What is the "front" of a simple geometric form?*

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A total of 670 undergraduate Ss were tested in three studies conducted in an attempt to define a set of cues that minimally specify perceived "frontness" and "backness" of objects. In Experiment I, Ss were instructed to identify the "front" and "back" of printed squares to which no, one, or two circles were attached. In Experiment II, different Ss made the same kind of judgment to a wider range of geometric forms. In Experiment III, different Ss judged the direction of "imagined" movement of forms from Experiment I. The results indicated that the "front" and "back" are asymmetric opposite sides, with "front" the side most different from the rest and the side toward which the form is imagined to be moving.

How do people tell the front of an object from its back? When the object is the human body, the answer seems simple and clear: the two sides bear distinctive features, the front, for instance, having the eyes and face, chest, and knees, and the back having the back of the head, the back itself, and heels. These parts of the body are parts named by 5- to 10-year-old children, who were asked to identify the differences between the front and back of their own bodies (Harris & Strommen, 1972). Different features of articles of clothing (zippers, buttons, shoes, sleeves) were sometimes named as well, and frequently children mentioned being able to see the front but not the back.

Learning the front and back of objects like the human body would seem to be a relatively simple matter of learning which name to apply to that side bearing these highly distinctive characteristics. It also means learning that front and back are opposite rather than adjoining sides. But people also learn the names "front" and "back" for the sides of a variety of other objects too, such as typewriters, chairs, automobiles, shoes, and wristwatches. What features do these objects have in common with human bodies? They all seem to share this characteristic: each has two opposite, asymmetrical sides, one called the front, the other, the back; and each has two symmetrical sides (or at least two sides much more like each other than the sides called front and back) that are simply called the "sides."

How, though, is the side called "front" distinguished from the side called "back"? Normally, the front is the side that the person approaches and to which he orients his action in relation to the object. This *functional* differentiation, however, must rest on a physical difference between front and back. The front side normally is the featured side, or the side most different from the remaining sides. It is hard, certainly, to think of any object whose front is distinguishable from its back only in function but not in appearance.

If these observations are accurate, it should be possible to define a minimum set of distinctive characteristics or "invariants" (Gibson, 1966) that specify the front and back of unfamiliar objects; and it should be possible for persons to agree on the proper designations of these parts. The three experiments reported here were a first attempt to identify this set of characteristics.

EXPERIMENT I

Method

Stimulus Materials. The test stimuli were 3-in.-square forms printed in the middle of 8 x 8 in. sheets of ordinary white paper. According to experimental condition, there were appended to each form either a single ¼-in. circle or two ¼-in. circles. The single circle was attached either to the outside of one corner of the forms (Form 1, Fig. 1) or to the outside of one side midway between two corners (Form 2). The two circles were attached either to the outsides of two adjacent corners (Form 3) or in the middle of two adjacent sides (Form 4).

Three additional forms were designed for control purposes. For two, the two circles were attached either to two opposite corners along the diagonal (Form 5, Fig. 2) or in the middle of two opposite sides (Form 6). Form 7 had no circles attached.

Each of Forms 1-6 was presented in each of the four cardinal orientations so that in the case, for example, of Form 1, the corner with the single circle attached appeared as the upper left, upper right, lower left, and lower right corner for different Ss. (In the case of Forms 5 and 6, only two different orientations

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Fig. 1. Front-back locations of featured forms for 251 undergraduate Ss; one judgment per S. Note: For Forms 1-4, judgments for all four orientations of each form have been combined. F = front, B = back, F v B = front for some Ss, back for other Ss. Numbers in parentheses indicate the number of Ss who drew a separating line but did not name the front and back sections. Those numbers between columns represent the number of Ss who drew lines like those in the forms in adjacent columns.

were possible.) An opaque face sheet was stapled to each stimulus sheet to make a booklet. Any given S made a judgment for only one form in one orientation.

Procedure. The Ss were asked to place the booklet directly before them with the staple in the upper left-hand corner, to keep the booklet oriented in exactly this position, and to not tilt their heads to the side when making their judgments. All Ss followed these instructions correctly.

The Ss were instructed to look at a "geometric form" as though they were looking down on it from above, and to draw a straight line "that separates the front part of your geometric form from the back part," and then to designate which part was

the front and which part was the back. The E then demonstrated the drawing of a variety of lines—vertical, horizontal, and diagonal—on a schematic drawing of the top view of a man. Afterwards, it occurred to us that some Ss might have seen the nose in the drawing as similar to the circle attached to the outside of the experimental form. Therefore, with a new group of Ss, we gave the same instructions with plain squares, thereby precluding the possibility that some feature of the drawing might influence Ss' judgments.

After testing, all Ss were asked to explain their judgments as best they could.

Subjects. The Ss were 397 undergraduate students. Two

Fig. 2. Front-back locations of "control" forms for 143 undergraduate Ss; one judgment per S. Note that, for Forms 5 and 6, judgments for both orientations of each form have been combined. For Form 7, scores are shown according to the orientation of the line drawn in reference to the body of the S. To read the figure, see note for Fig. 1.

