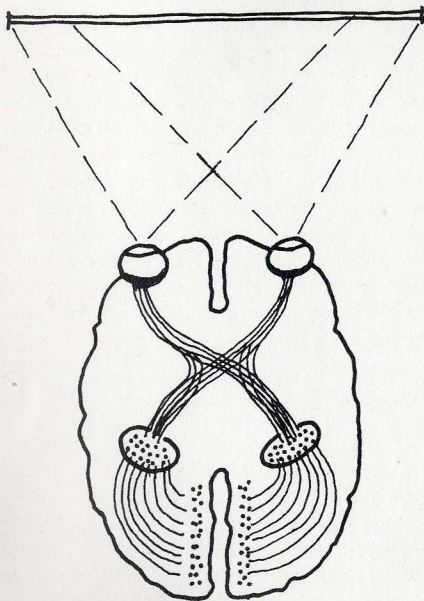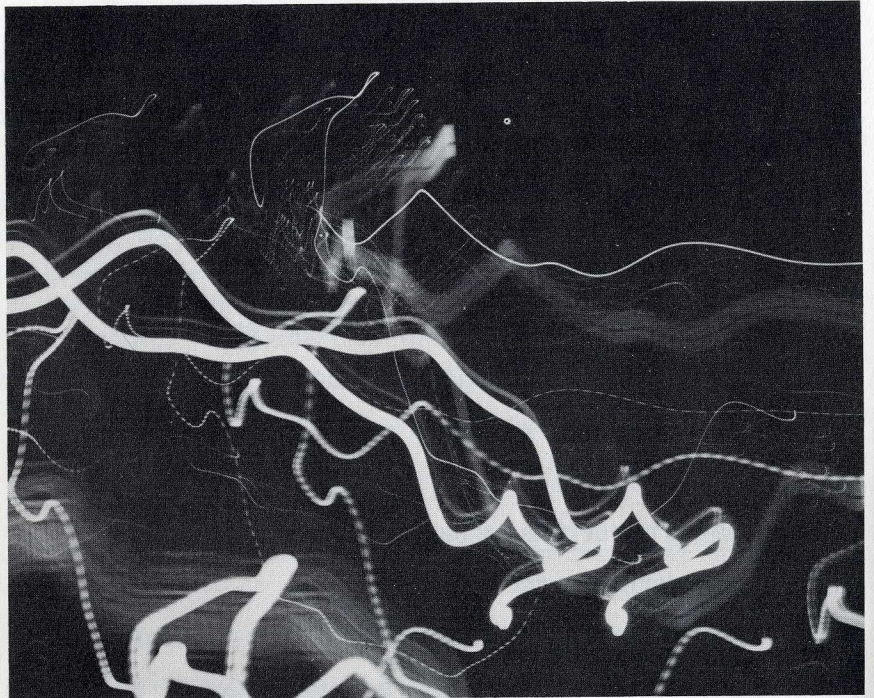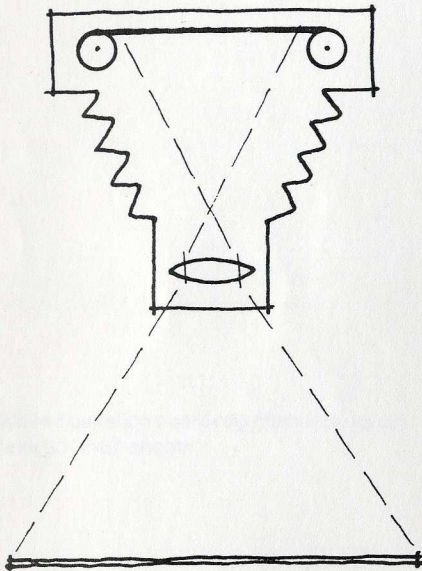# Problem 1

The optical mechanism of the camera provides a two-dimensional *record* of light-events in time and space.

Photograph by Kenji Thiel

The mobile perceptual system of the eye and brain interprets available light information to derive denotational, connotational, and prescriptive *meanings* in the context of time, place, and occasion.

