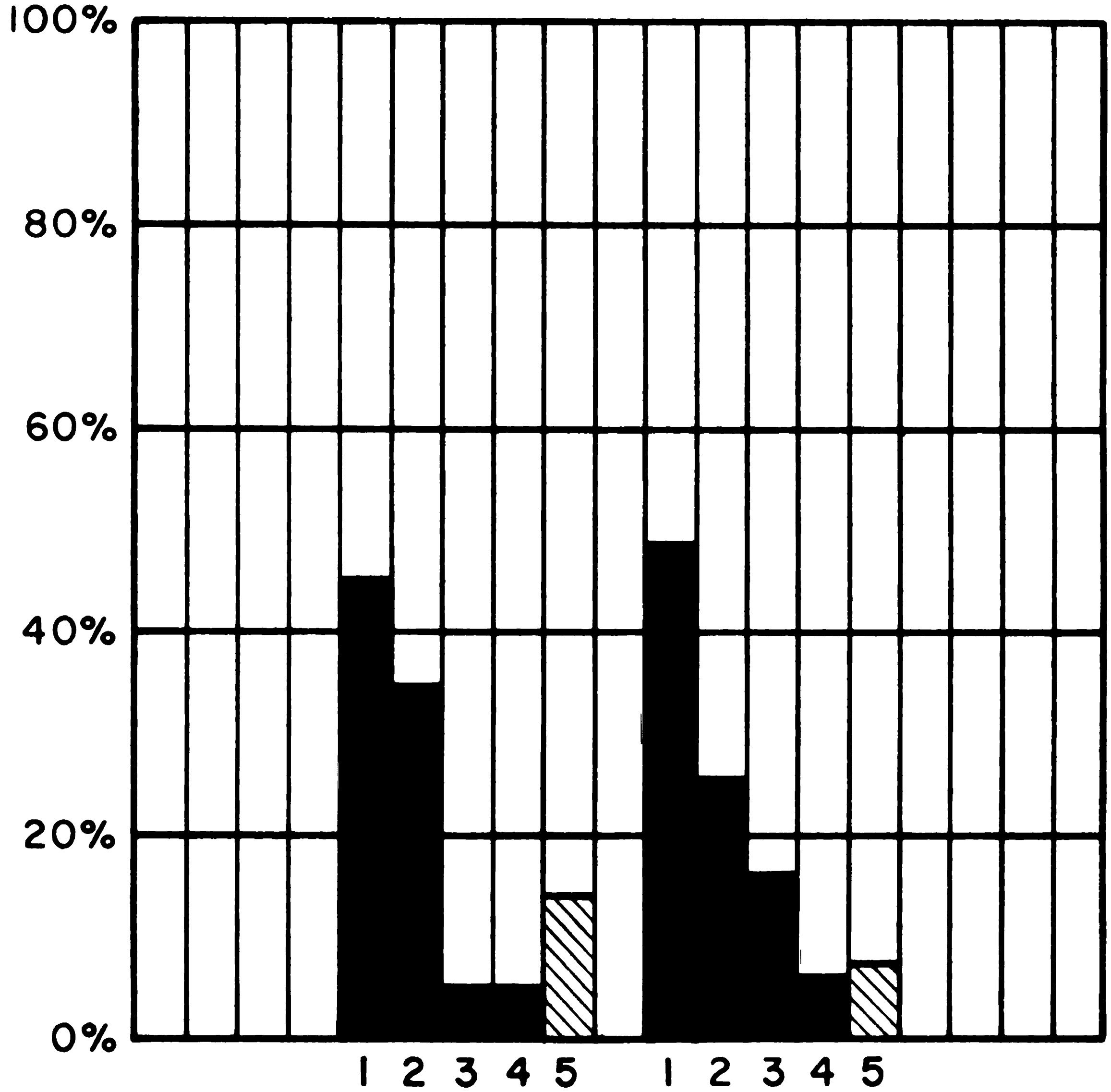

Figure 5. Distributions of judgments for all forms for all grades (kdg., 2nd, 4th) in the Harris and Schaller (1970a) study. Sixty subjects made 15 judgments each in both the up-side-down and the upright conditions. Judgments represented by Categories 1 through 5 are equivalent for the up-side-down and the upright conditions, with Categories 1 and 2 representing equivalent vertical judgments, 3 and 4, horizontal judgments, and 5, oblique judgments. These two distributions therefore resemble each other to the extent that the two sets of instructions (upright and up-side-down) produce empirically converse results. (From Harris & Schaller, 1970a,)

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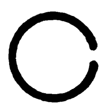
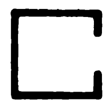
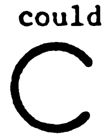
This constraint was even stronger for the up-side-down instructions. In addition, the two instruction conditions were significantly different from each other and it was concluded that asking the subject to place the form in the "up-side-down" orientation was not the empirical converse of asking him to put it in the right-side-up position, which presumably is the question of interest.

Finally, several of the forms elicited markedly different types of orientations. In fact, it was mainly these forms which contributed to the significance of the constraint by the binary procedure. It has been noted that several of the forms resemble certain English letters (Howard & Templeton, 1966) and that this undoubtedly influenced their orientation. The forms  ,  ,  ,  , and  resemble the English letters C and D, both of which would normally be oriented with the line of symmetry horizontal instead of vertical. And, as might be expected, these letter-like forms were oriented with the axis horizontal with significant frequency.

One of the most interesting findings of the study was a non-linear distribution of choices of "letter-like" orientations of these C-like forms. With grade, the frequency of orientation into a C-like position first increased, then decreased. This was interpreted as a growing familiarity with letters which first led subjects to more frequently recognize the forms as letter-like, but then led them to reject the forms as not letter-like enough. The frequency of letter-like orientation was lower for those forms which could be considered as less C-like (for instance,  , as opposed to  ; see Harris & Schaller, 1971, p. 229).

In general, the findings of strong agreement on the orientation of the forms were substantiated. Table 1 shows the most frequent orientations for each form.

It is also obvious from the table that there is more agreement among

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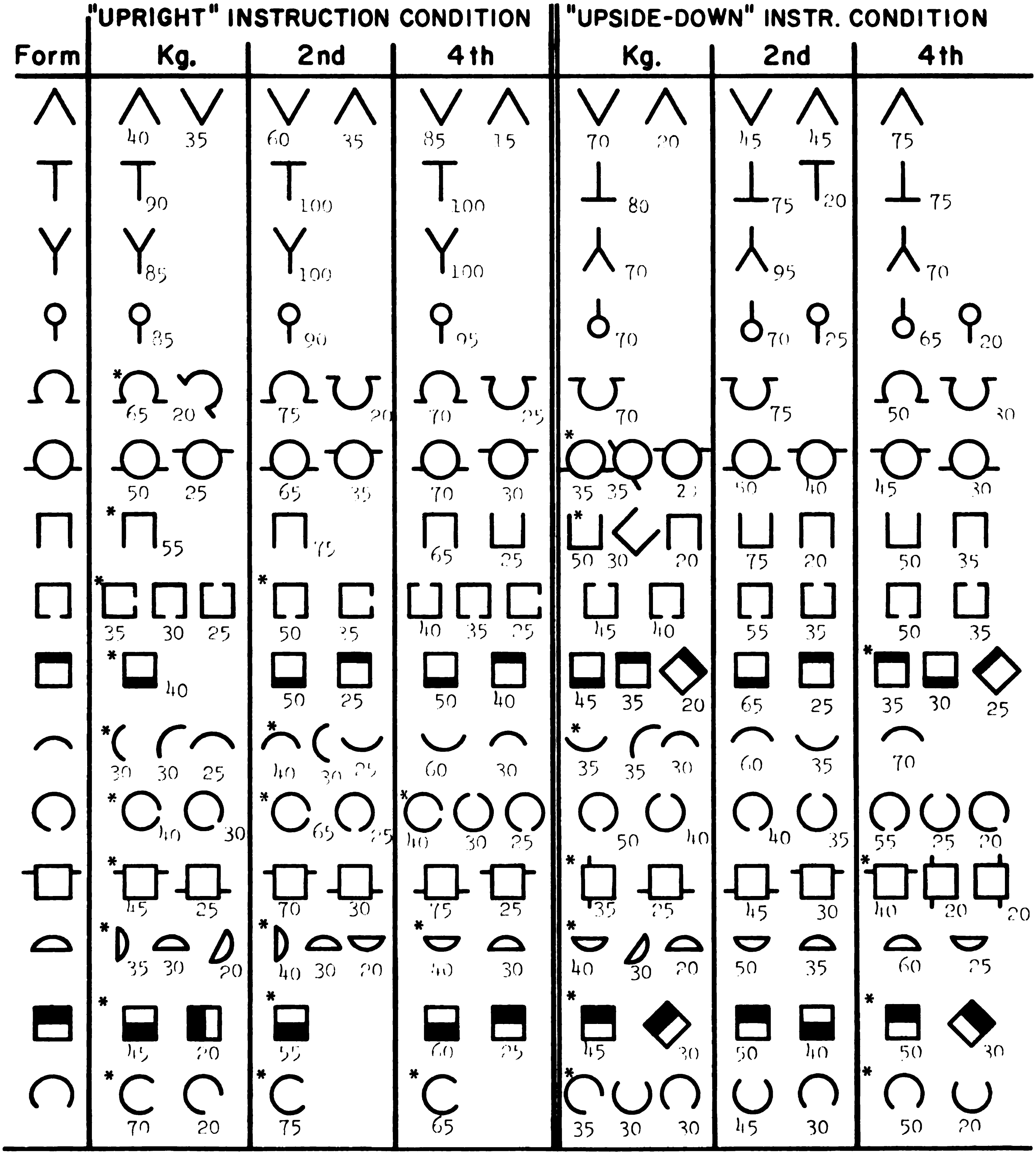

Table 1. Frequent (20% or more of judgments made) orientations for each form in three age groups under the two instruction conditions. Subscripts indicate percent judgments in the orientation shown. The 30 cells marked with asterisks are those cells in which distributions of orientation judgment differed significantly (p .05) from an hypothesized binary-vertical distribution. Oblique forms indicate <u>any</u> oblique orientation. N = 20 per cell. From Harris & Schaller, 1970a.

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the older subjects than among the younger. This is somewhat in contradiction to the Braine (Ghent, 1961) findings of greater agreement among the four- and five-year-olds than among her older subjects (up to eight years). However, this finding would be consistent with the view proposed by Davidson (1935), for instance, who suggested that she had detected a turning point in the perceptual behavior of her subjects which appeared to come at a mental age of five-and-a-half to six-and-a-half years. Braine (1965) too, as was mentioned before, found an apparent turning point in the mode of internal scanning, though the transition period appeared to be about four-and-a-half years of chronological age.

Another study tested the difference between asking the child to orient the forms "the way they were supposed to be, the way they are right" and asking him to orient them "the way you like them best, the way they look the nicest" (Harris & Schaller, 1970b). In general, it was found that the "preference" instructions differed markedly from the "upright" instructions by producing many more oblique judgments and a greater range of judgments. Sex differences were also found, indicating greater response variability among boys than girls.

These studies have demonstrated that the consistency of judgment of orientation is a reliable phenomenon, at least for these particular forms. In addition, they have identified one of the bases of this agreement (letter resemblance). The problem now is to identify other bases for the judgment of upright orientation.

The Present Study

Howard and Templeton (1966), in their review of research on human spatial orientation, state that an object cannot be perceived as having any distinct orientation unless it has some recognizable "intrinsic axis": (1) an axis of symmetry (or greatest symmetry), (2) a main-line axis, determine

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determined by the direction of the main lines of the figure, or (3) a polar axis, an axis between "significant landmarks" in the figure (p.295). Presumably, the term polar axis includes such features as Braine's "focal point," by means, say, of considering the approximate center of the form as the other polar feature (the polar axis is then the line connecting the two points), though this seems a rather roundabout way to define the features of an object which might determine the adjudged orientation. There may indeed be other features of an object which determine its perceived orientation. As Howard and Templeton state, "There has been no systematic attempt to isolate and compare these three types of axes" (p. 295). The aim of the present study was to begin to make a systematic attempt to assess the effects of the features of an object on the object's adjudged right-side-up orientation.

To accomplish this aim, an attempt was made to devise new forms which would incorporate various features suggested by Howard and Templeton and by Harris and Schaller as possible determinants of the perceived orientation. Among these were the three types of axes already mentioned, taper, mass distribution, closely related to light-dark distribution, texture gradient, apparent stability, and resemblance to familiar objects (faces). It proved to be extremely difficult to design forms which incorporate only one possible cue at a time, so in most cases multiple determinants were included, either in a complimentary or antagonistic way.

As James Gibson (1966) and others have pointed out, cues do not occur singly in nature. There are multiple cues in visual stimuli, for instance, which normally work in congruence to produce the perception of depth. And the various perceptual systems often work together, as in the perception of "fire." We expect that the perception of the upright orientation of forms is also multiply-determined. This is reflected in the difficulty

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difficulty of designing forms which incorporated only one feature. So the question asked here, then, is not so much on what single feature the judgment of upright orientation is predicated, but rather what relative effect each of the characteristics has. The eventual aim of the research is a more basic understanding of the importance of each of an array of cues to the visual judgment of orientation.

Following is a short summary of definitions of each characteristic. For more discussion, see Harris, 1969, or Howard and Templeton, 1966 .

Axis of symmetry: An imaginary line drawn in the plane of the form around which the form would be symmetrical. This seems, on the basis of our earlier work and analysis by others, to be an important determinant of orientation, though it should be obvious that this feature could only determine the "up-down" alignment of a form and cannot determine which end is "up," and which "down."

Main lines: The longest lines (straight or nearly so) in the border or outline of the figure. This use is in contrast to that of Howard and Templeton (p.296), who include what here shall be called "texture lines" in main lines. The longest straight sides would be the predominant main line, ordinarily.

Polar axes: The axes running between different and "significant landmarks in the forms," as Howard and Templeton have put it. They have also suggested that in order for a form to have any identifiable upright orientation the form must possess at least one of these first three types of axes, and more importantly, that an object can have no recognizable up-side-down orientation unless it has at least one polar axis (p. 297).

Texture lines: Lines or other indications of texture which have a predominant direction, and lie inside the form, as distinct from main lines, which are on the border of the form. For example, a bamboo tree has main lines which run vertically and texture lines which are at right angles to

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angles to the main lines, running horizontally.

Texture density: Different spacing of texture lines, with a gradient in one direction, as for instance, in railroad ties getting closer in the distance.

Taper: Gradual approach or "closing" of the main lines or outlines of the form, from one end to the other. Here the example might be railroad tracks, which appear to converge in the distance. Howard and Templeton (p. 298) suggest that there may be a tendency for things which do not taper toward the top to look "off-balance," though there are exceptions in everyday life.

Weight: The largest area of visual mass whether by virtue of largest area or greatest number of features.

Light-dark opposition or gradient: Predominantly lighter areas opposed to or grading into predominantly darker areas. Theorists such as James Gibson (1966) have pointed out that in the outdoor visual field the rule is, radiant light from above, reflected light from below. Thus, the usually lighter sky is above the darker ground. However, Braine (Ghent, 1961) found that her subjects judged the forms with the light area on top and the dark area on bottom up-side-down in that orientation.

Stability: An orientation in which the form looks most stable. For flat-sided forms this would be that orientation in which there is a flat side on the base or bottom. For forms lacking a flat side, an orientation on which the form could balance on a flat surface would be a stable orientation.

Next, since it was desired to test a greater number of forms, a new method of presentation was designed. With the original through-the-window apparatus, both the subject and the experimenter were bothered by the tedium and length of each trial (since it took so long for the experimenter to remove

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The experimenter reported trouble in getting subjects to pay attention throughout the 16 trials (forms) used. Some method of presentation which would reduce the interval between trials was required. This was accomplished by designing a new apparatus which presented slides of each figure and allowed the subject to rotate the slide by turning a yoked wheel.

Finally, we were interested in further extending the age range at which the effects have been studied. We therefore tested older subjects, including college students.