*For Forms 5, 6, and 7, there were, respectively, three, one, and four additional Ss who failed to draw a separating line.

Table 1
Summary of Distribution and Statistical Evaluations of Ss' Judgments of Forms Shown in Figures 1 and 2

Form Number	(1) Did Ss divide forms into asymmetrical front-back sections with symmetrical sides? (Solutions A and B vs Solutions C, D, E, Figs. 1 and 2)					(2) Given Solutions A and B, is front on the featured side? (Solution A vs B, Figs. 1 and 2)*				
	Yes	No	χ^2	df	p	Yes	No	χ^2	df	p
1	44	16	13.07	1	.061	35	9	7.68	1	.01
2	59	2	53.26	1	.001	51	6	35.53	1	.001
3	62	7	43.84	1	.001	52	9	30.31	1	.001
4	37	20	2.77	1	> .05, < .10	36	1	33.11	1	.001
5	2	56	50.28	1	.001	1	1	< 1		
6	7	45	27.77	1	.001	3	4	< 1		

*Ss failing to label the sections (those Ss shown in parentheses in Figs. 1 and 2) are not included in these comparisons.

hundred and one Ss were given the example of the human figure drawing, and 196 Ss were shown the plain square. Total testing time took about 3 min. The Ss were tested in groups of 35-70 persons.

Results and Discussion

The great majority of Ss in both instruction conditions were able to comply with both parts of the instruction. Of the 201 Ss given the human figure example, 175 (87.1%) drew a separating line and made the front-back identification. Of the 26 remaining Ss, 22 drew only the line and 4 drew no line (refused the task). Of the 196 Ss given the square example, 172 (87.8%) drew a separating line and made the front-back identification. Of the remaining 24 Ss, 16 drew only the line and 8 drew no line.

With some exceptions (discussed later), the judgments made in the two instruction groups were essentially the same. Therefore, we have combined the scores from the two groups in Figs. 1 and 2, which illustrate the different kinds of judgments made for the seven forms.

In Fig. 1, all dividing lines bisect the form. In fact, a few Ss drew their lines so as to create unequal areas, but in every case, the divisions were of the same "family" as the ones shown here. In Fig. 2, all such unequal-area divisions are shown, since this represented the only way asymmetrical front-back sections could be produced.

For Forms 1-6 (Figs. 1 and 2), judgments for all four orientations of the form have been combined, since orientation played only a secondary and weak role in the judgments made. For example, the distribution of judgments for Form 1 was about the same in whichever corner the circle appeared.

Forms with Features (1-6). We have asked two major questions of the data: First, did Ss divide the forms so as to create asymmetrical front-back sections while preserving symmetry for these sections' sides? Second, did Ss then call the section containing the feature the "front," the section lacking the feature the "back"? In Table 1, data pertaining to the first question are summarized in Section 1, and data pertaining to the second question are summarized in Section 2. The answer to both questions, for Forms 1-4, is yes. Of the 60 Ss given Form 1, 44 Ss separated the front and back parts in a manner consistent with our first question

(summing over Forms 1A and 1B in Fig. 1), while only 16 Ss did not (Fig. 1, Forms 1C, 1D, and 1E). This difference was significant by chi-square test (Table 1, Section 1). As for the second question, of the 44 Ss, 35 called the section containing the circle the front (Fig. 1, 1A, and Table 1) and 9 called it the back (Fig. 1, 1B). This was a significant majority (Table 1, Section 2). Of the 16 Ss, 14 (Forms 1C and 1D) could be so compared, with 6 calling the featured section the front and 8 calling it the back—a nonsignificant difference. Figure 1 and Table 1 show equally clear-cut results for Forms 2 and 3.

In the case of Form 4, to make asymmetrical front-back sections with symmetrical sides, the line had to be drawn as shown in 4A and 4B. Apparently, this requirement weakened the effect: only 37 of 61 Ss drew such a line, a nonsignificant majority. But of the 37, 36 named the sections (4A), and all 36 called the featured section the front. Therefore, while the tendency to create asymmetrical front-back sections with symmetrical sides was weakened, among those Ss who did draw such a line, the provision of two circles on *adjoining* sides apparently strengthened agreement of judgment of which section was front.

Sixteen additional Ss failed to meet the first criterion; they drew a line creating *asymmetrical* front-back sections with asymmetrical sides by bisecting one circle (4C and 4D). Fifteen named the sections, with 10 Ss calling the section containing the unshared circle the front. As for the second criterion, these 10 Ss did not constitute a significant majority ($\chi^2 = 1.67$, $df = 1$, $p > .10$). Note that Judgments 4C and 4D are analogous to Judgments 1C and 1D. Considering these two sets together, the results suggest that Ss who do not implement the first principle, that front-back sections must be asymmetrical with symmetrical sides, are also less likely to implement the second principle, that the front shall contain the feature.