For an example of the wide range of meanings which may be ascribed to an available pattern of light-energy, consider the following description (of a domestic interior) from a classic children's book:

"The floor was well-worn red brick, and on the wide hearth burnt a fire of logs, between two attractive chimney-corners tucked away in the wall, well out of any suspicion of draught. A couple of high-backed settles, facing each other on either side of the fire, gave further sitting accommodation for the socially disposed. In the middle of the room stood a long table of plain boards placed on trestles, with benches down each side. At one end of it, where an arm-chair stood pushed back, were spread the remains of the Badger's plain but ample supper. Rows of spotless plates winked from the shelves of the dresser at the far end of the room, and from the rafters overhead hung hams, bundles of dried herbs, nets of onions, and baskets of eggs. It seemed a place where heroes could fitly feast after victory, where weary harvesters could line up in scores along the table and keep their Harvest Home with mirth and song, or where two or three friends of simple tastes could sit about as they pleased and eat and smoke and talk in comfort and contentment. The ruddy brick floor smiled up at the smoky ceiling: the oaken settles, shiny with long wear, exchanged cheerful glances with each other; plates on the dresser grinned at pots on the shelf, and the merry fire-light flickered and played over everything without distinction."

—Kenneth Grahame, *The Wind in the Willows* (New York: Charles Scribner's Sons, 1933)

Form Perception

Some evening while you are downtown (where the lights are bright), bring your camera and take a variety of time-exposures as you stroll about. You will get some interesting "abstract" photos, but hardly anything that looks like what you saw while you were there. Why?

You and your camera were in the same environment and were both exposed to the same scene. The second-by-second patterns of radiant energy available to your eyes and to the camera lens were essentially similar, yet you saw objects in space while the camera registered only streaks and blurs of light. The reason is, of course, that although the time-patterns of light reaching the retina of your eyes and the surface of the film were analogous, the camera does not have a system to process this sensory material and make something out of it.

In this problem we will examine some of the conditions under which the brain does (or does not) "make something" out of an environmental scene.

"The fact that the eye has a lens that forms an image on the retina leads at once to an analogy to a photographic camera, and it may be true that knowledge about the eye led to the addition of a lens to the 'camera obscura' to improve its image. The analogy, however, is very misleading in that it suggests that the mind sees the image so formed.

"A somewhat better, although still misleading, analogy is to a television camera. In this the scene is scanned constantly, point for point, at high frequency. Thus its image is transient and constantly being renewed. In a way this resembles the rapid 'saccadic' movements of the eye that make it constantly traverse boundaries and, to some extent, the frequent blinking of the eyelids. Modifications of the image in the circuitry in television, particularly the so-called 'crispening' circuits, may also have close parallels in vision, but little is gained by pursuing the analogy. . . .

"The analogies with photography and television break down because it is not the image formed by the eye lens that we see. The image of a room, or any other situation, is in the mind. Any details in that image, except the very broadest, have been built up by successive glances directly *at* these details; both the details and the broad image are retained by the mind for as long as they are wanted and then as quickly erased. The optical image is constantly changing and moving as the eye jerks rapidly from one point to another; the mental image is stationary for stationary objects regardless of the eye motion, or, for that matter, the motion of the head or of the person."

—Ralph M. Evans, *The Perception of Color* (New York: Wiley, 1974)

See the following books by James J. Gibson: *The Ecological Approach to Visual Perception* (Boston: Houghton Mifflin, 1979), and *The Perception of the Visual World* (Boston: Houghton Mifflin, 1950). See also Carolyn M. Bloomer, *Principles of Visual Perception* (New York: Van Nostrand Reinhold, 1976); J. S. Bruner, "On Perceptual Readiness," *Psychological Review* 64 (1957): 123-52; R. L. Gregory, *The Intelligent Eye* (New York: McGraw-Hill, 1970); and R. L. Gregory, *Eye and Brain: The Psychology of Seeing* (New York: McGraw-Hill, 1970).

Materials

20″ x 30″ white illustration board, as specified in the list of materials

Casein glue, knife, metal straightedge

Drafting equipment, scale, pencils

White construction paper

Black and white tempera paint, brushes, etc.