METHOD

Subjects

A total of 80 subjects viewed the figures, with 16 subjects (eight boys) at each of five grade levels. Children selected at random in kindergarten, first, third, and fifth grades from a nearby school, and college volunteers from an undergraduate child psychology class taught by the experimenter made up the five groups. The mean age for each group was: kindergarten, 6.1 years, 1st, 7.0, 3rd, 9.3, 5th, 11.2, and college, 27.3[3].

Materials

Two sets of forms were used. Twenty-three new forms (see Fig. 6) were designed in an attempt to test various hypotheses of the basis or bases of the judgment of orientation. It proved to be extremely difficult to design forms which had only one basis of judgment, and as a result, most of the forms incorporate more than one. Several of the forms represent variations on a theme.

In addition, the forms designed by Ghent (1961) and used in the Harris and Schaller (1969) study were used again to see how older age groups responded to them. These 16 forms are shown in Figure 7.

(The standard forms from the Gibson, Gibson, Pick and Osser (1962) and the Schaller and Harris (1969) studies of discrimination of letter-like forms were also shown to half the subjects for purposes of another study and will not be discussed in detail here. These forms are shown in Figure 8.)

Each of the forms was drawn in black on white and photographed for slide presentation. Each slide, when projected, showed a white circular ground, within which appeared the form. The circle was approximately 20 cm

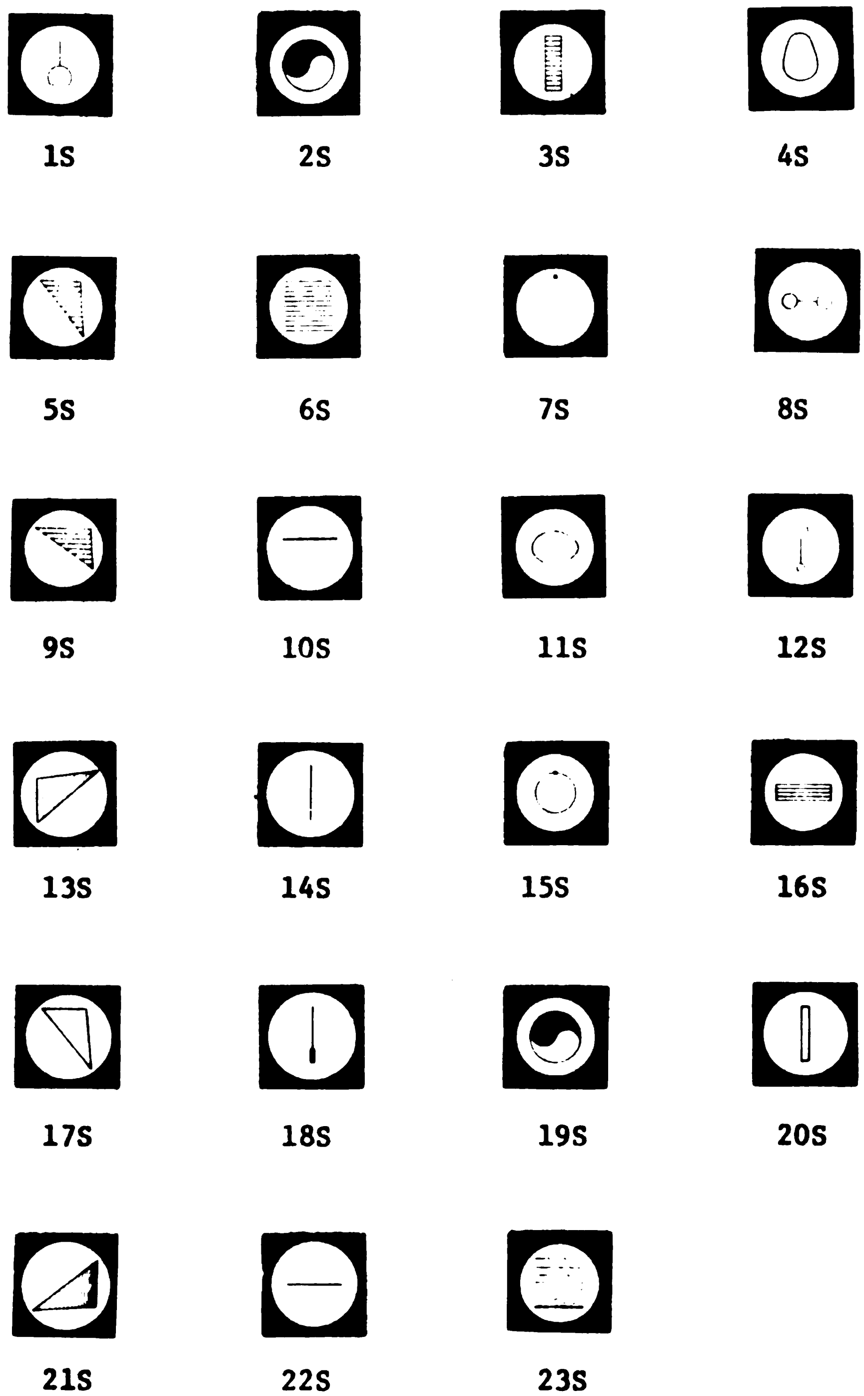


Figure 6. New forms used in this study. The forms are numbered here in the order in which they were shown to subjects. (These numbers are in parentheses in Table 4.) Some subjects saw the reverse order. The two 'yin-yang' forms differed by virtue of color: 2S was blue and 19S was black.

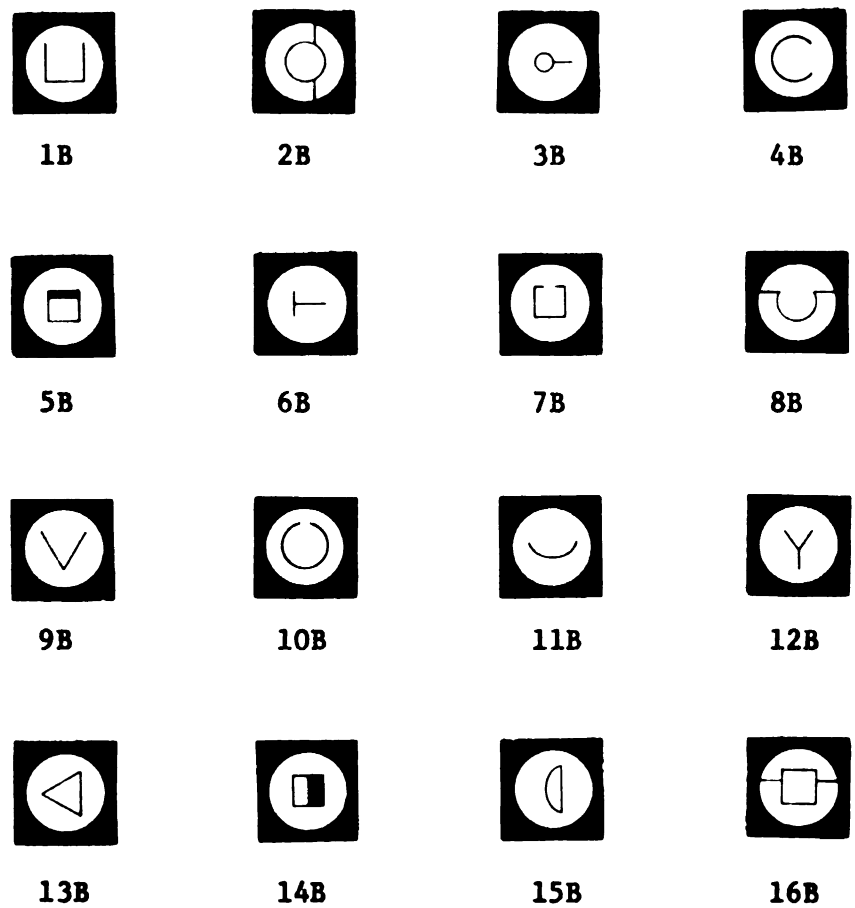


Figure 7. The forms from Ghent (1961) used in this study. The sequence here is that shown subjects, with half the subjects shown the reverse order.

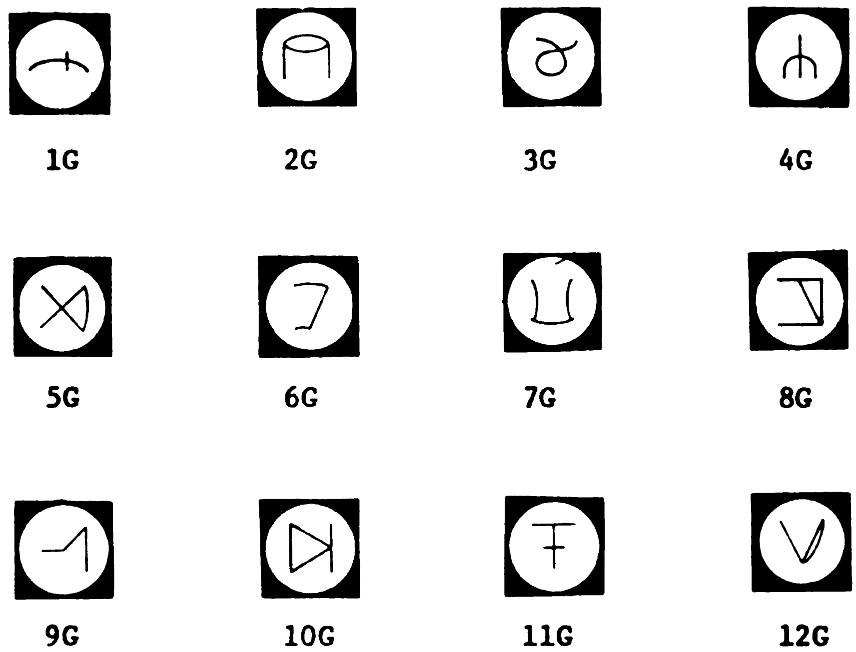


Figure 8. The "standard" forms from Gibson, Gibson, Pick, and Osser (1962) used in this study. Although these forms were also shown to subjects in the current study, they were included mainly for purposes of another study, and will not be discussed in detail in this paper. In general, these forms elicited no systematic responses of the type subjects gave to the Schaller (see Figure 6) or the Braine (see Figure 7) forms. The forms are numbered in the sequence shown subjects or, for half the subjects, in reverse order.

(8 in.) in diameter when projected at a distance of 2 meters from the subject, thus subtending an angle of approximately 4^{o} 44'.

Apparatus

The forms were projected by a specially-designed slide apparatus (Fig.9) which allowed the subject to rotate the slide to any orientation he desired by turning a 43 cm solid wheel in front of him. The projected image turned in exact correspondence to his manipulation of the wheel. Figure 9 shows the apparatus. In pretesting, the wheel proved to be a little difficult for the youngest children to turn easily, so the apparatus was modified until these children reported that the wheel was "pretty easy" to turn and the experimenter judged the amount of apparent effort to be low. If the subjects' enthusiasm in turning the wheel was any indication, the effort required was indeed not high enough. Some young children seemed more interested in turning the wheel than in aligning the forms. However, it is important to keep in mind that the stronger subjects could manipulate the apparatus more easily. It was partly this fact that prompted us to not test children below the grade of kindergarten at this time.

The forms were projected onto a flat white cloth measuring approximately 2 X 3 meters, suspended with the edges vertical and horizontal. The room was dimly and diffusely illuminated from behind the subject so that no texture cues from the sheet would be visible to him. It was felt that the screen was large enough in comparison to the projected image that the borders would not unduly influence the orientation of the form. In everyday perception, visual cues to the upright are present anyhow, and thus it was felt that the cues provided by the borders would be acceptable, since the ground around the figure itself was circular.

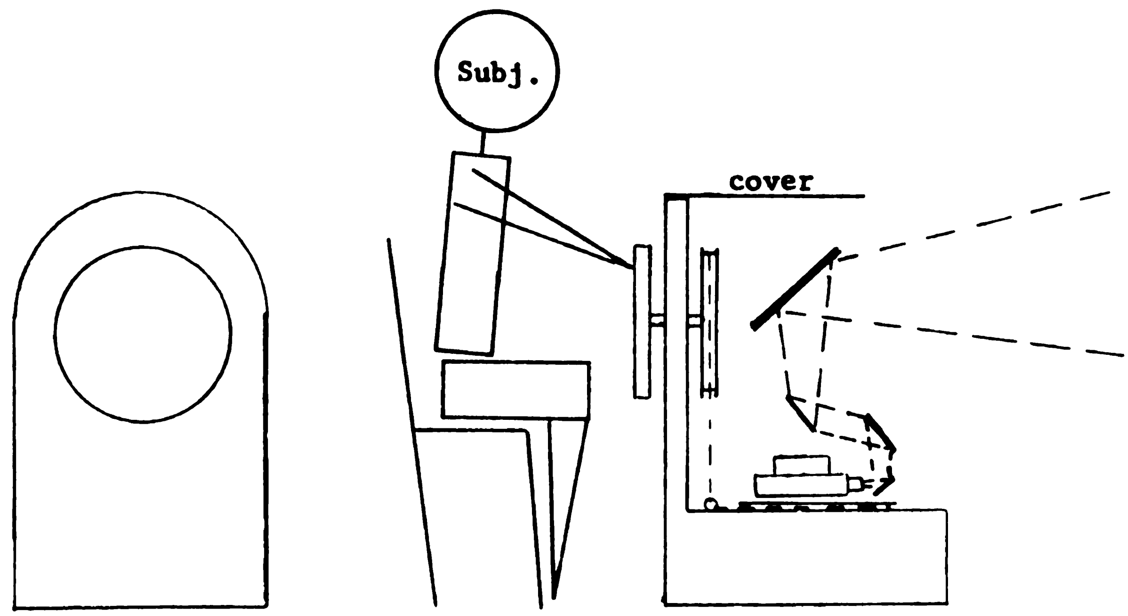


Figure 9. Apparatus. a. Front view of the slide projection apparatus used in this study. The subject was allowed to rotate the slide to any orientation he desired by turning the 43 cm solid wheel in the center. The subject viewed the slide by looking over the apparatus. The top of the apparatus was curved and was covered by a curved cover, to minimize vertical or horizontal cues. The entire apparatus was covered with matte-finish black plastic. There were no distinguishing marks on the wheel or the front surface of the apparatus.
b. Side view of the mechanism of the apparatus. The subject's wheel was connected to another wheel by a shaft. This wheel was connected by means of a rope and pulley arrangement to a turntable on which the projector was placed. The projector and the three small mirrors in front and just above it rotated with the turntable. The large mirror above the rest was fixed and reflected the incident projection out onto the screen in front of the subject. Proper alignment of the mirrors resulted in a flat projected image with no keystone distortion, which rotated in its position on the screen. A scale surrounding the turntable allowed the experimenter, sitting to one side, to record the orientation of the projector to the nearest five degrees.

Procedure

Each subject was tested individually in a spare room (at the school for the gradeschoolers; at the psychology building for the college students). After seating the subject behind the apparatus, the experimenter spoke the following instructions from memory: "I asked you to come today because I'm interested in how boys and girls can know which way things are right-side-up, the way they're supposed to be. So, for instance, if I asked you which way these toys should go, you'd know, wouldn't you? Here, put them the way they're supposed to be, so they're right. [The experimenter held out a toy truck and a lion, both on their sides, for the subject to stand up on the experimenter's hand.] OK. Good. You know. Now how about this picture here? See, this machine lets you move the picture any way you want. [A picture of a child's face came on the screen. The experimenter turned the apparatus wheel in both directions, ending with the face on the screen in some non-vertical orientation.] There. You try it. [The subject played with it for a few seconds; several spontaneously turned the face right side up. If this happened the experimenter turned the face so it was again obliquely oriented.] He looks pretty funny that way, doesn't he? [Most subjects seemed to agree that it was hilarious.] Make him the way he should be. Put him right. [All subjects performed quickly and correctly.][4] OK. Good. Now, I've got some other pictures here and I want to see if you can do the same thing. OK? You look at each picture and then turn it until you think it's just right, the way it's supposed to be, just like you did with him and the truck and the lion. OK? Here's the first one. You turn the wheel until you think it's just the way it's supposed to be, so it's just right."