For Forms 5 and 6 (Fig. 2), there is no bisecting line that will make sections with only one section containing both circles. Thus, the criterion of asymmetrical front-back sections with symmetrical sides cannot be met. Eighty-one of the 110 Ss assigned Forms 5 and 6 created symmetrical front-back sections with symmetrical sides (5E, 5F, 6E, and 6F), while 17 Ss

Table 2
Percentage of Ss in Each Instruction Condition Making Judgments A, B, C, and D for Forms 1, 2, 3, and 4 (See Fig. 1)

	Type of Judgment Made											
	A		B		C		D		A + C		B + D	
	Human*	Square†	Human	Square	Human	Square	Human	Square	Human	Square	Human	Square
Form 1	70.6	42.3	14.7	15.4	0	23.1	8.8	19.2	70.6	65.4	23.5	34.6
2	82.5	85.7	12.5	4.8	0	0	5.0	9.5	82.5	85.7	17.5	14.3
3	86.7	54.2	6.7	25.0	0	0	0	0	86.7	54.2	6.7	25.0
4	90.6	28.0	0	0	3.1	36.0	6.3	16.0	93.7	64.0	6.3	16.0
Total	82.6	52.6	8.5	11.3	0.8	14.8	5.0	11.2	83.4	67.3	10.8	22.5

*Ss given human figure example

†Ss given square example

created sections with both asymmetrical front-back sections and sides (5D and 6D).

Unequal-Area Front-Back Sections. The restriction imposed by Forms 5 and 6 can be circumvented by drawing lines creating unequal-area front-back sections. Only 11 of the 110 Ss (10%) did so. Nine of these dividing lines are illustrated in Fig. 2 (5A, 5C, 6A, 6B, and 6C). Of the 11, front was the larger section in 7 cases.

This solution was not peculiar to these control forms; 15 Ss assigned Forms 1 through 4 used a similar strategy (not drawn separately in Fig. 1). For these, front was the larger section in four cases.

Instruction conditions also had some effect: 9.8% of Ss given the "plain square" instructions and 4.4% of Ss given the "human figure" instructions made such solutions. In both cases, the proportion was less than 1/10th of the total.

Form 7. If the creation of asymmetrical front-back sections depends on a feature, Form 7 cannot be said to have a front and back. The implementation of the principle of asymmetrical front-back sections with symmetrical sides would be only through the creation of unequal-area sections. Only one S did this, by drawing a horizontal line.

Use of Body Coordinates. Twenty-seven of the remaining 31 Ss assigned Form 7 nevertheless drew the separating line. Of these 27 Ss, 26 drew horizontal lines, while 1 drew a vertical line. (Again, the judgments in the two instruction conditions were not different and therefore are combined.) Where the form lacked a feature, the Ss located the front and back sections along the front-back coordinates of their own bodies. Most of these Ss also located the front in the "nearer" section (bottom section in Fig. 2), that is, the section closer to their own bodies ($\chi^2 = 3.86$, $df = 1$, $p < .05$). This same preference for locating the front in the "nearer" section also was present, but only marginally significant by z tests of proportions, in the judgments of Ss assigned featured forms who drew horizontal or diagonal lines. One hundred and sixty-four Ss drew horizontal or diagonal separating lines, restricting the feature(s) to only one section. Eighty-four percent (138/164) called the featured section the front. Of these Ss, 54% did so when the featured section was nearer and 46% did so

when the featured section was farther. These results imply a primary effect of feature together with a secondary effect of body coordinates.

Effect of Examples in Instructions to Ss. The major difference in results between Ss whose instructions included the human figure example and Ss whose instructions included the geometric form example is shown in Table 2, which lists the percentages of Ss in each group who made judgments A, B, C, and D for Forms 1, 2, 3, and 4. There were no differences for Forms 5 and 6. In both instruction conditions, most judgment types, averaging across the four forms, employed the symmetry principle (Solutions A and B). Except for Form 2, proportionately more "man-example" Ss made "best solutions" (Solution A) than did "square-example" Ss. That is, the man example increased the likelihood of use of a symmetry principle. This suggested effect of the example apparently was stronger when a symmetry solution required S to draw an oblique line, as in the cases of Forms 1 and 4. But note that for all forms and instruction conditions, of Ss who used a symmetry principle (Solutions A and B), most chose the best solution (A) and called the featured section the front. In the case of Form 4, where only 28% of the square-example Ss employed a symmetry principle, all chose Solution A. Of the remaining Ss who made Judgments C or D, thus failing to use a symmetry principle, the majority still identified the featured section as front (Solution C).

Combining Categories A and C and Categories B and D, we see that in both instruction conditions, the great majority of Ss identified the section with the feature as the "front" of the form. Therefore, while the frequencies of solution types differed with the two kinds of examples, the basic findings regarding the use of symmetry and the identification of the featured section as "front" are comparable.