One yard (3′ x 3′) of black-and-white patterned cloth

Procedure

Phase A

Construct three 4″ cubes of white illustration board. A "cube" is taken here to mean a three-dimensional opaque solid form bounded by six identical square surfaces. The "tolerance," or allowable variation from the 4″ dimension, is ±1/16″. In other words, your cubes should go through an opening 4 1/16″ square but should not go through an opening 3 15/16″ square. (A pair of such go/no-go gauges made of plywood or masonite should be available for this test. Note that each cube must be tested in three orientations with each gauge.)

Your subproblem here will be to devise ways of accurately cutting the panels, jointing the edges, and assembling them into cubes. It may be expedient to make some "trial and error" experiments first, and certainly you can collaborate with your classmates on this.

Gauges made of ⅛″ tempered Masonite or ¼″ plywood.

4 1/16″ square — GO GAUGE

3 15/16″ square — NO-GO GAUGE
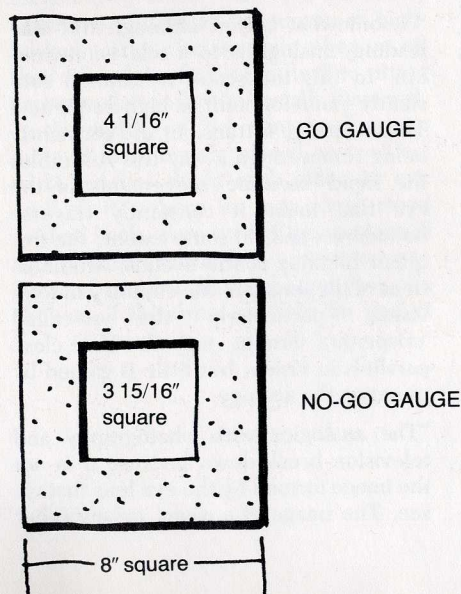
8″ square

Phase B

Using only paint, (a) treat one cube so that visually it either disappears as a form, *or* becomes unrecognizable as a cube; and (b) treat another cube so that it appears to be a "three dimensional opaque solid form bounded by identical square surfaces," when in each case the cube is placed in a random manner against your irregularly draped piece of cloth as a background.

In both cases the physical form of the cube is to be preserved, and in feeling them a blind person should perceive no difference. But to a normally sighted person one cube should be practically invisible, or unrecognizable as a cube, when seen in the given context; and the second cube should appear to be the epitome of cubicity under the same conditions.

At this point (with reference to the flow chart of the design process described in Introduction B, Design and Designers) the context and constraints have been *identified,* and the goals and criteria *specified.* Your task now is to *hypothesize* the first of many tentative solutions to (either part of) the problem.

You should quickly *simulate* your idea by painting it, freehand, on white paper taped over three sides of one of your cubes; and *test* this idea in position against your cloth backdrop.

But how can you evaluate your design? In Phase A there was an objective test: assuming that the cubes held together in normal handling, each one either would "go" in three orientations with the appropriate gauges, or it would not, and that was the end of the matter. However, here in Phase B there are no "objective" gauges, and although quite possibly you will subjectively feel that there is some merit in your design hypothesis, you (should!) have a nagging suspicion that it may not be the best idea of which you are capable.

Thus a different evaluation procedure is necessary. The method is to hypothesize an alternative solution: not just a minor variation of your first one, but a basically different concept; and simulate it just as in the first case. Then *compare* the two alternatives simultaneously, side by side in the context of the cloth. Undoubtedly, one will appear to be better than the other, and, from a consideration of the reason why this is so, some further ideas will occur to you.

By now you certainly get the picture, and begin to realize that design is an *active* process, involving continuous simulation. By your use of this process of hypothesis, simulation, testing, and simultaneous comparison of adjacent alternatives, your designs will quickly evolve in effectiveness. As you evaluate the alternatives, you will become increasingly confident that you are not overlooking any good bets.

