CHAPTER 5

Reception strategies in concept attainment

Up to this point, our concern has been almost exclusively with the means whereby an individual may *select* instances in such a way as to isolate easily and efficiently the attributes that are useful for inferring a conjunctive grouping. What is perhaps most distant from life about this procedure is its Olympian quality. The universe is spread before one and one has freedom of choice as to what one will take as an instance for testing. There are perhaps times when an experimentalist in science has the good fortune to work on problems that have this feature. More likely, his plight is that he must make sense of what happens to come along, to find the significant groupings in the flow of events to which he is exposed and over which he has only partial control. *His major area of freedom is in the hypotheses he chooses to adopt, not in the manner in which he can choose instances to test.* The clinician's condition is perhaps more typical than that of the experimentalist.

Take again as an example the problems of neurophysiology, familiar from the last chapter. A clinical neurologist in the course of his practice encounters a patient with a damaged brain exhibiting the set of speech defects called aphasia. Now the concept of aphasia need not be "formed" for it already exists. The aphasia case is referred to him by an examining diagnostician. The diagnostician's statement that the case "shows aphasia" is the criterion of a positive instance. The research neurologist is now trying to find out about the neural correlates of aphasia. He must, in other words, seek the neural defining attributes of the class of patients known as aphasics. If one wishes to say that the neurologist is trying to find the "causes" of aphasia, this in no sense changes the basic problem, which is to find

what neural conditions lead to the inference of aphasia with maximum certainty.

If the experimentalist were engaged in such a pursuit and could find laboratory animals capable of speech and on whom surgery might be performed, then he would be in a position to act much as our subjects of the last chapter. This would take the form of systematically removing areas of the brain in certain combinatorial orders until the answer was forthcoming. But the clinician has to take his cases as they come. He must employ a *reception strategy.*

Let us begin at the beginning of modern neurology by taking Paul Broca as our subject: a gifted neurologist of the mid-19th century.* He has a chance to carry out an autopsy on an aphasic patient. He finds massive damage in that portion of the brain at the base of the third frontal convolution (since named, in his honor, Broca's area), "the speech center." But this describes only part of the properties of the "instance." For Broca's exact description of the patient's lesion shows a softening of the brain in the left hemisphere all the way from the frontal lobe dorsally to the parieto-occipital junction, extending downward as far as the superior portion of the temporal lobe. One can sum this up more simply by saying that there is much more destroyed than Broca's area alone. It is at this point that Broca is able to exercise his major freedom: the freedom to formulate an hypothesis. He could attribute the aphasia to *all* of the destroyed areas or to any part thereof. He takes his option and proposes that aphasia is caused by damage to a speech center: the famous "Broca area." Perhaps there is reason in the fact that this is the area of most concentrated degeneration. Nonetheless, the die is cast. The neural defining attribute of aphasia is this particular "speech center."

At the other extreme we have Flourens, who adopts another option. No *specific* lesion is taken as a defining attribute of aphasia. If the aphasic's brain shows specific damage, it is the interaction of the damaged areas and the intact areas together that create the final common path of aphasia.

What is of great interest about these two innovators is that each has a line of descendants, call them the localists and the totalists. The former seek always a specific area where possible: some set of limited defining attributes, adding new attributes only when forced by the

---

* In the interest of exposition, we shall take certain liberties with the history of this complex field. If the reader finds that our historical license leads us to over-exaggeration, he will, we hope, forgive us and treat our examples as fictional rather than real figures.

burden of much evidence. The list of localists, requiring oversimplification in its compiling, includes such names as Fritsch, Hitzig, Bianchi, Flechsig, and Adrian. The totalists have wanted to stay as close as possible to the whole cortex as an explanation, and it is only with the greatest reluctance that they will subtract any of its attributes as irrelevant. Here too we find a distinguished list: Goltz, Munk, Hughlings Jackson, Head, Goldstein, Lashley. The interesting thing about each group is not only that they attempt to proceed as they do but that they urge the absurdity of proceeding in any other way.