Ss' Reasons for their Judgments. We assume that a symmetry principle underlay the judgments of the great majority of Ss. Did Ss invoke such a principle to explain their judgments? To answer this question, each S's explanation was assigned to one of the following six categories: (1) Analogy to objects—reference is made to some object, e.g., animal, door, building, without specification of an underlying principle (e.g., "it looked

like a house"); (2) feature is named, no explicit reason given, e.g., "It's the circle"; (3) feature named, explicit reason given, e.g., "The side with the circle is usually the front"; (4) symmetry principle named—the S explicitly states that the front-back sides are asymmetrical and that the featured (or featureless) side is the front; (5) the S explains his judgment in terms of his own body coordinates, e.g., "It's facing me" (nearer side is named as front) or "It's facing in the same direction as I'm facing" (farther side is named front); (6) no reason given—S either calls his judgment "random" or says that he has no explanation.

The incidence of these different explanations, expressed in frequency and percentage, for Ss given Forms 1-4 and for Ss given Forms 5-7, is summarized in Table 3.

Table 3 shows that the distributions of reasons differed according to whether the solutions permitted a "best" solution (Forms 1-4 in Fig. 1) or did not (Forms 5-7). A total of 58.6% of Ss given forms that fostered division into asymmetric sections with symmetrical sides (Forms 1-4) explained their judgments in terms of the attributes of the form itself (Categories 1-3). By contrast, only 9.3% of Ss given forms that did not foster such division (Forms 5-7) offered such explanations. These Ss instead fell back on reasons external to the forms themselves (Category 5) or gave no explanation at all (Category 6).

Fewer than 10% of the Ss in each instruction condition actually stated the symmetry principle (Category 4). This finding in itself should not be surprising; most persons similarly cannot state the principles of English grammar, though they speak well-formed sentences. But the discrepancy between the small number of Ss stating the principle and the large number using the principle raises the question, what *do* the explanations mean? Were they thought of beforehand or only afterwards? This seems an especially important question with respect to those Ss who analogized the forms to real objects, for one could argue that these Ss "saw" fronts and backs on these geometric forms only because for them the forms physically resembled certain animals or objects. Presumably these Ss first asked themselves, "What does this form look like?" or they recognized the forms as particular animals or objects immediately when they were presented. If any such explicit associations did indeed underlie their judgments, the results might seem trivial in the sense that these Ss might be said to have merely made judgments about meaningful, representational objects, and we already know that even very young children can do this. In other words, for these Ss it could be argued that the abstract forms were not abstract at all. Possibly supporting this view are results of reanalysis, by instruction condition, of the responses summarized in Row 1 of Table 3 ("Analogy to objects"). This reanalysis disclosed that a greater proportion of Ss receiving the human figure example (29.1%) gave real

Table 3
Incidence of Different Explanations, Expressed in Frequency and Percentage, for the 239 Ss Given Experimental Forms (1-4) and for the 108 Ss Given Control Forms (5-7) Who Drew the Dividing Line and Named the Sections

Category	Forms 1-4		Forms 5-7	
	Fre- quency	Per- centage	Fre- quency	Per- centage
1 Analogy to objects	66	27.6	4	3.7
2 Feature, no reason	30	12.6	6	5.6
3 Feature with reason	44	18.4	0	0
4 Symmetry	12	5.0	10	9.2
5 Reference to self	24	10.0	42	38.9
6 No reason given	63	26.4	46	42.6
Total	239	100.0	108	100.0

object associations than did Ss given the square example (11.0%). Presumably, the human-figure example had more strongly disposed the Ss to see the geometric form as a representational object, and this tendency, in turn, underlay the larger proportion of "best" solutions by Ss given this example (Table 2).

Other evidence, however, works against this explanation. First, several repetitions of this basic experiment, where no example was given, have yielded distributions of judgments of approximately 65%-70% and 15%-20% for Solutions A and B, respectively. Thus, use of the symmetry principles and specification of the featured section as the front do not depend on the provision of a specific example either of a human figure or of a geometric form. Second, proportionately far more Ss in the current study made "best" solutions (Type A judgments) than gave real object associations. Third, many more Ss did not offer such explanations than those who did. A reanalysis of the responses summarized in Row 6 of Table 3 ("no reason given") according to instruction condition indicated that a sizeable number of Ss in both instruction conditions (human figure example, 25.3%; square example, 43.4%) could not or would not give any explanation at all. These facts suggest that in the great majority of instances, the symmetry principle functioned to specify the front-back axis, and the asymmetric feature functioned as a cue for frontness, in a more basic way than an explanation in terms of resemblance to real objects would suggest.