By following your time schedule, you will be able to spend the maximum amount of time on design development, and still have adequate time to rank your hypotheses and prepare your final presentation, painted on all six sides of the cubes. Then, for the meeting of the Raspberry Club convened to review the class performance on this problem, we will employ a similar process:

1. With a table placed next to a wall, three, four, or five persons should pin and drape their cloth on the wall and over the table in irregular folds, so as to provide a series of adjacent backdrops for the display of the cubes.

2. Each person should place one cube representing his or her solution of the form-concealment problem in a "random" manner against the appropriate backdrop.

3. A concurrent, side-by-side comparison of these several solutions is then made, with the intent of ranking the several designs in order of effectiveness.

4. This sequence of steps is repeated for a similar consideration of the second set of cubes which were prepared so as to display their form.

This procedure provides a reasonable means for the relative evaluation of different design hypotheses, and can be generally applied in all other problem areas where "absolute" measures (such as "go/no-go" gauges) do not exist, or where subjective criteria are involved. It should be used for all the problems in this course—in both the public assessment of the "final" presentations, and prior to that in your personal assessments of your simulations. It will be clear to you now that this side-by-side comparison is a means by which you can evolve a series of better and better solutions converging toward an optimum resolution of the problem. Note that it requires the simultaneous, adjacent presence of several tangible alternatives. This brings us to the three magic words in visual design:
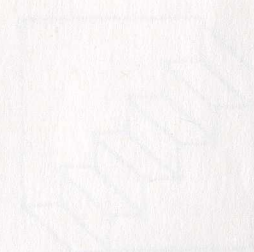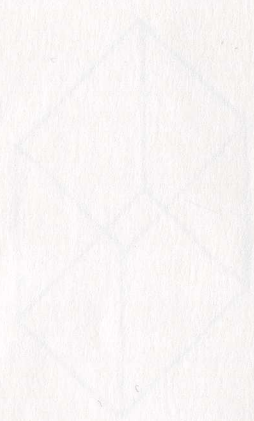
COMPARE ADJACENT ALTERNATIVES
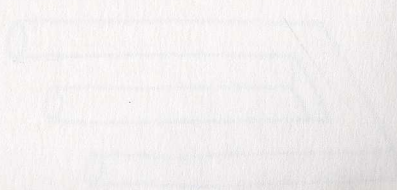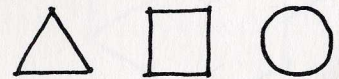
Discussion

What does this exercise tell us about form perception?

First let us consider the following: tourists arriving in London for the first time and wishing to send postcards home may have some difficulty in finding a place to mail them. Eventually they will discover that the British mailboxes are large vertical cylinders painted a bright red and embossed with the royal initials. After making this discovery, they will have no trouble in "seeing" a mailbox the next time they need one. But note that mailboxes were present in the visual environment before our tourists made this discovery. They did not *perceive* them to be mailboxes until some additional knowledge became available to them. Perception, defined as "the ascription of meaning to one's environment through the interpretation of sensory data," can now be understood (given both a functioning sensory system, and adequate illumination) to depend on:

1. empirical experience or prior knowledge serving to support your interpretive hypothesis,

2. the situational context and your perceptual "set,"

3. your personal needs or interests, and

4. the visual context, and the patterning of the elements in the visual field.

Thus in London if you see someone drop a letter in a large red vertical cylinder embossed with the royal initials, your hypothesis that the object is a mailbox will be reinforced; such highway signs as "Deer Crossing" or "Rocks on Highway" are warnings provided to alert you, or change your "set," so that you will be more likely to see these hazards; if your stomach is empty or your bladder is full you will be more likely to notice means for relief in either department; and if the British mailboxes were not painted to contrast with the usual colors of the British streets, they would be much harder to see.

In the case of our exercise we were all familiar with the concept "cube" and had an image of what a cube is. We knew that all our cubes were physically identical (± 1/16″), we were looking for cubes, and we expected to see cubes; yet in many cases one set of cubes was "hard to see."