The toy sequence was omitted and the instructions shortened for the fifth and college grade groups.

The experimenter recorded each response to the nearest five degrees as indicated by a scale on the back of the apparatus out of the subject's sight. When the sequence was finished, each subject was told that he had done very well, that that was all, and was thanked for coming.

For any classroom in which children participated in the experiment, all children in the classroom were given some sort of experience in the experiment so they would not feel left out. (This consisted of coming to the experimental room in groups of 3 or 4, taking turns "driving," and voting on which way the forms should go.)

The forms were presented in blocks, two to each child, with the Braine forms on Slides 2 - 17, the new forms on Slides 19 - 41, the Gibson et al. forms on Slides 43 - 54. Slides 1, 18, 42, and 55 were faces of young children and served as the starting and end points. The face in the middle of the sequence for any child was quickly presented and skipped with the comment, "I know you can do that one." The slides were presented in four sequences: 1 - 42, 18 - 55, 42 - 1, 55 - 18. One-quarter of the subjects (counterbalanced) saw each of the sequences; thus all 80 subjects oriented the new forms, 40 of those subjects also oriented the Braine forms, and the other 40 subjects also oriented the Gibson forms.

RESULTS AND DISCUSSION

Analysis

The Kolmogorov-Smirnov goodness-of-fit test was the main statistical test used.[5] Tests were performed for each figure separately within each grade and over all grades to determine whether significant sex or order differences existed and to determine whether each distribution could justifiably be viewed as different from a random distribution. In addition, comparisons to detect grade effects were performed. The data were transformed so that equivalent orientations for special figures (e.g., the  or the ) were grouped together. In addition, before the tests were carried out, the beginning of the distribution was moved from the arbitrary zero point (0° from reference orientation) to a point higher in the distribution where very few orientations fell. This procedure was used to avoid the possibility of finding significant differences based merely on a difference between, say, 5° and 355°, which though physically very similar, would be analyzed as coming from opposite ends of the distribution.

Only three comparisons on the basis of sex of subject yielded significant[6] ($p < .05$) effects. Of the total of 255 tests on sex, approximately 13 could be expected to reach significance by chance. There were no significant sex effects over all grades taken together for any of the 51 forms. It was concluded that no sex effects were detected.

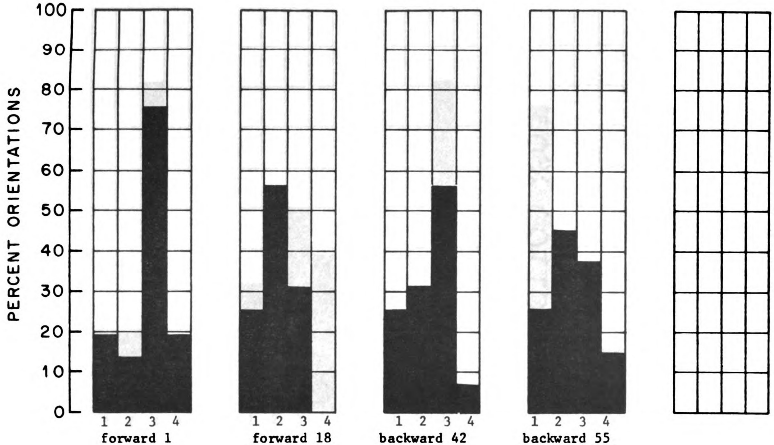
Order differences were also negligible. Of the 1530 comparison tests for order effect within grade, only 18 were significant. Approximately

77 of these tests would be expected to reach significance by chance alone. However, for two of the figures, 10 and 36, multiple occurrences of significant Kolmogorov-Smirnov D-values suggested closer examination. For Form 10, the effect of order does not appear to be systematic, as shown in Figure 10. For Form 36, | , however (see Figure 11), starting at Slide 55 produced an effect which seems to be roughly consistent across grade: the predominant orientation chosen by subjects in Order 55 (Gibson-backward, new-backward) is with the "i" up-side-down. For the other three orders, the "i" is oriented right-side-up. We do not know how to explain this phenomenon, assuming it is reliable. Otherwise, there were no effects of order of presentation of the slides on orientation.

The tests for systematic groupings (H_o is uniform distribution) disclosed three figures for the grades taken together which did not show groupings consistent enough for the test to distinguish them from random distributions of orientations. These were Forms 31 and 32, the modified yin-yang symbols, and Form 45([). Forms 10, 2, 13, 24, 23, 7, 42, 43, and 51 could not be distinguished by the test from random distributions in a majority of grades. Visual inspection of the distributions discloses that there were indeed groupings of the orientation judgments, though in some cases they were dispersed over about 15^o on either side of a central point. The same is true of the three forms 31, 32, and 45, as can be seen from examining Figures 12, 13, and 14. Thus, it must be concluded that there were probably significant groupings of judgments for all figures, even if some judgments were more spread out within the groupings.

Several apparently systematic grade effects were present. These will be discussed individually by forms.

Chi-square tests were performed on each of the forms, using only



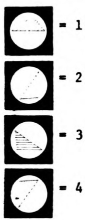


Figure 10. Distributions of upright orientation judgments for each of the four starting point-order combinations for Form 10. Order forward-18 was significantly different from order forward-1 within the kdg. and for all grades together; and from backward-42 within the 5th grade. These differences are considered chance.

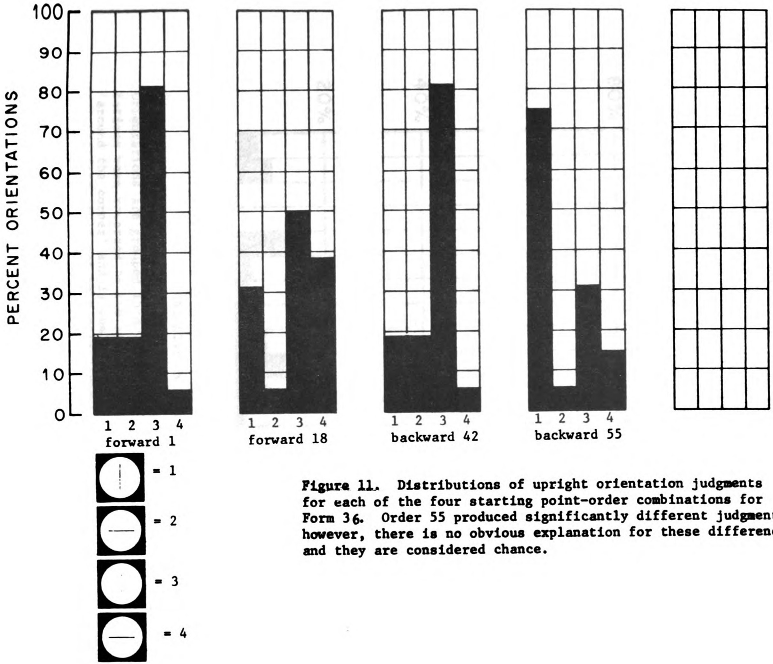


Figure 11. Distributions of upright orientation judgments for each of the four starting point-order combinations for Form 36. Order 55 produced significantly different judgments; however, there is no obvious explanation for these differences and they are considered chance.

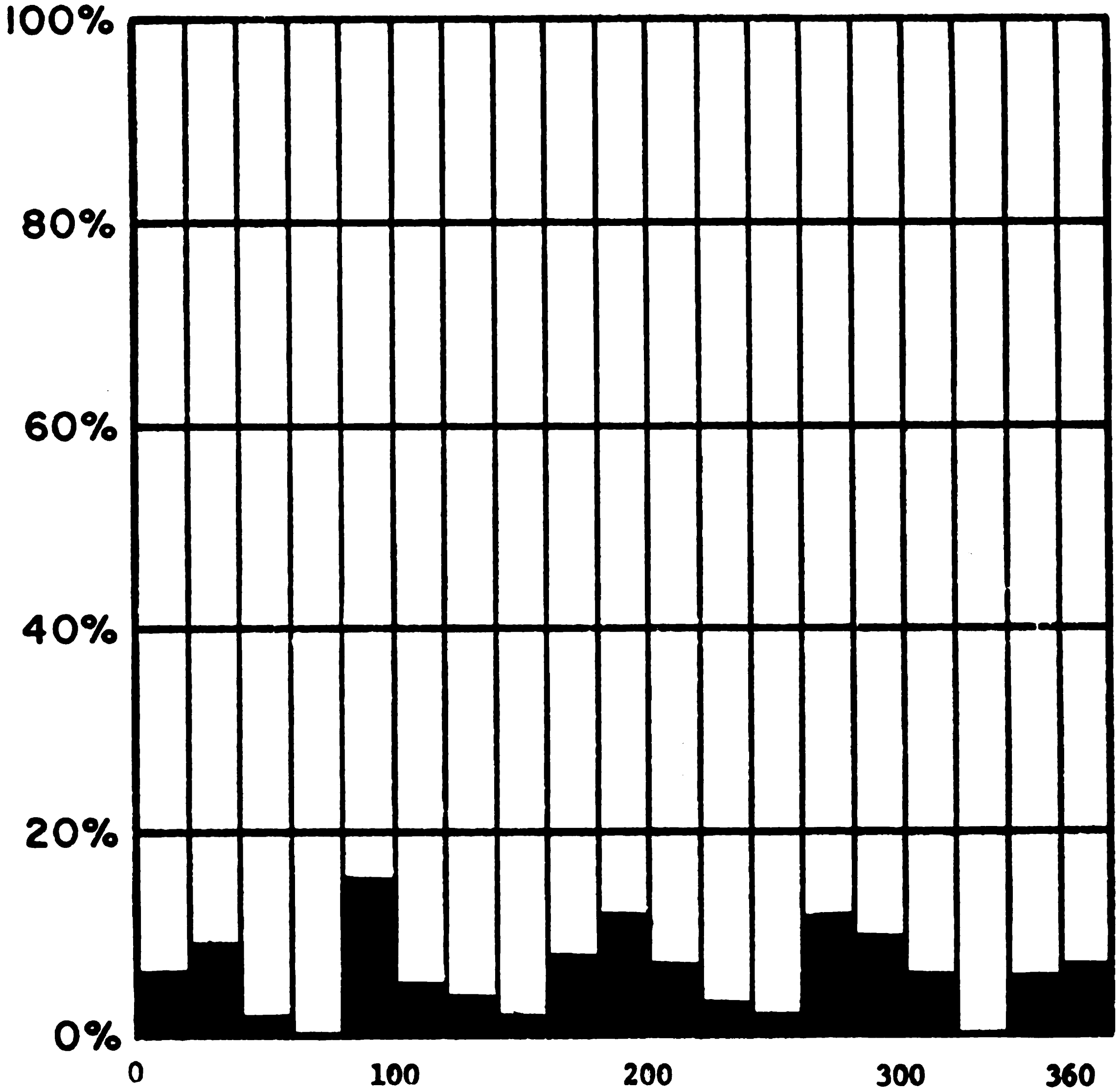


Figure 12. Distribution of upright orientation judgments for Form 31. Orientations are grouped into 20° wide categories, although the orientations were recorded to the nearest 5°. The category beyond 360 goes 'around the corner' and is the same as 0-20°. This distribution of orientations could not be distinguished from a random (rectangular) distribution by the Kolmogorov-Smirnov goodness-of-fit test.

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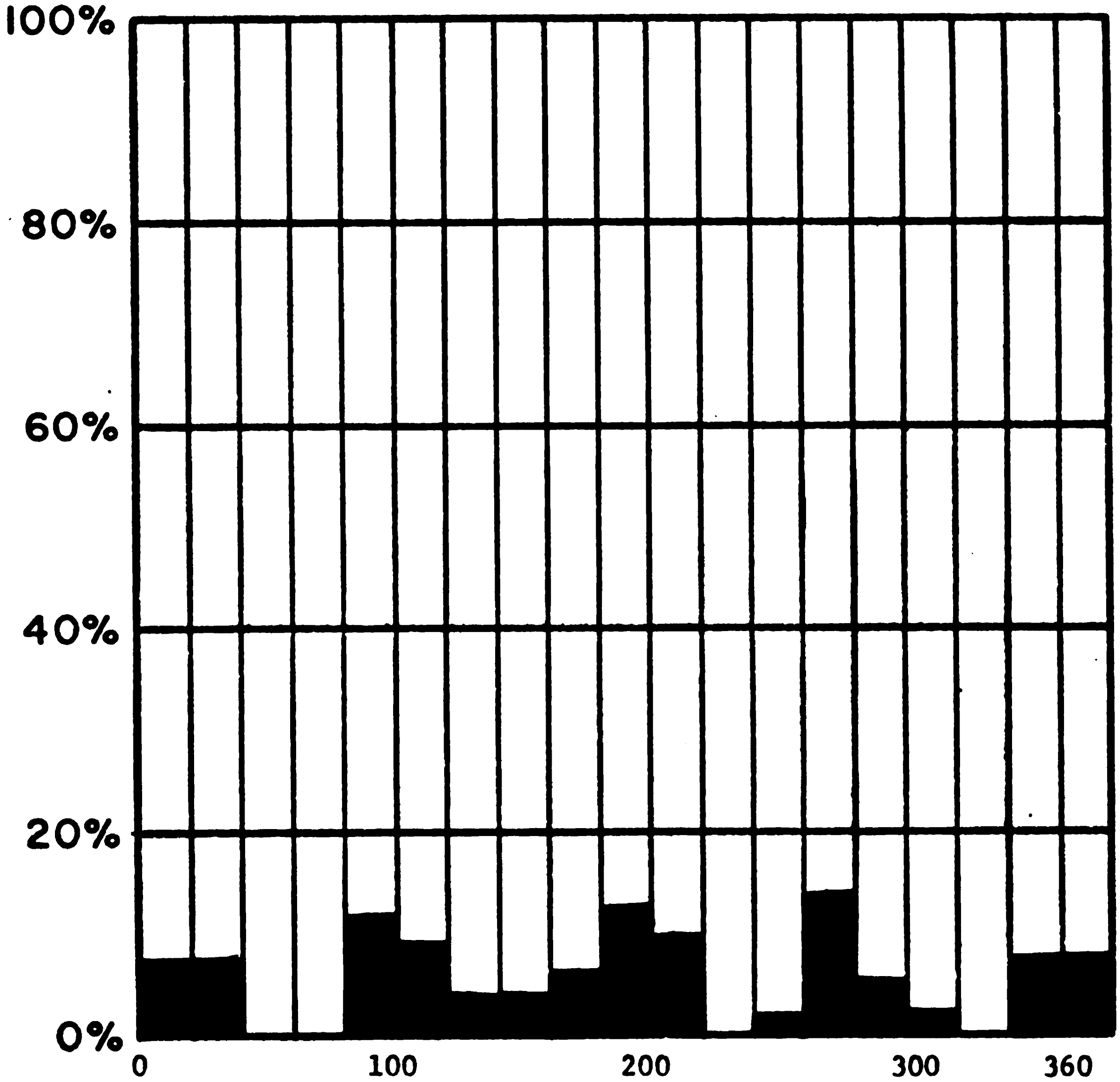

Figure 13. Distribution of upright orientation judgments for Form 32. Orientations are grouped into 20^{o} side categories, although the orientations were recorded to the nearest 5^{o}. The category beyond 360 goes 'around the corner' and is the same as 0-20^{o}. This distribution of orientations could not be distinguished from a random (rectangular) distribution by the Kolmogorov-Smirnov goodness-of-fit test.