EXPERIMENT II

Having established, for forms with one or two protruding features, that front and back are asymmetric, opposite sides with the featured side in front, the nonfeatured side the back, we then asked whether the asymmetric opposite sides would define the front-back axis for any design—whether this asymmetry was accomplished through the addition of a protruding feature or not. We tested this notion in a second

Fig. 3. Numbers of judgments of "front" and "back" in given locations for 11 different forms. $N = 30$ undergraduate Ss. Each S made 44 judgments (1 judgment per form in each of the four cardinal point orientations). The total number of judgments made for each of the 11 forms equals 120 (30×4). Where the total is less than 120, some Ss failed to make a judgment. F = front; B = back; F v B = judged front by some Ss, back by other Ss.

experiment with the 11 different geometric forms shown in Fig. 3.

For Forms 1-7, three sides were identical and one side was different ("odd side"); for Forms 8-10, two opposite sides were identical and two opposite sides were different.

In Experiment I, each S made only a single judgment. This time, each S made four judgments of each form, one judgment in each of the four cardinal orientations, for a total of 44 judgments.

The variety of the designs assured that from one judgment to another, S could not rely on a characteristic in any absolute way, but instead had to use a principle common to all the forms. For instance, for Form 1, also used in Experiment I, front-back sections would have to be drawn by a line parallel to the side bearing the circle in order to create asymmetrical front-back sections. But the principle is not simply to draw a line parallel to any side bearing a feature; rather, it is to draw a line parallel to two opposing, different sides. For example, for Form 9, the line creating asymmetrical front-back sections but symmetrical sides would have to be drawn through the circled sides and parallel to the broken side; for Form 10, it must be through the broken side and parallel to the circled side. Form 11 is an oval, so a judgment would have to be based on the sides themselves rather than on any feature or lack of feature. To create asymmetrical front-back sections with symmetrical sides, the line would have to be drawn through the form parallel to the two farthest points.

The Ss were 30 undergraduates. They were told, before starting, "Don't feel that you have to be consistent from one picture to another. Make your judgment according to how each individual object looks to you."

Results and Discussion

The results are summarized in Fig. 3 and in Table 4. Again, we have asked the same two questions of the data: Did the Ss divide the forms so as to create asymmetrical front-back sections with symmetrical sides, and if they did, did they call the "odd" section the front? The numbers of judgments shown in Fig. 3 cannot be contrasted by simple chi-square tests because of the repeated-measures design (the same Ss may be represented in more than one column). But since each S made only one judgment of each form in each of the four cardinal orientations, we calculated chi-square values for each Form X orientation combination. The ranges of judgment frequencies, chi-square values, and p values are shown in Table 4 for each form. For example, for Form 1, the numbers of Ss making Judgment A or Judgment B (Section 1 in Table 4) in each of the four orientations in which the form was presented ranged from 24 to 27. The numbers of Ss making Judgments C, D, or E ranged from 3 to 6. The chi-square values obtained for the four contrasts ranged from 10.8 to 19.2, with all p values $< .01$. Therefore, in each of the four orientations of Form 1, a significant majority of Ss made Judgment A or B. Of the 11 different forms, in only one instance (Form 10) and in one orientation were Judgment A or Judgment B not made by a significant proportion of the Ss. So these results clearly support our previous findings with respect to the implementation of

Table 4
Summary of Distributions and Statistical Evaluations of Ss' Judgments of Forms Shown in Fig. 3

Form Number	(1) Did Ss divide forms into asymmetrical front-back sections with symmetrical sides? (Solutions A and B vs Solutions C, D, E)					(2) Given Solutions A and B, is front on "odd" (usually featured) side? (Solution A vs B)				
	Yes	No	χ^2 s	df	ps	Yes†	No††	χ^2 s	df	ps
1	24-27	3-6	10.8-19.2	1	< .01	18-22	2-9	3.0-16.7	1	> .05 - < .01*
2	26-28	2-4	16.1-22.5	1	< .01	22-23	4-5	10.7-12.5	1	< .01
3	26-28	2-4	16.1-22.5	1	< .01	14-16	11-13	< 1.0	1	n.s.
4	24-27	3-6	10.8-19.2	1	< .01	13-14	11-14	< 1.0	1	n.s.
5	21-24	6-9	4.8-10.8	1	< .05	11-13	10-12	< 1-1.6	1	n.s.
6	23-26	4-7	8.5-16.1	1	< .01	11-12	12-14	< 1	1	n.s.
7	25-28	2-5	13.3-22.5	1	< .01	20-22	4-6	7.5-12.5	1	< .01
8	25-27	3-5	13.3-19.2	1	< .01	7-14	13-18	< 1-4.84	1	n.s. - < .05**
9	24-27	3-6	10.8-19.2	1	< .01	19-22	3-5	8.2-14.4	1	< .01
10	20-26	4-10	3.3-16.3	1	> .05 - < .01*	16-22	3-8	3.2-12.5		> .05 - < .01*
11	24-26	4-6	10.8-16.1	1	< .01	17-19	5-9	2.5-8.2		> .05 - < .01*

*One of the four contrasts was statistically nonsignificant
†Solution A ††Solution B

**Only one of the four contrasts was statistically significant

a symmetry principle irrespective of the orientation of the form.