To explain this you must understand, first of all, that the only "material" of visual perception that enters our eyes is radiation in the electromagnetic spectrum between 400 and 700 millimicrons in wavelength. This energy reaches our eyes directly from light sources, and/or indirectly as reflections from illuminated surfaces in the environment. In all cases this light-energy is modulated, or *patterned,* in both its spatial and temporal dimensions by the interaction of the specific light sources in reflection, refraction, and diffraction with the atmosphere and the environmental surfaces. If no radiant energy reached our eyes, or if the energy reaching our eyes were unpatterned and uniformly distributed in space and time, we would see "no-thing," or no event. But any modulated pattern of light-energy that does reach our eyes, because of its environmentally caused differentiation, carries latent information about that environment. Visual perception is thus the process of decoding the latent environmental information contained in the space-time pattern of light energy reaching our eyes. We can also say that visual *design* is the purposeful modulation of the light-energy reaching our eyes, as accomplished by our interventions in the environment.

To perceive, then, we must interpret the fluctuating pattern of light-energy that constitutes our field of view. We attempt to make sense of, or find meaning in, this sensory raw material by creating the simplest organization of the elementary units of this pattern that is in accordance with our situation and set, our current needs and interests, and our past experiences. Sometimes the patterns may be interpreted in several different ways, as illustrated by the so-called "ambiguous figures" which, as we study them, tend to fluctuate between alternative explanations.

In other cases the information is contradictory and no reasonable interpretation is possible, as illustrated by the so-called "impossible" forms.
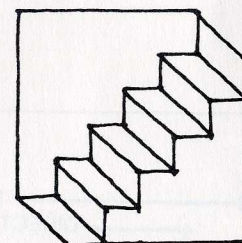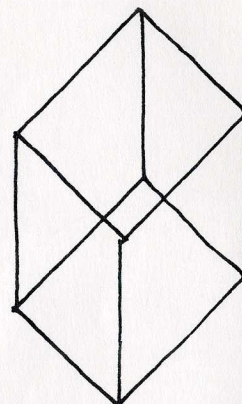

Ambiguous or reversing figures. (Which corner, edge, or surface is nearest to you? When?)

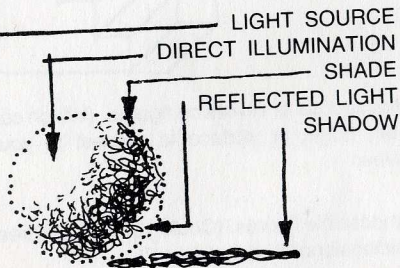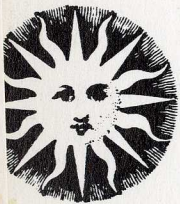Impossible figures. (Could you build a three-dimensional model of them?)

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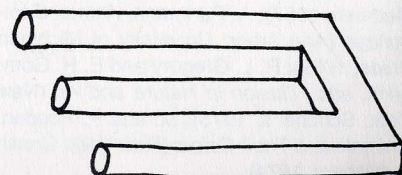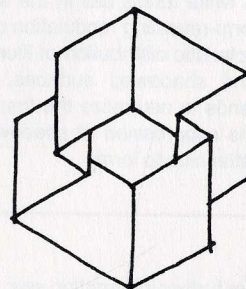
The principles underlying this creative assemblage of the elementary pattern units have been described by the Gestalt psychologists in the "laws" of perceptual organization. We will study them later, in Problems 8 and 16.
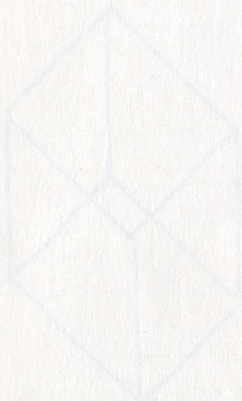
In some instances our interpretation is correct, as far as it goes, but "there is more 'there' than meets the mind." This occurs when the elementary units of the patterned field have such a strong visual relationship to one another that we are unable to organize them into an alternate arrangement. Such a suppression of perceptual alternatives, of course, is called camouflage, and is an important technique in animal survival and military disguise. By reviewing some applications we may illustrate this principle.

In general there are six types of camouflage. The first, called **somatolysis,** or "body dissolution," describes the situation where the size, shape, and color-patterning of the surface of the object to be concealed are similar to that of its usual background environment, and have no reference to the form, edges, or contours of the object itself.