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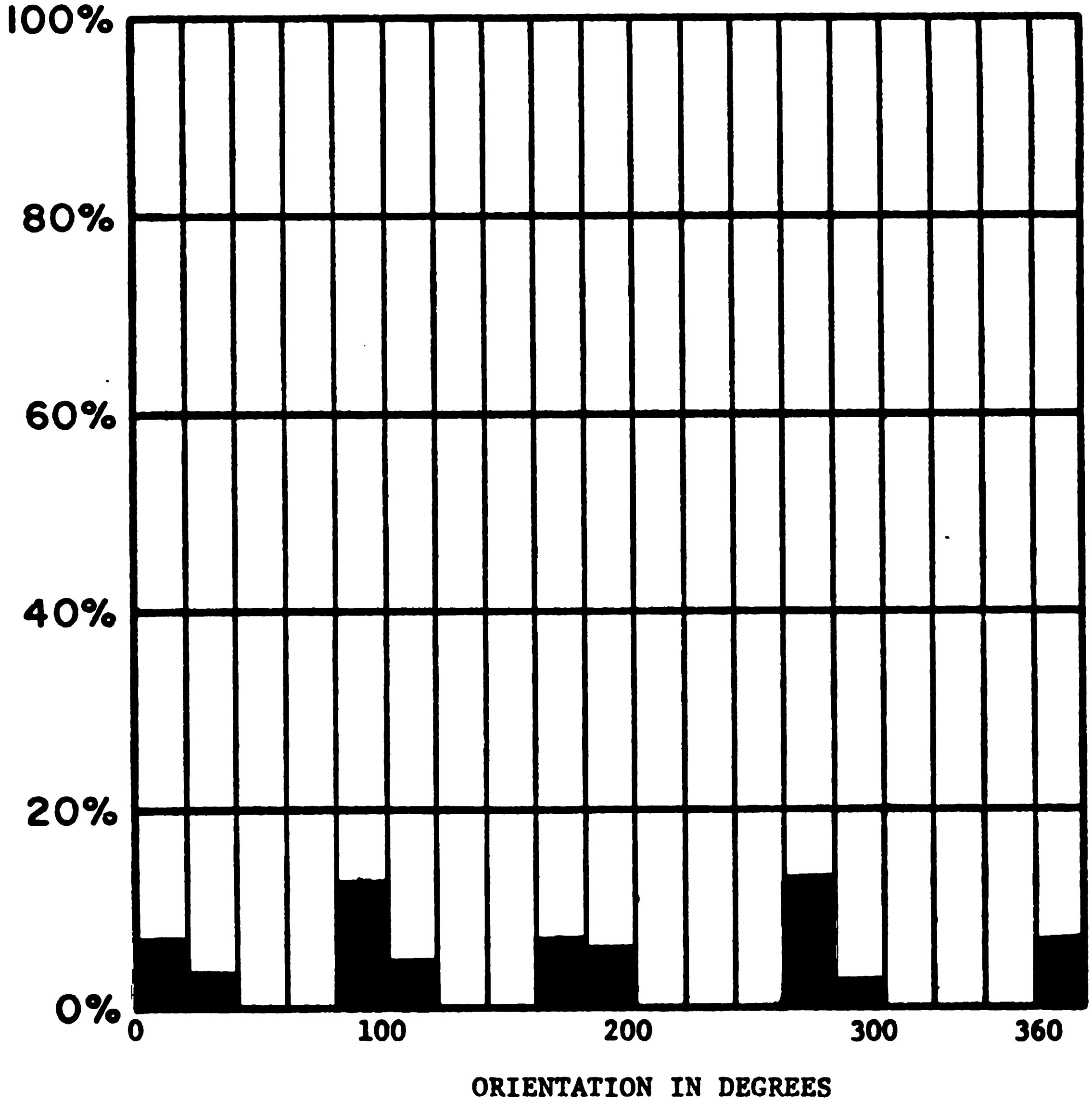
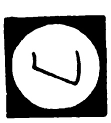


Figure 14. Distribution of upright orientation judgments for Form 45. Orientations are grouped into 20° wide categories, although the orientations were recorded to the nearest 5°. The category beyond 360 goes 'around the corner' and is the same as 0-20°. This distribution of orientations could not be distinguished from a random (rectangular) distribution by the Kolmogorov-Smirnov goodness-of-fit test.

 = 0 degrees.

those orientations which elicited more than 10% of judgments, to determine whether there were significant differences in frequency of selection of these orientation categories. Table 3 shows the results of these tests. Though all forms, with the possible exception of the "yin-yangs" and the  , as discussed earlier, elicited agreement across grades on orientation into from one to four categories (with frequencies of 10% or more), 17 of the 51 showed no significant differences between categories. It becomes obvious,however, that for several figures, this lack of agreement is a reflection of a systematic grade change.

We point out, in passing, that the conclusion already drawn in the Harris and Schaller (1970a, 1970b) study again holds, namely, that presentation of the forms in only two orientations would significantly constrain the subjects' range of choices for a number of forms. However, the results indicate that the subjects' choices of orientations for most forms would not have been significantly limited had the forms been presented in four specially-selected orientations (not always the four "cardinal" points). Exceptions to this statement are the yin-yangs and  . Note that lack of clear orientation was not predicted for these latter forms. Thus it would probably be incautious to assume that use of only four categories for additional, different forms would always have no significant effect on subjects' choices of orientations.

<u>Individual Forms</u>

Table 4 shows the forms in their most frequently chosen orientations (at least 10%). Significant grade differences are noted. The forms are shown within groups of similar or related forms, rather than in the order in which they were shown to the subjects.

Some comments on the findings concerning possible general bases for

Table 3

Chi-square tests of significant differences in frequency of judgment of upright orientation into N most frequent categories. N = number of categories with 10% or more of judgments for any form. Asterisks indicate forms for which there were significant grade changes

Form	N	X^2	p	Form	N	X^2	p
1S	2	.62	N.S.	1B	2	.71	N.S.
2S	4	.94	N.S.	2B	2	.71	N.S.
3S	2	5.58	.025	3B	2	15.16	.001
4S	2	10.6	.005	4B	2	7.5	.01
5S	3	71.	.001	5B	2	6.74	.01
6S	2	.80	N.S.*	6B	2	19.6	.001
7S	3	9.06	.01	7B	3	5.6	N.S.
8S	2	2.45	N.S.*	8B	3	2.92	N.S.
9S	3	11.3	.005*	9B	2	7.41	.01
10S	4	11.5	.01	10B	3	9.21	.01
11S	4	37.5	.001	11B	3	12.4	.001
12S	3	33.8	.001	12B	1	--	--
13S	2	33.1	.001	13B	1	--	--
14S	4	29.3	.001	14B	2	4.0	.05
15S	2	7.90	.01	15B	2	2.31	N.S.
16S	2	1.03	N.S.*	16B	2	10.53	.01
17S	3	11.1	.001*				
18S	2	.47	N.S.*				
19S	4	1.43	N.S.*	1G	4	8.74	.01
20S	2	2.45	N.S.*	2G	2	10.53	.01
21S	3	47.8	.001	3G	2	1.4	N.S.*
22S	2	5.58	.02	4G	2	.10	N.S.
23S	4	5.90	N.S.	5G	3	7.95	.01
				6G	4	2.0	N.S.
				7G	2	4.9	.05
				8G	2	2.78	N.S.
				9G	3	8.45	.01
				10G	2	4.33	.05
				11G	2	.02	N.S.
				12G	3	5.2	N.S.

Table 4. Forms as they were judged to be upright by 10% or more of subjects in grade groups. The forms are displayed in one of two formats: 1. For forms for which there were significant differences between grades in choice of the upright orientation, the direction of these differences is illustrated by showing the orientation selected by the majority of the kindergartners and the majority of the college students. The percentage of these two grade groups choosing the orientation shown is given beside the form in the "from...to" captions. In most cases the changes are orderly progressions from kindergarten through the middle grades to college. The grades between which there were differences in distribution of orientation judgments are indicated under "Comments" in parentheses (k = kindergarten, 1 = first grade, 3 = third grade, 5 = fifth grade, c = college; N = 16/grade, 80 total). 2. For forms for which there were no significant differneces in the distributions of upright judgments between grade groups, judgments from all groups taken together are shown. Each of the orientations of the form made by 10% or more of the subjects is shown, with the percentage of subjects in all grade groups selecting that orientation written below the form. Except as noted, all distributions differed significantly from random placement (i.e., from uniform distribution of responses). Asterisks in Column 1 indicate forms for which the placements of the forms into the categories shown constitute a significant choice among the displayed orientatinns (taken from Table 3). Forms shown here are exact duplicates of the slides used in the study. Each form appeared projected as shown in a white circular ground on an otherwise blank field (i.e., the square borders were not present). The form was about 20 cm. in diameter, 2 meters from the subject (4° 44'). The subjects could rotate the projection by turning a 'steering wheel' on the apparatus. Forms are displayed here in order of discussion, not the order presented to the subjects. Except for Forms 31, 32, and 45, the forms shown here had to be within $\pm$12 1/2 deg from the orientation shown here to be categorized in that orientation. Forms 31, 32, and 45 were the three forms whose distribution was nearly rectangular, and are categorized here in approximate quadrants.

Table 4.

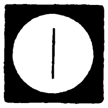
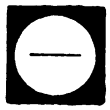
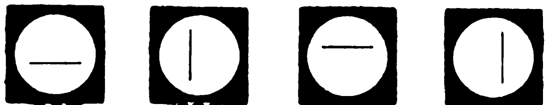
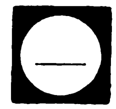
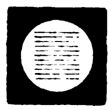
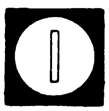
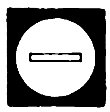
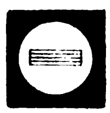
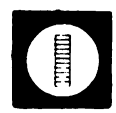
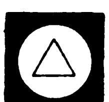
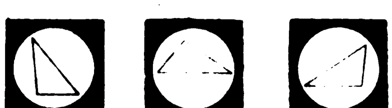
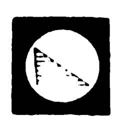
FORM NO.	ORIENTATIONS	COMMENTS
1* (22S)	from 94% k  to 87% c 	significant grade changes (k-c, 1-c, 3-c) See Figs. 15 and 28
2* (10S)	 36% 28% 20% 16%	See Fig. 16  c 87%
3 (6S)	from 75% k  to 75% c 	significant grade changes (k-c) See Fig. 17
4 (20S)	from 81% k  to 87% c 	significant grade changes (k-c, 1-c, 5-c) See Fig. 18
5 (16S)	from 87% k  to 100% c 	significant grade changes (k-c, 1-c, 3-c, 5-c) See Fig. 19
6* (3S)	 63% 36%	increase in See Fig. 20  c 75%
7 (13B)	 99%	See Fig. 23
8 (17S)	 43% 23% 16%	significant grade changes (k-3) unsystematic See Fig. 21
9* (5S)	 55% 13% 11%	equidistant texture lines See Fig. 21
10 (9S)	 40% 29% 13%	significant grade changes (1-3, 1-5, 1-9) equidistant texture lines See Fig. 21 strength of  c 56%

Table 4 (continued).

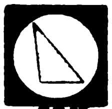
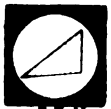
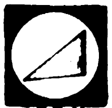
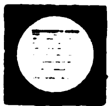
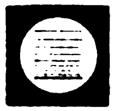
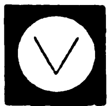
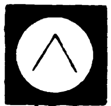
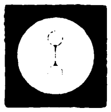
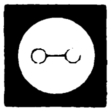
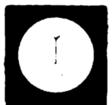
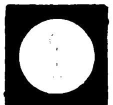
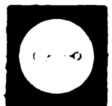
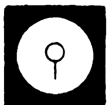
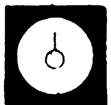
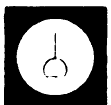
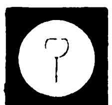
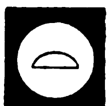
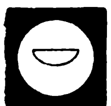
FORM NO.	ORIENTATIONS	COMMENTS
11* (13S)	 69%  11%	texture gradient closer at top in orientation 1 See Figure 21
12* (21S)	 61%  11%  11%	texture gradient closer at base in orientation 1 See Fig. 21
13* (23S)	 31%  29%  24%  14%	significant grade changes (1-c, 3-c, 5-c) See Fig. 22  c 75%
14 * (9B)	 70%  28%	inverted-U distribution for V See Figs. 23 and 28
15 (8S)	from 81% k  to 100% c 	significant grade changes (k-3, k-c, 1-c, 5-c) equal ends See Fig. 25
16 * (12S)	 60%  20%  13%	unequal ends See Fig. 24
17* (3B)	 83%  17%	See Fig. 24
18* (1S)	 54%  45%	See Fig. 24
19 (15B)	 55%  33%	See Fig. 28

Table 4 (continued).

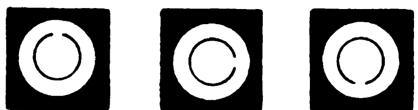
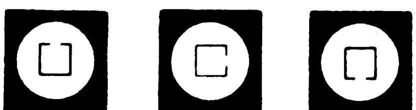
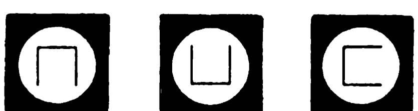
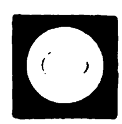
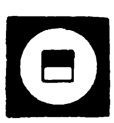
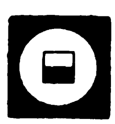
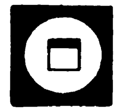
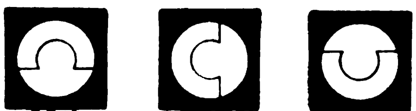
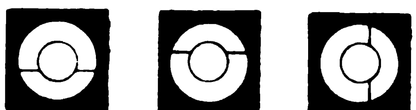
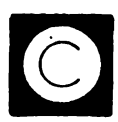
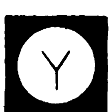
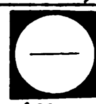
FORM NO.	ORIENTATIONS	COMMENTS
20 (18S)	 53% 44%	See Fig. 24
21* (7S)	 59% 28%	dot See Fig. 26
22* (15S)	 54% 28%	dot on circle See Fig. 26
23* (10B)	 53% 28% 15%	See Figs. 26 and 27
24* (7B)	 43% 40% 15%	significant grade changes (k-3) unsystenatic See Fig. 27
25* (11B)	from 63% k  to 88% c 	significant grade changes (k-c, 1-c) See Fig. 27
26 (1B)	 50% 38% 13%	See Fig. 27
27* (4S)	 64% 29%	See Fig. 29
28* (11S)	 54% 18% 16% 11%	significant grade changes (k-3) See Fig. 29  k 62%
29* (14B)	from 94% k  to 94% c 	significant grade changes (k-3, k-5, k-c) See Fig. 30

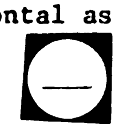
Table 4 (continued).

FORM NO.	ORIENTATIONS	COMMENTS
30* (5B)	 68% 28%	See Fig. 30  k 75%
31 (2S)	 24% 23 % 21% 19%	blue random distribution
32 (19S)	 29% 23% 23% 20%	black random distribution
33 (8B)	 40% 38% 20%	
34 (2B)	 50% 38% 10%	
35* (16B)	 73% 23%	
36* (14S)	 49% 29% 13% 10%	letter "i"-like break near one end See Fig. 28
37* (6B)	 85% 15%	See Fig. 28
38* (4B)	 63% 23%	significant grade changes (k-1, k-5) See Figs.26,27,28 inverted U distribution for C-like orientation 
39 (12B)	 93%	See Fig. 28

orientation will be made here in order to make clear the grounds for what might otherwise seem rather forward implicit assumptions in the discussions of individual forms and their relations. In general, the results indicate the following bases were used for orienting the forms upright: axes of symmetry were aligned vertically; main-line axes were aligned vertically by the younger subjects, horizontally by the older; and forms were aligned in a stable (usually flat-bottomed) orientation.

Lines, Texture Lines, Main Lines

Form 1, , is a straight line, centered in the circular ground. Braine (Ghent, 1961) found in her 4 - 5-year-olds a strong tendency to orient this form vertically (cf. Figure 2). The current results also indicate strong agreement among young subjects in favor of a vertical orientation. However, with grade there was a significant change, as shown in Figure 15. There was clearly a growing tendency to orient the bar horizontally, until by college age, the agreement was nearly as strong (87%) for the horizontal as it was for the vertical in the kindergartners (94%).