Given Solution A or Solution B, was the "odd" section designated the "front" of the form? In the case of Form 1, which is identical to Form 2 of Experiment I, the numbers of Ss making Judgment A (Section 2 in Table 4) ranged from 18 to 22 for the four orientations of this form. The numbers of Ss making Judgment B ranged from 2 to 9. The chi-square values obtained for the four contrasts ranged from 3.0 to 16.7, with all but the lowest significant at $p < .01$. The remaining form most comparable to those used in Experiment I is Form 2, for which, in all orientations, a significant number of Ss identified the featured side as the front.

Comparisons for other forms indicated that the "odd" side did not have to be defined by an external feature to be judged the front. For Forms 7 and 9, the odd sides lacked a feature but, regardless of orientation, were called "front" by a significant majority of the Ss. This effect was as great as the effect for Forms 1, 2, and 10, whose odd sides contained an external feature.

There seem, then, to be two principles at work here. First, the front is that side of the two opposite sides defining the axis of asymmetry that is most different from the rest of the form. This description seems to corroborate our initial abstract definition of "front." Second, "front" appears to be the "focal point" of the form, the side toward which attention is drawn. And the evidence appears to be that this focal point can be created either through the presence or the absence of a feature depending on the form's particular design.

Let us consider how the operation of these two principles might be reflected in the judgments of individual forms. In the case of Form 6, the odd side is featureless, and while more than 80% of the judgments place front and back on the asymmetrical axis, only about half of these judgments name the odd side as the front. The reason seems to be that the external feature

on the opposing side competes as the focus of attention.

Our analysis also forces the conclusion that an *internal* feature—Forms 3, 4, and 5—is not so effective a focal point as an external feature.

Finally, consider Form 11. In four orientations, the majority of Ss chose the narrow, or tapered, side as "front," a significant majority for three orientations. In terms of the "focal" point hypothesis, this result suggests that the tapered end draws attention more than does the broad end. This effect may also be working, though less strongly, for Form 8, where the side with the smaller circle tended to be chosen as "front" more frequently.

The results of both Experiments I and II therefore support the hypothesis that front and back are asymmetric, opposite sides. And Experiment II, while providing evidence for the generality of principles underlying designation of the front side, also suggests important qualifications to these generalizations.

EXPERIMENT III

There is a more fundamental question than that of the generality of principles underlying judged front and back: would the Ss have thought of the forms as having fronts and backs had they not specifically been asked this question? If a feature creating asymmetrical opposite sides is a basic, or "primitive," cue in something of the same sense in which, say, motion parallax is a distance cue, would the Ss have perceived the forms as having fronts and backs without specific instructions to identify the fronts and backs? There does not seem to be any direct answer to this question without actually putting the question to S. But there may be indirect ways. Objects and animals usually move forwards rather than backwards, that is, in the direction of their front sides. Thus, direction of motion can be a cue for front-back. We are speaking here about animals with bilateral symmetry. Such an expectation is

Form as presented to S	↓	↑	→	←	↗	↖	↘	↙	Misc.	None	Total Subjects
1	3 6.8%	5 11.4%	19 43.2%	2 4.5%	1 2.3%	0	0	0	0	14 31.8%	44
2	22 62.9%	2 5.7%	3 8.6%	1 2.9%	1 2.9%	1 2.9%	0	0	2 5.7%	3 8.6%	35
3	0	9 40.9%	9 40.9%	0	0	0	0	0	2 9%	2 9%	22
4	1 2.6%	2 5.1%	26 66.7%	3 7.7%	0	0	0	0	1 2.6%	6 15.4%	39
5	0	1 2.6%	9 23.7%	20 52.6%	1 2.6%	0	0	0	2 5.2%	5 13.2%	38
6	0	0	2 11.1%	4 22.2%	6 33.3%	4 22.2%	0	0	0	2 11.1%	18
7	0	1 5.3%	3 15.8%	1 5.3%	11 57.8%	0	0	0	1 5.3%	2 10.5%	19
8	0	0	3 21.4%	1 7.1%	0	0	0	6 42.9%	3 21.3%	1 7.1%	14
9	2 14.3%	0	3 21.4%	2 14.3%	0	0	4 28.6%	1 7.1%	1 7.1%	1 7.1%	14

Fig. 4. Number and percentage of Ss reporting direction of movement "seen" (shown by arrow) for a featureless form (No. 1) and for two different featured forms (Nos. 2-5 and 6-9), each in the four cardinal orientations. N = 44 undergraduate Ss (Form 1); N = 199 undergraduate Ss (Forms 2-9). Each S made one judgment of only one form. Note that, for Forms 2-9, those columns underscored represent directions of movement within the axis specified by the feature.

problematic in the case of animals with spherical or radial symmetry, since their natural environment is water, where environmental forces are as likely to act in one direction as another. From this observation, Weyl (1953) suggests that spherical symmetry gave way to radial symmetry and then to bilateral symmetry as land organisms evolved and as they developed the capacity to move, since linear movement is accomplished most efficiently by a bilaterally symmetrical system. In such a system, the organs of locomotion are arranged symmetrically so that movement is along the head-tail (or front-back) axis. We would go further to suggest that human beings—being bilaterally symmetrical creatures—would be predisposed to expect movement in any bilaterally symmetrical object along the *asymmetric* axis. Consequently, if the geometric forms used in the current studies are naturally perceived as having fronts and backs (i.e., without specific instructions to S), then we should be predisposed to see them move along the asymmetrical axis and in the direction of the featured side.