In point of fact, one could begin either way—adopting either a part or a whole hypothesis—and arrive at the same conclusion provided one did not become rigidified before the process of proof was completed. Here we must leave real neurology, for the issues are too tangled. But if one works with the kind of schematization used in the last chapter, it is possible that, when one encounters an aphasic, one may base an hypothesis on the state of *all* areas or upon the state of *one* particular area. What is even more important than the starting hypothesis is what one does with it when one encounters new instances that differ from it. For an hypothesis is not a final declaration so much as it is something to be tried out and altered. We shall be considering in this chapter the manner in which, in the kinds of problems we have been discussing, hypotheses are changed to conform to the arbitrary stream of events to which they are exposed.

The first and obvious thing about an hypothesis is that it can have any one of four fates when exposed to a new event to which it is relevant. Let us bring Paul Broca back on the scene. He has declared his hypothesis on the relevance of the speech center. Each new patient he sees can have his speech center intact or destroyed. Again, each patient he sees must either have the symptoms of aphasia or not have them. Broca's world, then, is made up of four contingencies.

	Speech Area	Symptomatology
1.	Destroyed	Aphasia
2.	Intact	Aphasia
3.	Intact	No aphasia
4.	Destroyed	No aphasia

It is apparent that two of the contingencies confirm, or at least fail to infirm, Broca's hypothesis. A patient with the speech center destroyed and the symptoms of aphasia confirms it. One with the center

intact and without aphasia at least fails to infirm his hypothesis. Two of the outcomes are damaging to Broca's hypothesis. A patient with speech center intact and aphasia is as infirming as one whose speech center is destroyed but who shows no sign of aphasia. Let us adopt the language of medicine, for the moment, and speak of any case as positive which shows the signs of illness we are investigating; its absence negative. Whether it is positive or negative, a case can confirm or infirm the hypothesis in force. In this fashion of speaking, then, the four contingencies that Broca can meet are:

1. Positive confirming: Aphasic with speech center destroyed.
2. Positive infirming: Aphasic with speech center intact.
3. Negative confirming: Nonaphasic with speech center intact.
4. Negative infirming: Nonaphasic with speech center destroyed.

A good reception strategy consists in being able to alter hypotheses appropriately in the face of each of these contingencies. At an even more primitive level, obviously, it consists in being able to recognize their existence and to formulate hypotheses in such a way that, whatever the contingency met, one will know how and whether to change one's hypothesis.

A PARADIGM AND TWO STRATEGIES

Three things are required to reproduce in the laboratory a task comparable to the examples we have given. *First,* one must construct an array of instances that are alike in some respects and different in others, so that there are multiple ways in which the instances in the array may be grouped. *Second,* instances must be encountered by the person in an order over which he has no control. *Third,* the subject must know whether each instance is positive or negative in the sense of exemplifying or not exemplifying a concept. *Fourth,* the subject must be given freedom to formulate and reformulate hypotheses on each encounter with an instance. Given these requisites, a task is easily set. A grouping or a concept to be attained is chosen, and the subject is shown in succession exemplars and nonexemplars of this concept. His objective is to formulate an hypothesis that will distinguish an exemplar from a nonexemplar among the instances he encounters.

We begin with instances such as those illustrated in Figure 1, composed of the combinations of three values of each of four attributes—cards each showing four properties, such as "two red squares and three borders" or "one black cross and two borders." We decide upon

a "concept:" say "all black figures." We present one instance at a time to the subject, telling him whether or not it exemplifies the concept, whether it is positive or negative. After each card, the subject is asked to indicate his best hypothesis concerning the nature of the correct concept. Thus, following the presentation of any given card, he offers an hypothesis. The experimenter makes no comment. The next card the subject encounters must perforce represent one of the four possible contingencies. It may be *positive* or it may be *negative*. Whether it is one or the other, it also has the property that it *confirms* or *infirms* the subject's previously held hypothesis about the nature of the correct concept.

Before examining the behavior of subjects dealing with such problems, it is perhaps well to consider the ideal strategies that are applicable. Logically, they are identical to the strategies discussed in the last chapter. First, there is a focussing strategy which, as before, is useful both for maximizing information yield and for reducing the strain on inference and memory. The surprisingly simple rules for the alteration of hypotheses with this strategy are best presented with the aid of an illustration.