Form 2, , is the same bar moved closer to the bottom of the ground. Although the grade differences are not statistically significant with this form (between Grades K and C, D = .4375, $p = 0.09$, two-sided), it is evident from Figure 16 that the college group chose the horizontal orientations, in contrast to the younger groups. In addition, the college group chose the horizontal orientation with the bar in the lower portion of the ground, in contrast to the young children in Braine's (Ghent, 1961) research, who chose the form as up-side-down when the bar was in the lower half.

The same progression with grade is found when more than one line is present in the form, as in Form 3, . Figure 17 shows the increasing

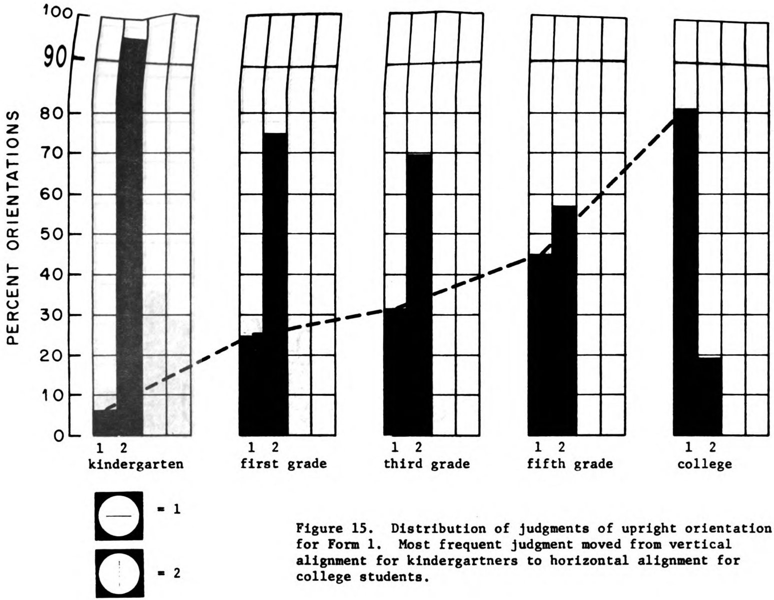


Figure 15. Distribution of judgments of upright orientation for Form 1. Most frequent judgment moved from vertical alignment for kindergartners to horizontal alignment for college students.

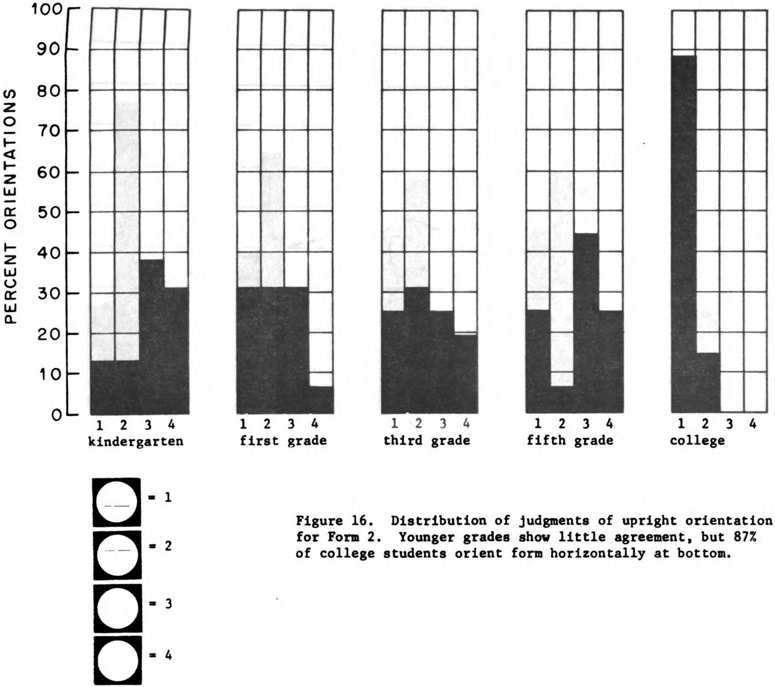


Figure 16. Distribution of judgments of upright orientation for Form 2. Younger grades show little agreement, but 87% of college students orient form horizontally at bottom.

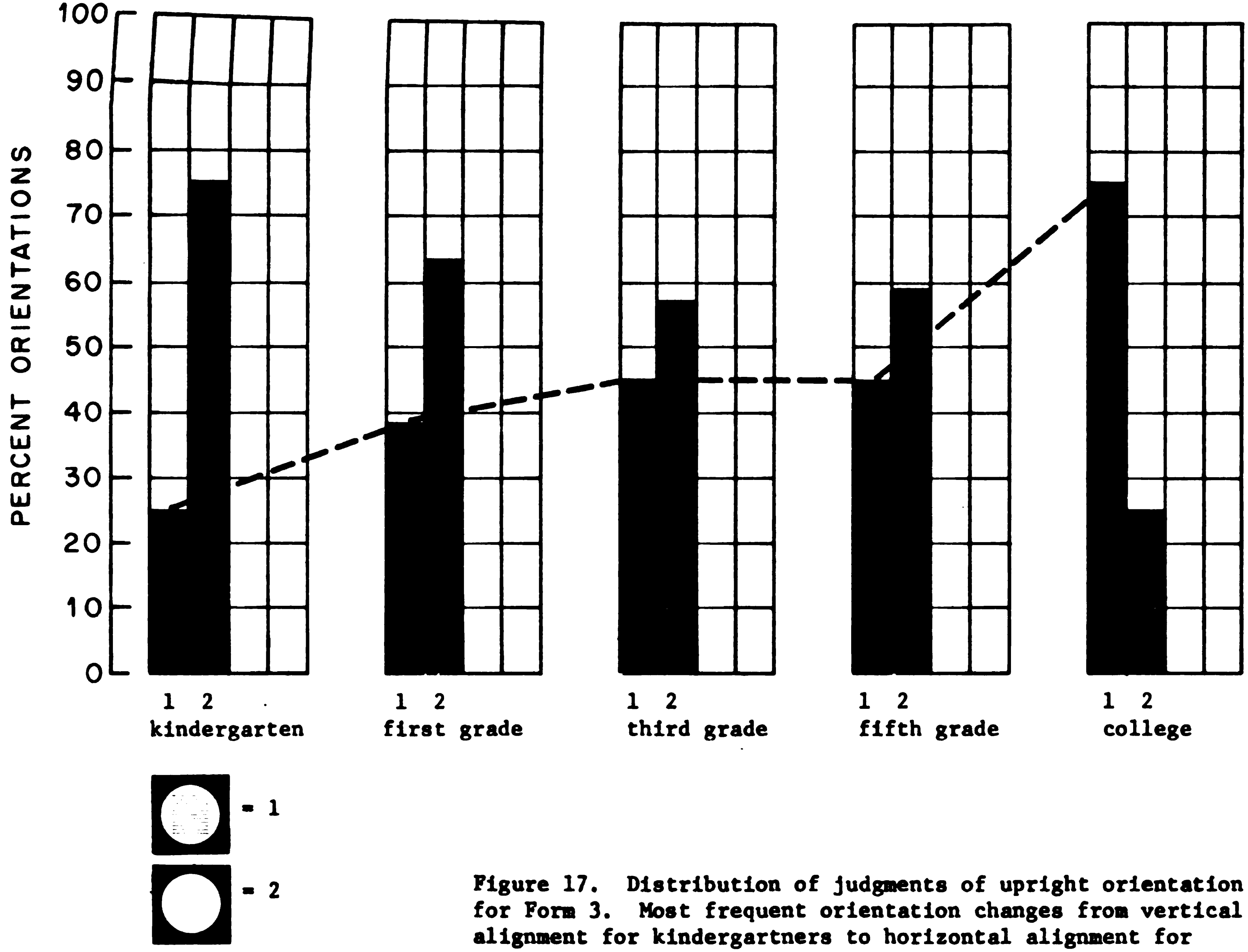
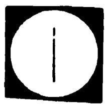


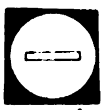
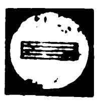
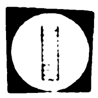
Figure 17. Distribution of judgments of upright orientation for Form 3. Most frequent orientation changes from vertical alignment for kindergartners to horizontal alignment for college students.

(without exception) choice of the horizontal orientation with increasing grade. The difference between the kindergartners and college students was significant.

A note of caution is appropriate at this point. It is tempting to view these consistencies across grade as possibly reflecting the operation of some perceptual constancy. The present research will not justify such a conclusion. It must be remembered that each of the subjects saw a number of forms, not just one, so that it is entirely possible that any consistency across forms reflects the subjects' attempts to be consistent, rather than some independent consistency. Indeed, one of the adult subjects said, as she was adjusting the orientation of several forms, "Now, let's see, which way did I put the other one?" Further research would have to consider this question carefully.

Returning to the forms, Form 36, , is also a bar, with a short break near one end. It somewhat resembles the lower case English "i" (refer to Table 4). Subjects across all grades most often placed the form in the right-side-up "i" orientation. Apparently the resemblance to the letter outweighed other considerations in its orientation. This is the case for a number of other forms as well and will be discussed more fully later.

Rectangles

The results for Forms 4, , 5, , and 6, , shed further light on the horizontal-vertical grade difference. Form 4 is the basic rectangle. Young subjects, except for the third-graders, again chose the vertical (main-line vertical) orientation as right-side-up, while the college students chose the horizontal (Figure 18).

When the texture lines are added, the effect of the main lines is

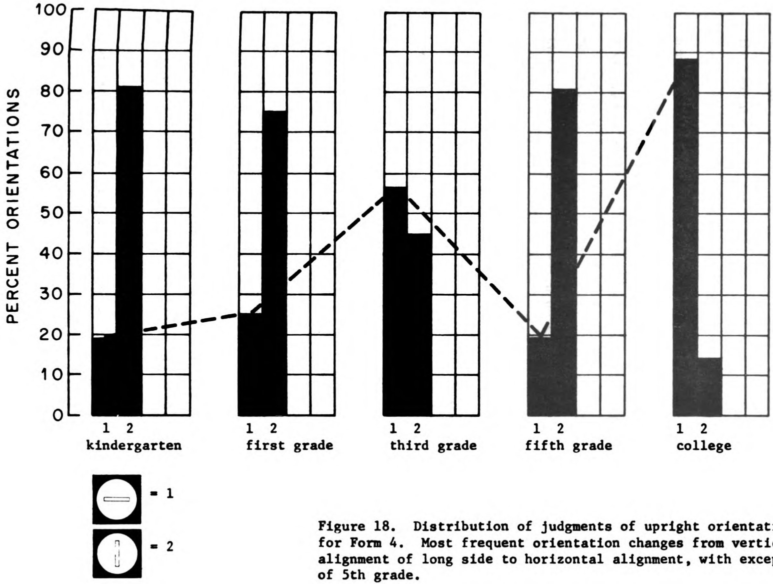
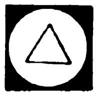
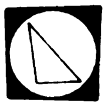


Figure 18. Distribution of judgments of upright orientation for Form 4. Most frequent orientation changes from vertical alignment of long side to horizontal alignment, with exception of 5th grade.

either strengthened or weakened, depending on whether the lines run in the same direction as (Form 5) or opposite to (Form 6) the main lines of the figure (compare Figures 19 and 20). For Form 5 (see Figure 19), with the texture lines congruent with the main lines, the younger subjects chose the vertical, the college students chose the horizontal, in both cases more consistently with this form than with the plain rectangle. When the texture lines were incongruent (see Figure 20), the vertical choice was disrupted at the lower grade levels, with a consistent progression to a new vertical choice for the college students. Apparently, the texture lines outweigh the main lines in determining the adjudged upright orientation.

Triangles

Both Braine's and the current data clearly show that the adjudged upright orientation of the equilateral triangle (Form 7, ) was with a base horizontal and a point up (99% agreement in the current study). This orientation is consistent with vertical symmetry, greatest stability, taper toward the top, and greatest mass at the bottom.

The orientation of the scalene triangle (Form 8,  , not a right triangle) is not so clear-cut. (Figure 21 shows the orientations for each of the scalene triangles.) Three orientations account for nearly all of the choices, with the orientation with the smallest base eleciting significantly more choices than the other two orientations. This orientation is not the most stable of the three "flat-bottomed" choices, but it is at least stable (not on a point, for instance). Nor is the most frequently chosen orientation consistent with the greatest mass at the bottom. It does, however, produce taper toward the top.

Comparison of the chosen orientations of Form 8 with the orientations

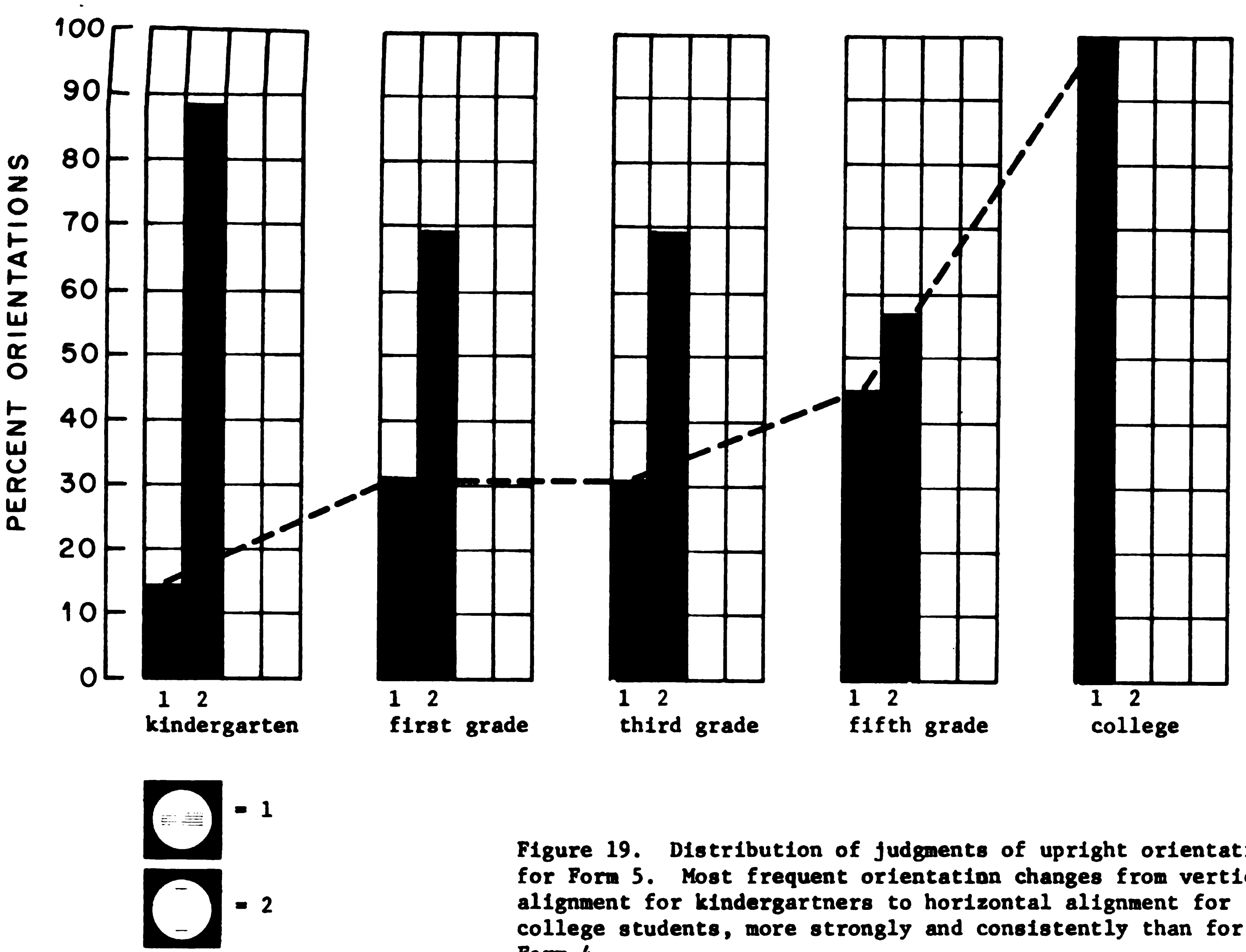


Figure 19. Distribution of judgments of upright orientation for Form 5. Most frequent orientatinn changes from vertical alignment for kindergartners to horizontal alignment for college students, more strongly and consistently than for Form 4.