Method

To test this idea, we showed Forms 1 and 2 from Experiment I in all four cardinal orientations to 199 undergraduates (one judgment each for one form in one orientation). A cover sheet initially hid each S's form from view.

The instructions made no mention of "front" and "back." Instead, E simply said, "On the next page there is a drawing. Imagine that it is moving on the page. In what direction is it moving?" The Ss were instructed to make a snap judgment—to indicate "the direction in which the drawing seems to be moving at the very moment you look at it," and to mark that direction with an arrow.

For control purposes, 44 additional Ss were shown a plain square (Form 1 in Fig. 4). Presumably, any reports of imagined movement by these Ss would reflect any predispositions to imagine movement in any particular direction in the absence of a feature that creates asymmetry in the form.

Results and Discussion

The distribution of motion judgments is shown in Fig. 4. Of the 44 control Ss, only 14 (31.8%) reported that the form did not seem to move at all across the page. Of the 199 Ss shown the featured forms, however, 22 (11.1%) reported no movement. These proportions were significantly different from each other ($z = 3.51$, $p < .0005$). We can conclude that movement is significantly easier to imagine with a feature than without.

Nonetheless, 30 of the 44 control Ss (68.2%) reported movement without the feature. Of these, 19 reported rightward movement, suggesting a predisposition to see rightward movement in the absence of any explicit directional marker. This finding may be consistent with

reports of laterality differences in perception favoring left-to-right processing (e.g., Braine, 1968). These results, in any event, provide a base line against which to measure the effect of the feature in Forms 2-9.

For these forms, significant proportions of the Ss who received forms 2, 4, and 5 reported imagined movement along the axis specified by the location of the feature. These are the columns *underscored* in the figure. For example, of the 35 Ss assigned Form 2, 24 reported imagined movement along the vertical axis. This difference was significant by chi square at $p < .05$ ($\chi^2 = 4.83$, $df = 1$). The proportions were even larger for Forms 4 and 5.

For Form 3, however, the tendency for rightward movement noted in the case of Form 1 apparently has weakened the effect so that as many Ss reported rightward movement as reported upward movement. There was some evidence of this tendency to perceive rightward movement in Experiment II in the case of Form 11 (the oval). The tapered end failed to be named "front" by a significant majority of Ss only when oriented to S's left.

We can also ask, of the directions *within* the axis specified by the feature location, did a significant proportion of Ss report movement in the direction of the feature? The answer is yes for all four forms: for example, of the 24 Ss who reported vertical movement for Form 2, 22 reported downward movement, while only 2 reported upward movement. This difference was significant ($\chi^2 = 16.8$, $df = 1$, $p < .0001$). Comparable comparisons for Forms 3, 4, and 5 disclosed significant differences as well.

The effect was weaker for Forms 6-9 (feature located on the diagonal). Of the 65 Ss assigned these forms, 59 reported movement, but of these, only 32 (54.2%) reported movement along the appropriate diagonal. The diagonal location of the feature nevertheless did have substantial influence when compared with the featureless form (Form 1): Of the 30 Ss who reported movement for Form 1, only 1 (3.3%) reported movement along the diagonal. And a significant proportion of Ss who did report movement within the diagonal axis for Forms 6-9 reported movement in the direction of the feature. For Forms 7 and 8, all reported movements were in the direction of the feature; for Forms 6 and 9, whose features would specify leftward diagonal movement, the majority of reported movements were in the direction of the feature, but apparently the tendency for rightward movement noted in the control, featureless, form and in Form 3 was influential here to attenuate the effect.

A comparison of these distributions with the distribution of front-back judgments made by the Ss in Experiments I and II thus discloses a sizeable degree of overlap. The Ss in Experiment III imagined the forms most often as moving across the page in what, on the basis of the front-back judgments in Experiments I and II by different Ss, would be called a *forward* direction, i.e., in the direction of the featured side.

GENERAL DISCUSSION

These three studies permit a first step in answering the question: How do people tell the front of an object from the back? The front and back clearly are the asymmetric, opposite sides. Of these, the front appears to be the side toward which attention is drawn, whether by a feature or by its absence. The front side also seems to be the side toward which the object is most likely to be seen as moving.