When the object must appear in a variety of environments, and under different lighting conditions, another approach is indicated. This is called **disruptive coloration,** or "dazzle painting," in which strongly contrasting colors are applied in bold, irregular patterns across the several different parts of the object in contradiction of the actual form.

LIGHT SOURCE
DIRECT ILLUMINATION
SHADE
REFLECTED LIGHT
SHADOW

A third method is called **countershading.** Here the form-revealing interaction of an object with the light source is negated by the use of a light color where a shaded surface would normally occur and a dark color where a lighter surface would usually appear.

A white tennis ball in the sun illustrates the form-revealing modulation of light by a characteristic distribution of illuminated, shaded, and shadowed surfaces. Countershading tends to neutralize the first two effects, and the suppression of shadows eliminates the latter clue to form.

A fourth type of disguise takes place in several ways: by means of the **suppression of** form-revealing **cast shadows** through the crouching or flattening of an animal on the ground; by an orientation to the light source such as to minimize an object's cast shadow; or by the use of flaps or screens to break up the shadow.

For further information see: H. B. Cott, *Adaptive Coloration in Animals* (London: Methuen, 1957); A. Portmann, *Animal Camouflage* (Ann Arbor: University of Michigan Press, 1959); R. L. Gregory and E. H. Gombrich, eds., *Illusion in Nature and Art* (New York: Scribner's, 1975); M. and P. Fogden, *Animals and Their Colors* (New York: Crown Publishers, 1974).

The remaining types of camouflage involve either the use of *masks* or the *imitation* of the form of other objects, neither of which interests us here.
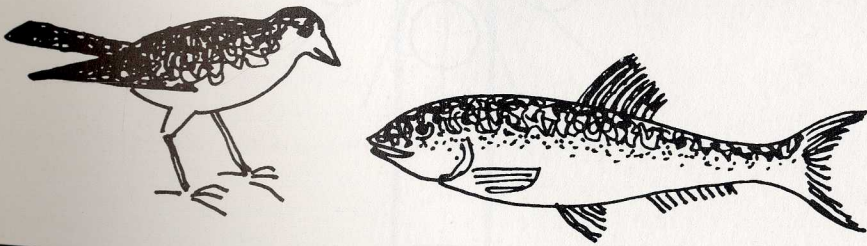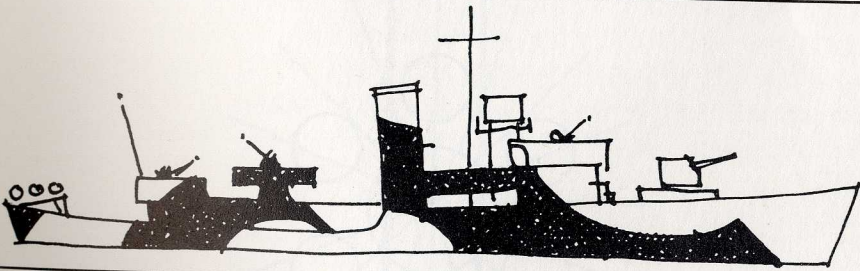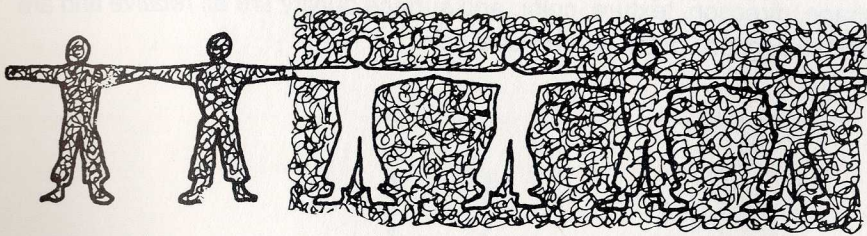
SHADOW

In any event it is important to realize that our mobile perceptual system, involving both the eyes and the brain (in point of fact, the retina of the eye is actually a part of the brain), deals with *all* the visual data or clues present in the visual field in a given situation. Like a detective trying out a number of hypotheses to account for all the data, it comes up with that probabilistic "explanation" which we call a perception.