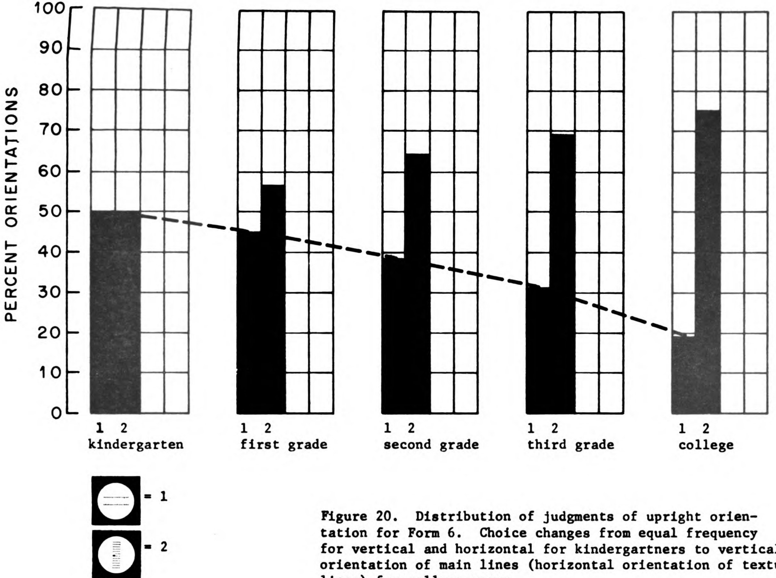


Figure 20. Distribution of judgments of upright orientation for Form 6. Choice changes from equal frequency for vertical and horizontal for kindergartners to vertical orientation of main lines (horizontal orientation of texture lines) for college group.
Note: This change is different from those in Forms 4 and 5.

Figure 21. Distributions of upright orientation judgments for Forms 8-12 (Scalene triangles) for all grades combined. Orientation of basic form is with most acute end up. Effect is increased by texture lines in 9, decreased in 10. Texture gradients in 11 and 12 do not achieve predicted effect for 12.

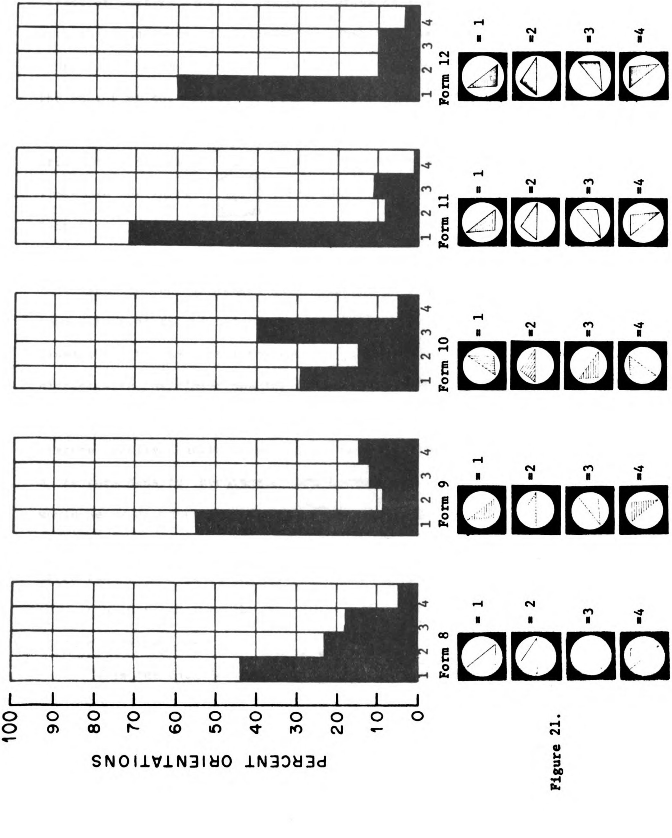
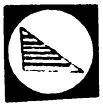

PERCENT ORIENTATIONS
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4
Form 8
= 1
= 2
=3
=4
Form 9
= 1
=2
=3
=4
Form 10
= 1
=2
=3
=4
Form 11
= 1
=2
=3
=4
Form 12
= 1
=2
=3
=4

Figure 21.

of modifications of the basic triangle again allows assessment of the effects of the changes (see Figure 21). Again, as with the rectangles, the effect of texture lines on the orientation of the basic form is apparent, with the grade interaction repeated. When the texture lines are horizontal (Form 9) in the most frequently chosen orientation of the basic figure, the choice of the "basic" orientation is increased. When the texture lines run vertically (Form 10) in the "basic" orientation, choice of the "basic" orientation is weakened and choice of the orientation in which the texture lines are horizontal,  , previously chosen by only 16% of the subjects (cf. Form 8, Orientation 3) is now chosen by 40% of them as the upright orientation (Form 10, Orientation 3). With grade, the strength of this latter effect increases significantly. Forms 11 and 12 were intended to test the effect of texture density changes. Form 11 has texture lines which become closer toward the "top" of the form, in a manner consistent with the closer spacing of natural elements on the ground farther away in the everyday visual field. In Form 12, on the other hand, the texture density changes occur in the opposite direction. On the basis of a "texture density" hypothesis, the frequency of selection of Orientation 1 would be expected to increase from Form 9 to Form 11 and decrease in 12. The actual percentages are 55%, 69%, and 61%, respectively. While the percentage for 11 is in the expected direction, that for 12 is not. Perhaps both increases are the result of more texture lines, rather than a texture density effect.

When the data for Form 13,  , are examined (Figure 22), it becomes even more apparent that what was intended to operate as a texture density cue is not responded to as such. There are significant grade effects on orientation for this form. For the younger grades, there is mixed performance, with the suggestion of a decline in choice of either of the

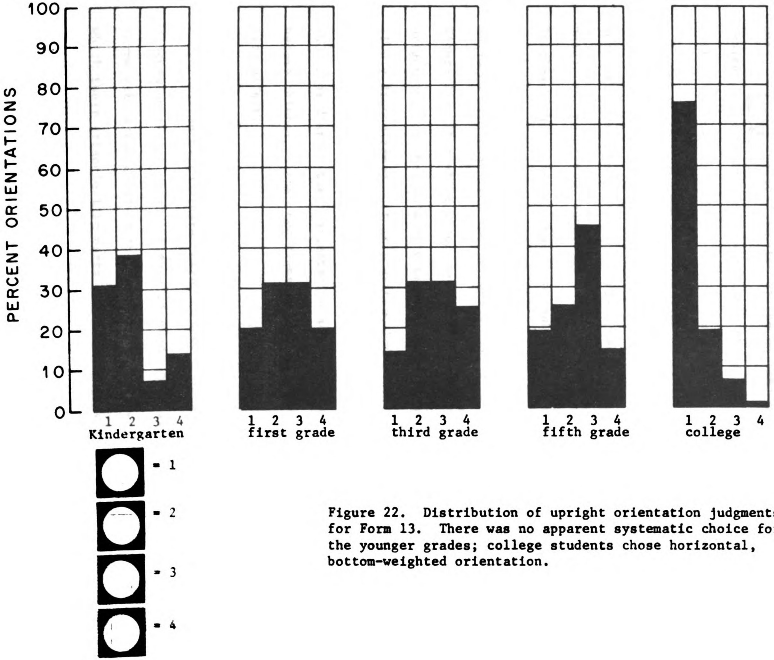
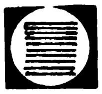
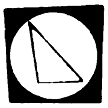
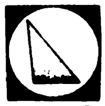
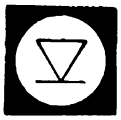


Figure 22. Distribution of upright orientation judgments for Form 13. There was no apparent systematic choice for the younger grades; college students chose horizontal, bottom-weighted orientation.

horizontal orientations. For the college group, however, there is a clear difference, with choice of the horizontals reaching nearly 100% and  (greater density at the bottom) accounting for 75% of the choices. The vertical-vs.-horizontal choices of the younger and the college groups can both be seen, perhaps, as in accord with their preferences on Form 3,  , discussed earlier, with the children's preference for the vertical disrupted by the lack of symmetry around the vertical axis when this form (13) is oriented vertically. As to the supposed texture density cues, the data for the only group whose agreement is clear, the college group, show that their choice is of the form which would contradict the usual texture density hypothesis. Thus, taking this evidence with that from the triangles (11,  , and 12,  , Figure 21), it must be concluded that the hypothesis of choice of upright orientation on the basis of greater texture density near the top is most likely disconfirmed. It is possible, however, that the lines used here, since they are all of the same width, are regarded more as "weight," which should predispose their orientation at the bottom. Using lines which also become thinner as they get closer might disclose the expected texture density effect.

Three more "triangular" forms (14,  , 50, , and 51, ) can be considered here, though what evidence they shed on the discussion is not clear. Figure 23 shows the orientations for these forms with arrangement of the data to allow inspection of the degree to which their triangle-like parts agree or disagree with the orientation of the equilateral triangle. The distributions of orientation for the three forms are very similar in shape and there is strong agreement that the orientation which would put the triangular part "up-side-down" is the upright orientation. In the case of the  we suppose we can

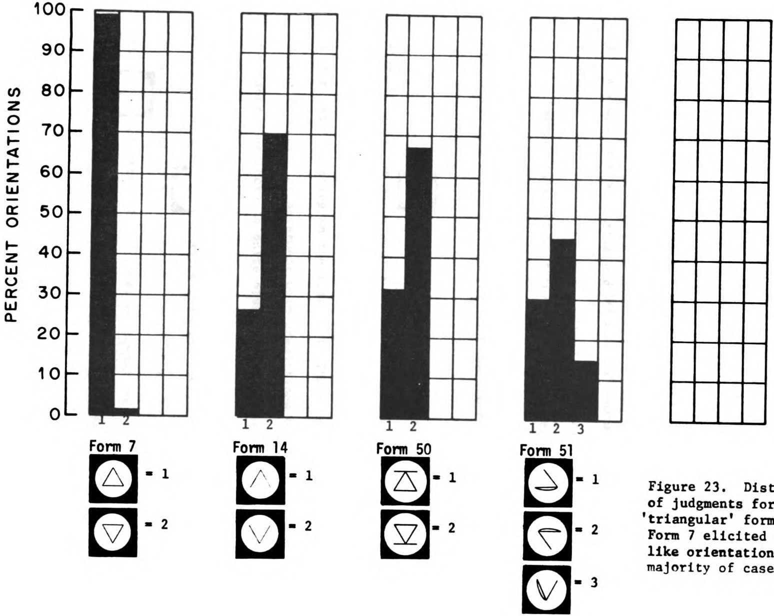
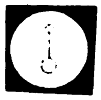
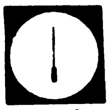
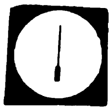
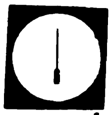


Figure 23. Distribution of judgments for several 'triangular' forms. Only Form 7 elicited triangle-like orientation in the majority of cases.

easily account for this choice, though there is a confusing grade difference here. For the other two forms we have no explanation.

Eyeglasses and Balloons

Next we consider a group of forms which vary the weight placed at the two "polar" points of the forms (15,  , 16,  , 17,  , 18,  , and 20,  ; see Figure 24). Form 17 is the "balloon" shape from the Braine study, for which she found very strong agreement for all age groups. **Harris and** Schaller (1970a) concurred with Braine's findings. And the current study also finds significantly greater choice of the balloon-like orientation across all grades. This orientation is contrary to expectations based on weight, or, stretching a point, taper or stability. Yet all three studies show the chosen orientation to be with the circle at the top.

Form 18,  , is the same balloon with a flattened top. This flattening brings about a drastic change in orientation. Slightly (non-significantly) more subjects now orient the form with the circle on the bottom as if resting on the flat spot. The slightly greater choice is in the direction of agreement with predictions based on weight, stability, and taper, but there is quite obviously still no great disposition to orient the figure in the orientation these factors might lead one to predict. Form 20,  , shows the same results. There are no significant grade differences for either of these forms, despite Braine's finding that the  elicited almost total agreement among her Ss that it was up-side-down as shown here, with the weight at the bottom, in contrast to our finding of slightly greater choice of this orientation as right-side-up. Perhaps this is an example of attempted consistency on the part of our subjects, suggested earlier. And yet, there are no significant order effects, contrary to expectation if exposure to another form were affecting

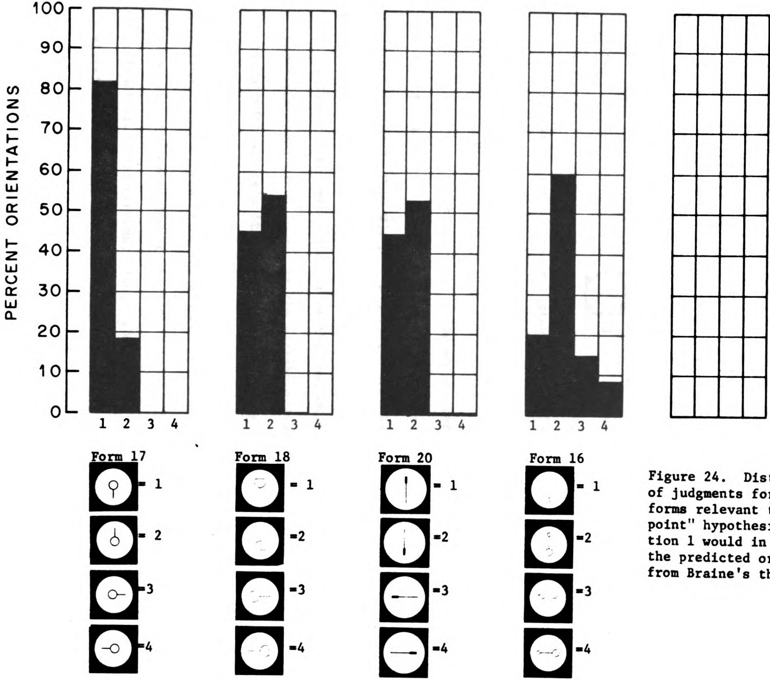
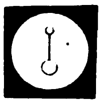
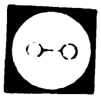
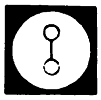
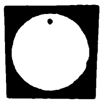


Figure 24. Distribution of judgments for several forms relevant to a "focal-point" hypothesis. Orientation 1 would in each case be the predicted orientation from Braine's theory.

the orientation of Form 20.

The results for Forms 15 and 16 seem easier to interpret. Form 16,  , is oriented significantly often in the expected direction: with the polar and symmetrical axis vertical, with the greater weight at the bottom. Form 15,  , with equal weight on both ends, elicits judgments concordant with the responses of each grade group on the vertical bar and rectangle (see Figure 25). There is a significant grade change from vertical orientation () at the lower grades to horizontal for the college group. The college group's most chosen orientation is also the orientation of greatest stability, while it orients the polar axis horizontally rather than vertically.