The results also show that in the absence of any feature that permits division of the form into asymmetrical sections with symmetrical sides, adults use their own body coordinates as the basis for judgment, more often identifying the near section as the front. Kindergarten and second-grade children make a comparable judgment when asked to place a plane cube (mobile object) in front of, behind, and beside another plane cube (fixed object) (Harris & Strommen, 1972). Ninety-four percent of the children's front-back placements were made along the front-back axis of their own bodies, with 67% of the "in front" placements made on the near side (i.e., between their own bodies and the fixed object) and 27% on the far side. At least in this sense, figures lacking any front-back features nonetheless can be said to have fronts and backs.

Many questions remain: For example, in Experiments I and II, can we infer the Ss' identification of the "sides" from their designations of the front and back? The great majority of judgments, as we have seen, had the effect of creating asymmetrical front-back sections with symmetrical sides rather than other possibilities such as asymmetrical front-back sections with asymmetrical sides or symmetrical front-back sections with symmetrical sides. Thus, the greatest number of judgments were "best" solutions, inasmuch as they most closely modeled real-life cases. But if the Ss had been instructed to designate the "sides" rather than the front and back, would they have produced the "best" solution by drawing lines creating symmetrical "side" sections with asymmetrical front-back sections? Though we assume that symmetry is a cue defining "sides," adults may not be able to use this cue so consistently as they use asymmetry in distinguishing front and back. This might be a source of difference between adults and children, with children perhaps less responsive to symmetry as a cue for "side."

Once we establish the generality of these various findings, the next and, for us, most interesting question is, *when* in an individual's lifetime do these cues for front and back become operational? Will children who can identify the fronts and backs of realistic objects be able to identify the fronts and backs of unfamiliar, simple forms as well? The defining characteristics of front and back of realistic, familiar objects are usually far more abundant (that is, for realistic objects, front-back identification is overdetermined). Children may need more cue redundancy than adults do.

The orientation of the form might be a point of

difference, too, between adults and children. When the children in the experiment mentioned earlier (Harris & Strommen, 1972) were asked to place one object (mobile object) in front of, behind, or beside another (fixed) object that *had* front-back features (e.g., doll, toy, truck), the children all made their placements in proper relation to the distinguishing features of the fixed object, irrespective of the fixed object's orientation in relation to their own bodies. But if children need more cue redundancy than is provided by such minimally specified stimuli as were used in the current study, their judgments might depend on the location of the feature in relation to their own bodies.

We intend our analysis of both motion and symmetry cues to be in the spirit of both Gibson's (1966) theory of "direct perception" and—in particular regard to motion cues—Michotte's (1956) theory of the perception of causality. In one of Michotte's basic paradigms, two spots of light were projected onto a screen, one spot ("B") in the middle, the other ("A") to the side. The Ss were told to fixate "B." At a given moment, "A" set off and moved toward "B." It stopped at the precise moment when it came into contact with "B," while "B" then started and moved away from "A." The Ss reported seeing "A" "bump into object B, and send it off . . . shove it forward . . . give it a push . . . [Michotte, 1956, p. 20]." Michotte stresses that this perception is not an "interpretation" "superimposed on the impression of movement; in other words, what is actually 'given' is not a mere representation or a symbol of causality [Michotte, 1956, p. 21]."

Michotte's Ss also often "animated" the spots of light, attributing to them characteristics of aggressiveness, fear, duplicity, and the like. Movement, under certain finely controlled circumstances, thus seems to be sufficient to give rise to the transformation of the spots of light into living, conscious, and planful things. Since living, planful, conscious things ordinarily have front sides (face sides), it is our guess that the perception of face sides on these spots of light was irresistible, and that the face side was the side toward which the movement was directed.

The major difference between Michotte's demonstrations and our own is that Michotte's Ss needed only to report what they "saw" on the screen. Their perception was immediate and, apparently, compulsory. They did not seem to have a "choice" about what they saw. In contrast, our Ss were asked to

perform an act of imagination, our plan being to discern whether and how we could bias the results of that act through the design of the forms. The results indicated that the Ss were predisposed to see the direction of movement in the direction of the feature because, we conclude, that side was seen as the "front" of the form. However, though we emphasize that Ss interviewed afterwards reported having responded instantly, that is, as *not* having had to deliberate or "interpret" when they first looked at the form, our Ss undoubtedly could, if so instructed, have imagined the forms to be moving in a direction opposite to the feature. In this case, we surmise, either the opposite side would be seen as "front" or the form would be seen as moving backwards. In either case, we think the act would have been more effortful because the imagined direction of movement would compete with the feature cue.

In a study with children now in preparation, we are trying to assess both the roles of actual motion and asymmetry in the specification of "front" and "back." The child will be shown a cube with a small sphere attached to one side. The cube will be made to move along the asymmetrical axis and in the direction of the sphere. Will the child then follow instructions to place a second cube "in front" of the first cube by putting it on the side of the sphere? Such a placement would suggest that seeing the cube move in a certain direction functions to define the front-back axis for the child. We therefore would have some evidence that, for children, direction of movement is a cue for front and back. The same procedure will also permit systematic comparison of the relative influence of symmetry and movement cues by pitting symmetry and movement cues *against* each other.

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