The dependence of perception on context can be readily illustrated by a number of demonstrations. The point of these visual illusions is to emphasize that there are no absolute visual attributes: size, position, number, shape, direction, texture, color, and surface quality are all *relative* and are partial functions of the entire visual field.
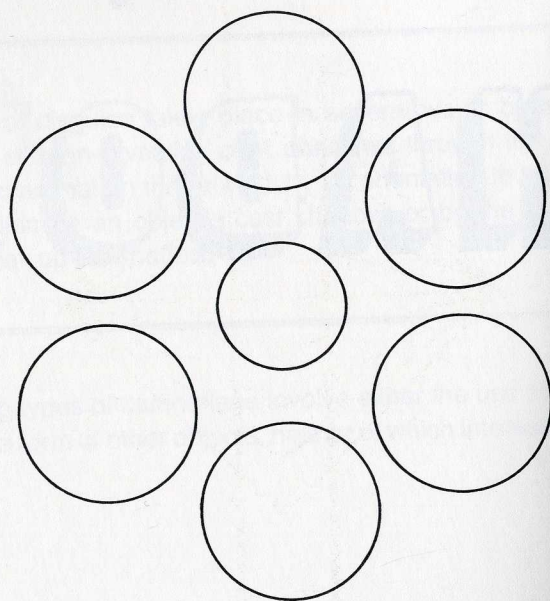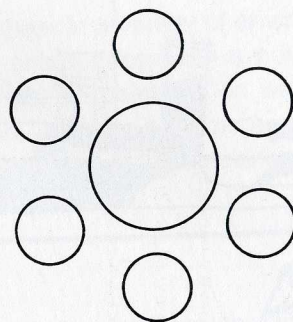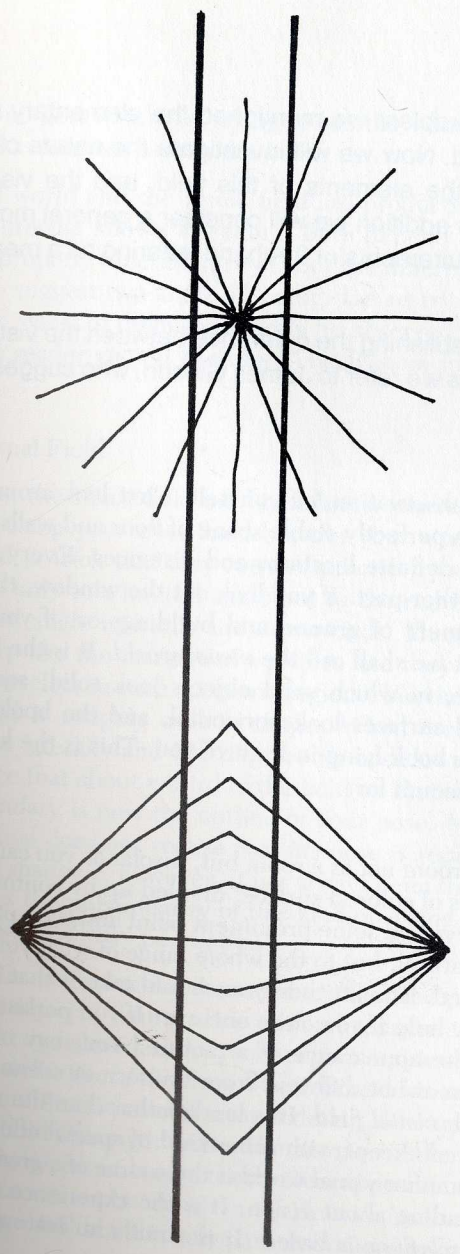
Visual illusions of size and shape. (Are the inner circles the same size? Are the vertical lines straight and parallel?)

For further information on visual illusions, see Matthew Luckiesh, *Visual Illusions* (New York: Dover, 1965); Richard Gregory, "Visual Illusions," *Scientific American,* November 1968; and Barbara Gillam, "Geometric Illusions," *Scientific American,* January 1980.