Circles and Dots

Figure 26 shows the orientation chosen for a group of forms which share circularity (or near-circularity), and presumed "focal" points as common features. Form 21,  , is the most basic. Within the white circular ground a single off-center dot was placed. Subjects chose significantly often to orient the dot at the top, while the dot at the bottom was second-most often judged as the upright orientation. This is consistent with Braine's findings and agrees with a focal-point hypothesis which specifies the focal point at the top for a judgment of upright orientation. Each of the other forms shown in Figure 26 has a similar distribution, with the exception of the "C", Form 38. For this form there are significant grade differences, with C-like orientations showing an inverted-U distribution and the orientation consistent with the focal-point hypothesis () making up nearly all the remainder of judgments (with a U-shaped distribution). This increasing, followed by decreasing, response to the form as letter-like gives further support to the hypothesis of letter discrimination advanced by Schaller and Harris in various papers (1969,

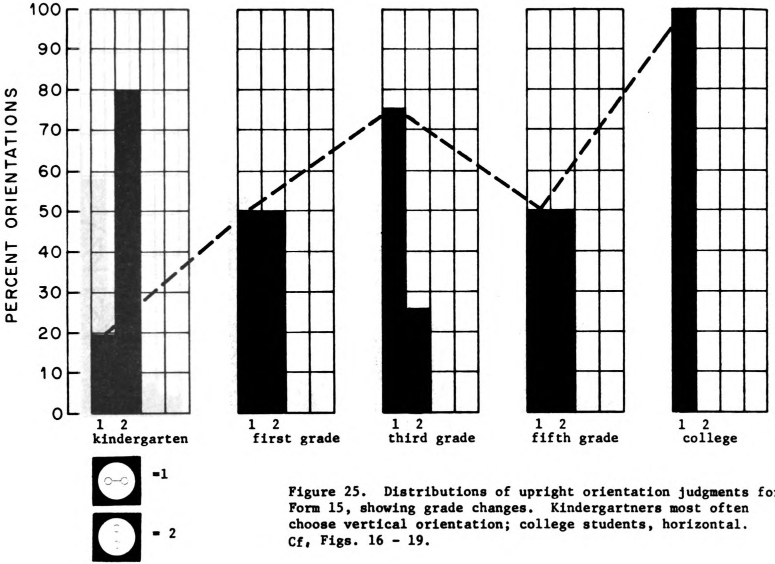


Figure 25. Distributions of upright orientation judgments for Form 15, showing grade changes. Kindergartners most often choose vertical orientation; college students, horizontal. Cf, Figs. 16 - 19.

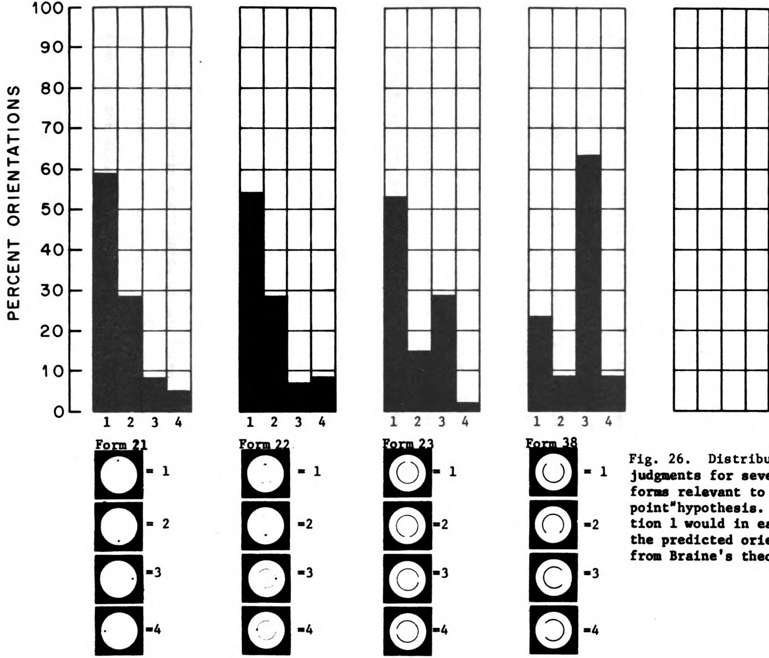
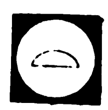


Fig. 26. Distribution of judgments for several more forms relevant to a "focal-point"hypothesis. Orientation 1 would in each case be the predicted orientation from Braine's theory.

1970a): namely, a period of growing recognition followed by a period of greater sensitivity in which merely letter-like forms are no longer good enough to qualify as letters. Where the letter-like orientation does not predominate, the orientation with the open portion at the top does. Note the somewhat lower, but still evident, C-like orientations of the nearly closed circle, Form 23.

Figure 27 enables a further examination of this non-linear developmental trend. The percentages of C-like responses are shown for each of four C-like forms (23, 24, 25, 26) as discussed in earlier papers (Harris & Schaller, 1969; Harris & Schaller, 1971). Orientation of the forms in C-like orientations appears to increase with age for a while, then decrease. In the current study, several of the forms are no longer oriented in the facing-right position by the college group. We consider this to be strong evidence in favor of our hypothesis. It is possible that the same effect accounts for the inverted-U distribution of orientations of the V-like form as well.

Figure 28 shows the percentage of letter-like orientations for a number of additional forms which we judged might resemble letters to some extent. We presume that these forms would elicit, in adults at least, early associations to English letters which resemble them in shape, if subjects were asked to indicate their associations to the forms, or at least if they were asked which of the forms resembled English letters. ("Letter-like" is not used here in the sense of forms which, while resembling the alphabet in character, have no resemblance to any actual letter, as is presumably the case for all the Gibson et al. forms. Our calling the forms letter-like also does not imply that in the actual task a subject would necessarily regard them as letter-like.) Most of these letter-like forms elicited high frequencies of judgments of the upright in their letter-like positions (with the exception of the  , Form 19.)

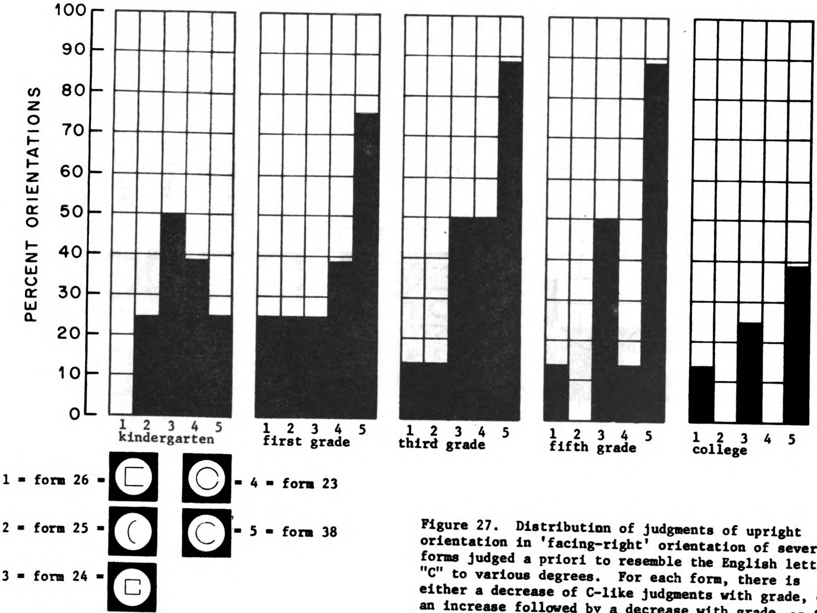


Figure 27. Distributinn of judgments of upright orientation in 'facing-right' orientation of several forms judged a priori to resemble the English letter "C" to various degrees. For each form, there is either a decrease of C-like judgments with grade, or an increase followed by a decrease with grade, as for Forms 23, 26, and 38.

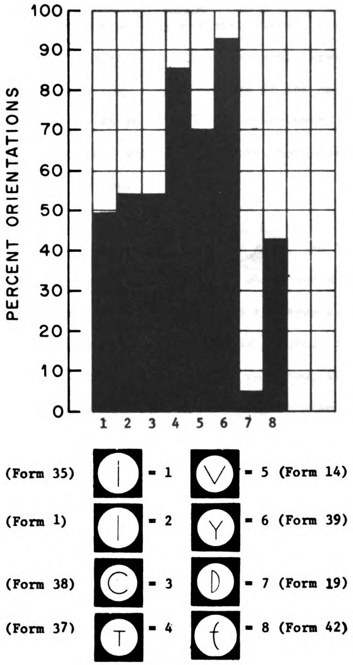
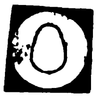
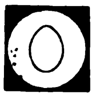
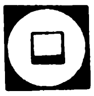
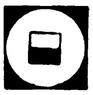
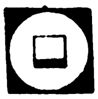


Figure 28. Distribution for several letter-like forms. Shown is the amount of agreement between subjects that each form should be oriented upright in an orientation which resembled that of the similar English letter.

For several of these forms, the resemblance to letters apparently outweighed other considerations affecting their placement.

Forms 27,  , and 28,  (see Figure 29) were intended to resemble the outlines of faces. They evidently were not responded to as such by the majority of subjects (or else they would have been oriented 180° from the orientations most chosen). Form 28 was spontaneously described by some subjects as an "egg." The most-chosen orientations in both cases served to maintain vertical symmetry. Both forms were oriented with the narrow end at the top.

Light-Dark

Forms 29,  , 30,  , 31,  , and 32,  (see Figure 30) all have one major area which is white and another which is dark or colored. The four forms were intended to serve as a test of the effect of relative darkness in one part of the figure. The 'yin-yangs', 31 and 32, were chosen because they included very few, if any, other cues to their orientation. Thus if darkness (or weight) itself were a basis for orientation, the 'yin-yangs' should have shown in which direction this basis would predispose orientation. Unfortunately, as has been mentioned earlier, there was no difference in the frequency with which any orientation was selected, except for a tendency to group around the four points (cf. Figures 12 and 13 earlier) where an imaginary line drawn through the points of intersection of the center curve with the edge would be vertical or horizontal. This seems somewhat strange, in view of the significant preferences for the square forms 29 and 30 (Figure 30 again). There was a significant grade change for Form 29,  , from choice of the black at the top for the kindergartners to choice of the black at the bottom for the older groups. There was a similar pattern for Form 30,  ,

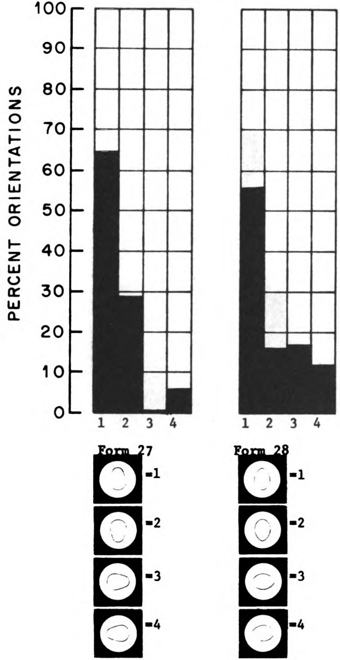


Fig. 29. Distributions of upright orientation judgments for two forms which resemble face shapes.

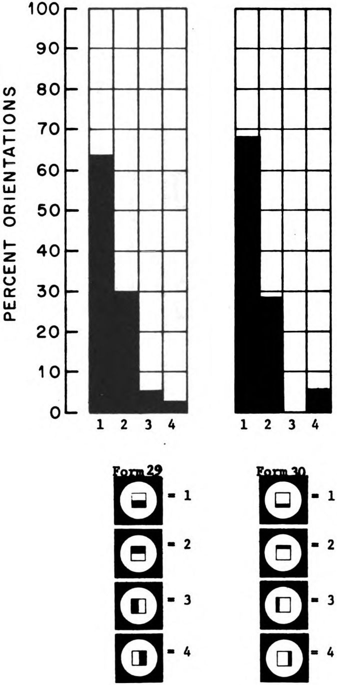
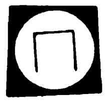
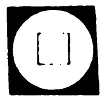
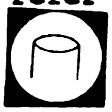
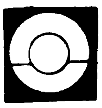
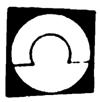
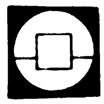


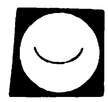
Figure 30. Distributions of upright orientation judgments for black-and-white squares.

with the kindergartners again providing the difference. (Grade K is significantly different from the other four groups taken together.) The data for the kindergartners agree with Braine's data, but the older grades in the current study show a reversal. The results for the kindergarten group are inconsistent with an evolutionary theory predicting choice of the light area at the top.

Miscellaneous

We will comment only briefly on the following forms. The reader may refer to Table 4. Forms 26, , 24, , 47, , 41, , and 46, , are related in shape. With the exception of Form 24, the orientation most frequently chosen is with the opening at the bottom (as the forms are drawn in the previous sentence).

Forms 34, , 33, , and 35, , are also related, all having the extended line from their sides. The most frequently chosen orientation is with vertical symmetry and the lines in the lower portion (as shown). Only for Form 35 is the frequency of choice significant.

Choices of orientation for Form 25, , underwent significant change with age from dome-shaped for the kindergartners to dish-shaped for the college group.

General Findings

One of the most significant findings of the current research is the number of striking changes in orientation of the forms with increasing grade level. The changes appear to be orderly and consistent between forms, although, as noted, the meaning of that consistency will become clearer only with further research. It is also clear that the degree of agreement among subjects on the upright orientation of the forms is greatest for the oldest subjects and next greatest for the kindergartners. This effect is greatest

for the newly-designed forms, with the Braine and Gibson forms showing no significant grade effects. The average of all the highest percentages for each new form for the kindergartners is 60.1%. The averages for the 1st, 3rd, 5th, and college groups, respectively, are 54.5%, 58.0%, 54.6%, and 70.5%. A chi-square test on the frequencies indicates significant differences between grades. We interpret the greater degree of concordance among subjects in the kindergarten and in the college groups (in conjunction with examination of the age effects for individual forms) as indicating that developmental changes in the perception of these forms are proceeding throughout the interim grades. The basis for perception of the upright is relatively more stable at the kindergarten level and is again stable by the time the college level is reached. The greater agreement among the college subjects, despite their more variable age, seems to indicate that the final basis for perception of or judgment of the upright is relatively uniform and long-lasting.

These age changes are particularly surprising and were unanticipated. In this connection, we note Wohlwill's comment, from his review of the literature on the developmental investigation of perception (1960): "It is patently not valid to extrapolate trends obtained from a few selected age groups to the whole course of develoment, since age trends in this area are frequently discontinuous, nonlinear, and even U-shaped. Ideally, then, the investigation should include enough age groups to allow a determination of the total developmental trend over the age span under consideration" (p. 250). This need for investigation of an extended age range is particularly evident in the area of the current study, since reversals of most frequent choice, inverted-U distributions, and, in some cases, increasing agreement where none existed, have each been found for several of the forms. Any further

research into this area will have to consider carefully the age range to be selected for study.

One of the strongest bases of judgment, which moreover appears to remain constant over age, is the axis of symmetry or greatest symmetry. Of the forms which have an axis of symmetry (including greatest symmetry), every one, with the exception of the C-like form, was made upright most often in the orientation which aligns the axis of symmetry vertically. Table 5, Column 1, shows the forms and the direction of agreement between the orientation predicted on the basis of vertical symmetry and the orientation judged by the majority of subjects to be upright. Comparison to the other predictive bases shows that vertical symmetry is by far the most consistent predictor of orientation, though, of course, one can predict only that the form will be aligned "up" or "down" on this basis, and must use other factors to predict which end will be there .

That vertical symmetry should be a strong basis for orientation of forms seems sensible, for as Howard and Templeton (1966) point out in suggesting symmetry as a basis, it is very difficult to find in a normal room an object which is not bilaterally symmetrical. And most of these objects are aligned with the axis of symmetry vertical. There are a number of possibilities for the origin of this fact. Howard and Templeton suggest that perhaps it is because things are most easily balanced this way that they are so often produced to be vertically symmetrical. Common experience of this consistency of the everyday world of objects might then become the basis for the judgment that a symmetrical object is upright when it is vertically aligned. But, on the other hand, the apparent universality of this effect across at least the grades tested by Braine and by us (and across cultures for the young children, Antonovski & Ghent, 1964) might be an indication of something more than just an effect of experience. It is as likely that

Table 5. Comparison of 1. prediction on various bases of orientation of forms with 2. orientation judged upright with greatest frequency by subjects in the current study. Pluses denote agreement between prediction and data; minuses, disagreement; question marks, uncertainty; blank spaces, no prediction. Double entries indicate comparisons for kindergartners (left) and college students (right) for forms for which there were no significant grade changes.

Table 5.

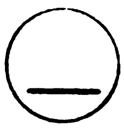
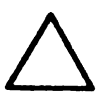
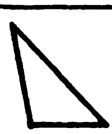
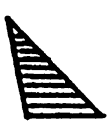
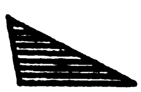
Form No.	FORM Kdg. College	1 Symmetry Axis Vertical	2 Main lines Vertical	3 Polar axis Vertical	4 Texture lines Horizontal	5 Texture lines Denser to top	6 Weight at Bottom	7 Dark at Bottom	8 Taper to Top	9 Stable	10 Focal point on top
1 (22S)		+ +	+ -							- +	
2 (10S)		+	-				+			+	-
3 (6S)		+ +	+ -		- +					+ +	
4 (20S)		+ +	+ -							+ +	
5 (16S)		+ +	+ -		- +					+ +	
6 (3S)		+	+		+					+	
7 (13B)		+	-				+		+	+	
8 (17S)			+?	+?			-		+	+	
9 (5S)			+?	+?	+		-		+	+	
10 (9S)			-	-?	+		+		+	+	

Table 5 (continued).

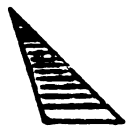
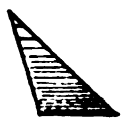
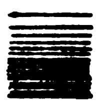
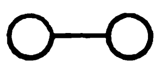
Form No.	FORM Kdg. College	Symmetry Axis Vertical 1	Main lines Vertical 2	Polar axis Vertical 3	Texture lines Horizontal 4	Texture lines Denser to top 5	Weight at Bottom 6	Dark at Bottom 7	Taper to Top 8	Stable 9	Focal point on top 10
11 (13S)			+	+?	+	+	-	-	+	+	
12 (21S)			+	+?	+	-	+	+	+	+	
13 (23S)		+	-		+	-	+	+		+	
14 (9B)		+	-				-		-	-	-
15 (8S)	 	+ +	+ -	+ -						- +	
16 (12S)		+	+	+			+		+	-	
17 (3B)		+	+	+			-		-	-	+
18 (1S)		+	+	+			+		?	+	-
19 (15B)		+	-?							+	
20 (18S)		+	+				+	+		+?	-

Table 5 (continued).

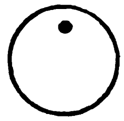
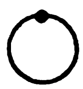
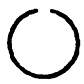
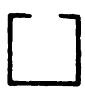
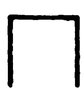
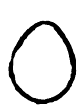
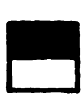
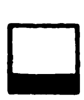
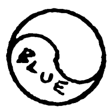
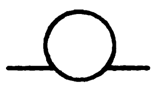
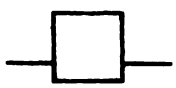
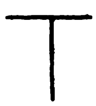
Form No.	FORM (Kdg. — College)	1 Symmetry axis Vertical	2 Main lines Vertical	3 Polar axis Vertical	4 Texture lines Horizontal	5 Texture lines Denser at top	6 Weight at Bottom	7 Dark at Bottom	8 Taper to Top	9 Stable	10 Focal point on top
21 (7S)		+		+			-?			-?	+
22 (15S)		+		+			-			-	+
23 (10B)		+		+			+			+	+
24 (7B)		+		+			+			+	+
25 (11B)	 	+ +					- +			+? +	
26 (1B)		+					-			+	
27 (4S)		+					+?		+	+	
28 (11S)		+					+		+	-	
29 (14B)	 	+ +		+? +?			- +	- +		+ +	
30 (5B)		+					+	+		+	

Table 5 (continued).

Form No.	FORM Kdg. College	1 Symmetry axis Vertical	2 Main lines Vertical	3 Polar axis Vertical	4 Texture lines Horizontal	5 Texture lines Denser to top	6 Weight at Bottom	7 Dark at Bottom	8 Taper to Top	9 Stable	10 Focal point on top
31 (2S)	 N.S.						-	-			
32 (19S)	 N.S.						-	-			
33 (8B)		+	-				+			+	-
34 (2B)		+	-				+?			+?	
35 (16B)		+	-	-			+			+	
36 (14S)		+	+	+						-	+
37 (6B)		+		+			-		-?	-	+
38 (4B)		-		-			-			-	-
39 (12B)		+	+?	+?			-		-	-	

the basis for the commonness of vertical bilateral symmetry goes beyond mere use and is a reflection of a basic perceptual phenomenon. Perhaps vertical symmetry is perceptually "preferred" and its absence induces a kind of perceptual "unease." Possibly there are reasons why higher organisms should be able to detect when objects are in a bilaterally symmetrical and vertical position. There might be some built-in basis for the current findings of high frequency of choice of vertical bilaterally-symmetrical orientations as upright. There are undoubtedly other explanations as well. In any case, the current study shows an extremely strong tendency to judge symmetrical forms as vertical when the axis of symmetry is vertical. Other research, while not speaking directly to the question of the effect of the axis of symmetry, has shown a general tendency to reproduce and draw abstract and geometric, as well as real, shapes with their main axis vertically aligned (or a flat bottom horizontally aligned; cf. Perkins, 1932; Hanfmann, 1933; Radner & Gibson, 1935).

The forms used here are not entirely systematic in their incorporation of the characteristics which might be used to predict orientation, so it is not possible to compare strictly the effects of one characteristic versus another. However, we can look at the relative strength of each as a basis for further research, and we can compare those cases where one characteristic seems to outweigh another.

To repeat, the columns in Table 5 show the direction of agreement or disagreement of the empirically observed orientations with the predictions which might be made on the basis of the characteristics of the forms. Column 2 shows the effects of the "main-line" axis, where we presume the longest lines on the border of the form to be the main lines. On the basis of earlier research (Ghent, 1961), it was predicted that main-line axes would tend to be oriented vertically. There seems to be some agreement among the young subjects that the vertical orientation is right-side up, but this agreement declines with age and is replaced by strong agreement among the college subjects that the horizontal orientation is upright. In some cases, the main line effect is opposed by either the axis of vertical symmetry (e.g., Form 34) or the texture lines in the figure (e.g., Form 10). Vertical symmetry usually is stronger. But for forms which are relatively "pure" and contain main-line axes, it appears that young children will align main lines vertically and college students will align them horizontally.

Most of the forms used here provide no basis for differentiation of the effects of polar axis from the main line axis or the axis of vertical symmetry. In most cases, the polar axis seems to have been aligned vertically.

The finding for main lines holds also for the texture lines within the form. Form 3, which we had construed as texture lines alone, was oriented vertically by the young children and horizontally by the college students. When the texture lines are within the form, as in Form 10 or Form 5, the form was more likely to be oriented with the texture lines horizontal, especially by the college students, for whom the effect is much more evident. Texture lines can apparently outweigh main lines in effect (cf. Form 6) though a stronger test is needed. In addition, the next step would be to find a way to more systematically posit texture lines against vertical symmetry, to see which feature has the stronger effect.

One possible explanation of the difference in orientation of forms with texture cues by the young children as compared to the college students is that sensitivity to what we have called "texture lines" must be learned as the result of substantial amounts of experience. By the younger children, the lines may be regarded merely as more "main" lines. This does not help to explain the difference in the orientation of simple lines and rectangles, however.

"Stability" does seem to provide a somewhat reliable basis for prediction, especially if there are flat sides to the form. When there are not, however, as in Forms 16, 27, or 17, then stability seems to have little effect.

Other features are somewhat less clear in their effect. Taper, for instance, appears to operate fairly regularly in the triangles, predisposing taper toward the top. But this finding could as easily be interpreted as an effect of stability (in this case, "flat-bottomedness"), though one might find it more reasonable to put the broadest side at the bottom if stability were the aim.

A number of negative instances of taper-to-top are, of course, forms which resemble letters. The letter-like quality seems, in fact, to outweigh all the other factors, even vertical symmetry, as shown, for example, by the results for the C-like Form 38. "Weight" and light-dark differences are other features which appear equivocal in operation. There is some evidence from the squares, Forms 29 and 30, that a form is oriented as upright with the black part at the top for the kindergartners, with the black part at the bottom for older subjects, but the clear-cut test of these hypotheses (the 'yin-yangs') failed to give any evidence for an effect.

Texture density, as mentioned before, appears to have little or no effect.

There is some evidence against a "focal-point" hypothesis, given by Forms 18, 20, and some others. Forms 20 and 17, in the Braine study, gave strong support for the focal-point hypothesis. If anything, the addition of the flat spot to the balloon should make that portion more focal, but the tendency is to orient both 18 and 20 with the expected focal portions on the bottom. Perhaps "focal point" may be considered to be epiphenomenal to the basis of orientation and as a way of summarizing which separate characteristics of a form are most important to the judgment of the upright orientation. This summary nature might underlie the seemingly great difficulty (at least for us) of specifying exactly where the focal point is.

Finally, there is the matter of associations to the forms. This is a complex problem. A number of the forms elicited spontaneous descriptions by one or two of the subjects. This probably means that for these subjects, at least, the resemblance to other forms from the everyday world influenced the judgment of orientation of the forms. But does this suggest that resemblance to everyday objects influenced orientations of any of the other forms or of the other subjects? The answer to this question does not lie in simply asking the subjects to tell us what the forms remind them of, which we had considered doing in this study. From other testing (Harris & Gutkin, in progress), it became clear that the subjects' associations did not bear any consistent relationship to their orientation judgments. It appeared that in many cases the subjects were simply inventing the associations for the special occasion of the asking. In addition, it appears from that testing that subjects do not necessarily try to associate to the forms as a basis for orientation. In any case, the associations may have no effect whatsoever on their final judgment of orientation, for the subjects often decided, it seems, to reject the association as being too unlikely, as is presumably the case for the college students with the orientation of Form 38, the most C-like form. There are probably strong

context cues which operate on subjects' associations (or lack of them). The fact that we used both toys and faces as pretraining might have conceivably produced effects different from using only the toys or especially different from referring to the forms as letters. This is a difficult area to which attention must be given.

It can be clearly concluded that children indeed are not "insensitive" or "indifferent" to the orientation of forms. Children may not show concern when pictures or text are disoriented, but this does not imply that they cannot detect the disorientation. In addition, they show strong agreement when asked to judge the upright orientation of the forms used in the current study.

Nor does there appear to be less agreement among adults as might have been expected. The decline with age in strength of agreement on the upright orientation found in earlier research evidently is not really a true decline but rather reflects a shift in the orientation chosen as upright. Certainly it is reasonable to argue that the adults' choices are based on experience. The current findings suggest that some features which had been characterized as evolutionarily important and therefore possibly innately prepotent (specifically, texture lines and gradient, and the light-dark distribution) are instead features to which a response in accord with 'everyday experience' must be learned. The findings concerning light-dark distribution for the young children are particularly disturbing to this type of evolutionary theory, since one would expect to find at least no significant choice by them, rather than choice strongly in an opposite direction to that predicted by the theory.

The finding of an inverted-U distribution of "letter-like" responses to some forms which we judged to resemble English letters has again been substantiated.

Further Research

A number of suggestions for additional research have been made throughout the text, in order to make clear certain points about the interpretation of the current results. We shall reiterate them now and incorporate them into proposals for the next studies to be conducted in this series.

First, it appears that with careful pretesting, using apparatus similar to that in the present experiment, i.e., apparatus which would allow 360° rotation of the forms, one could determine a set of four orientations into which all forms would be judged upright by the great majority of subjects. (It might not be valid, however, to assume that one could predict these orientations without testing.) Using this information, which could be obtained with a minimal number of subjects, testing could proceed with larger samples using projection of the four orientations before entire sub-samples at one time. This could save much time. Subjects would choose the orientation among the four which they judged upright. Besides saving time and effort, this procedure would be more desirable than the one used in the current study in another way, since it would assure that subjects are at least exposed to and presumably attend to each of the "major" orientations of the form. In the present study, it appeared that most subjects "visualized" one orientation, which they then tried, sometimes rejecting the first and trying another. We are not completely sure what the effect of this "trial-and-error" procedure by subjects is. In addition, in the current study the subject's last response necessarily dictated in what orientation he would view the next slide, though, of course, the orientation of the slides in the apparatus was randomized (within the four constraints of square frames). Presenting the slides simultaneously would assure that each subject saw the same four "starting positions."

Secondly, we will design forms which will provide additional comparisons of the strength of one combination of factors with another, and allow the testing of only one of the variations on one "theme" for any subject in order to rule out the possibility of the apparently systematic changes with variation being due merely to subject's attempts to appear consistent. The aim, after all, is to discover perceptual consistency, not social consistency.

A second study would investigate these forms using tachistoscopic recognition techniques. This could indicate the extent to which the judgments in the current study reflect cognitive, as opposed to strictly perceptual, operations.

Finally, investigation will be extended to a larger age range, especially to younger children, in order to further explore the striking age changes found in the current study. We suggest that other research in perception (at least in perceptual development) would also benefit from testing of a wider age range, since it is clearly not advisable to extrapolate the type of developmental changes found in the current research. In fact, most of the research reviewed earlier needs to be repeated with a direct comparison of the behavior of adults and children, in place of the presumption of or absence of knowledge about the performance at one end of the age range.

NOTES

[1]Howard and Templeton's use of "shape" and "form" to refer to two distinct concepts involved in visual perception reflects a general need for terms which consistently will make clear the meaning intended. While they accomplish this aim by appropriate definition in their book, I do not feel that "shape" and "form" would adequately meet the general need. The two terms are synonymous and, according to Webster's (second) Unabridged Dictionary, define each other. To redefine one term, in addition to contributing to jargon, would be confusing because both terms are so frequently used. Perhaps another word such as "image" could be used to describe the aspect of form which changes with orientation.

[2]We mean to make clear that by frame cues we mean portions of the form or ground which move with the form as it is rotated, as in Braine's case the edges of the card would rotate with the form. We do not mean by frame cues edges or lines or walls in the room such as doors or tables which remain in a constant orientation despite rotation of the form. These cues, which are equivalent in function to the subject's orientation to gravity, are the reference in relation to which the subject orients the forms. They are not,however, the basis on which the subject orients the form itself.

[3]Table 2 shows the ranges and means for each of the groups in the experiment. The college group had an unexpectedly high mean age, due to the volunteering of several older teachers who were enrolled in the course, during the summer. The range of age was also greatest in this group. In addition, the female college group was older by over four years. The median age for the college group was 24.6 years.

Table 2. Mean ages of subjects in the current study. Half of the subjects viewing the new forms also viewed the Braine forms, the other half the Gibson et al. forms.

	Kindergarten		1st		3rd		5th		College	
	M	F	M	F	M	F	M	F	M	F
Viewing	6.11	6.11	6.99	6.98	9.28	9.29	11.31	11.09	25.14	29.47
new forms	6.11 N = 16		6.99 N = 16		9.29 N = 16		11.20 N = 16		27.30 N = 16	
Range	5.57 - 7.11		6.45 - 7.52		8.75 - 9.93		10.55 - 11.95		19.80 - 43.74	
viewing	6.26	6.08	6.97	7.1	9.28	9.29	11.52	11.20	23.55	27.32
Braine forms	6.17 N = 8		7.04 N = 8		9.29 N = 8		11.36 N = 8		25.43 N = 8	

[4]There was one exception: a kindergarten girl, later identified by the principal as "emotionally disturbed." It happened that her teacher inadvertently send her down just as school was being dismissed, with the result that she was uncooperative from the start. After a few attempts to get her to respond, E realized the time and ended the session without her participation.

[5]The Nonparametric Statistics (after Siegal, 1956) programs of the Computer Institute for Social Science Research at Michigan State University were used to perform the tests on the CDC 3600 at the MSU Computer Center. The Kolmogorov-Smirnov one-sample test tests goodness-of-fit between a cumulative distribution of a set of sample values and some specified theoretical distribution; the two-sample test, between two sample distributions to see if they could reasonably be regarded as having come from the same population. According to Siegal (1956), Hays (1963), and other statisticians, the tests are more appropriate than chi-square for small samples.

[6]$p \leqslant .05$ will be used as an acceptable level of significance throughout.

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