The clinician begins, let us say, with an aphasic showing a badly damaged brain—Areas I to VI destroyed. He takes as his first hypothesis that destruction in *all* six areas must be responsible for aphasia. If he should encounter a positive-confirming instance (another aphasic with like destruction), he maintains the hypothesis in force. If he should meet a negative-confirming instance (a non-aphasic with some or all of the areas intact), he still maintains his hypothesis. The only time he changes is when he meets a positive-infirming instance. An example of one such would be an aphasic with Areas I to III intact, and Areas IV to VI destroyed. Under these circumstances, he alters his hypothesis by *taking the intersect between his old hypothesis and the new instance:* those features common to the two. The features common to the old hypothesis and the new positive instance can be readily seen:

Old hypothesis: Areas I, II, III, IV, V, VI destroyed produce aphasic.
New positive instance: Aphasic with Areas I, II, III, intact; IV, V, VI destroyed.

Thus the clinician chooses as his new hypothesis: "Areas IV, V, and VI destroyed produce aphasia."

Now consider the rules in their barest form. The first one is of central importance. *Take the first positive instance and make it in*

toto *one's initial hypothesis.* From here on, the rules can be simply described. They are:

	Positive Instance	Negative Instance
Confirming	Maintain the hypothesis now in force	Maintain the hypothesis now in force
Infirming	Take as the next hypothesis what the old hypothesis and the present instance have in common	Impossible unless one has misreckoned.* If one has misreckoned, correct from memory of past instances and present hypothesis

By following this procedure, the subject will arrive at the correct concept on the basis of a minimum number of events encountered. The strategy has only two rules in addition to the initial rule that one begin with a positive instance *in toto* as one's hypothesis. These two rules are:

1. Consider what is common to your hypothesis and any *positive-infirming* instance you may encounter.
2. Ignore everything else.

It is apparent, of course, that focussing in the present case is analogous to the focussing strategy under conditions where the subject chooses the order of the instances that he will consider. In both types of problems, the first positive card encountered is used *in toto* as a guide, in the reception case as the basis for all subsequent hypotheses, and in the selection case as the point of departure for all subsequent choices of instances whose positive or negative character will systematically delimit the concept. In focussing where one chooses instances, the problem-solver tests attribute values of the focus card one at a time as a means of seeing which features of the initial focus card are relevant to the concept. In the reception case, one embodies this focus card in one's initial hypothesis and then evaluates its attribute values in the light of subsequent instances encountered.

In the interest of brief nomenclature, we shall refer to the ideal strategy just described as the *wholist strategy* since it consists in the adoption of a first hypothesis that is based on the whole instance initially encountered, followed by an adherence to the rules of focussing just described. From time to time, we shall also use the expression *focussing* to describe the strategy.

---

* For a fuller exposition of this point, see pages 149–150.

Broca or a Flourens from problem to problem and from contingency to contingency.

2. The second is to examine change in performance over a long series of problems varying in the cognitive strain they impose.

3. Finally, we wish to raise some questions about the effectiveness of the two strategies under varying work conditions. We know, for example, that scanning is more dependent upon memory and inference that is focussing. What difference does this make for success and failure in attaining concepts?

AN EXPERIMENTAL DESIGN

Our experimental operations can be sketched rapidly so that the present design may be contrasted with some of the classical studies. At the outset the nature of the task is fully described for the subject. As noted earlier, an array of instances is constructed. The subject is presented instances from this array one at a time, and each is designated as either positive or negative. The first instance presented is always positive. The subject is asked after each instance to state his hypothesis concerning the correct concept: what it is that the first positive card exemplifies. Instances are presented until the subject has had at least as many instances as would be required logically to eliminate all hypotheses save the correct one. At no time does he have more than one instance before him, and should he ask about instances previously encountered, the experimenter demurs. No such aids as paper and pencil are permitted him. Moreover, it is explained at the outset just what it is about the instances that need be considered: the shape of the figure they contain, the color of these figures, their number, etc.*

For the reader not well acquainted with the literature on concept attainment, we should like to point out here several crucial differences between the conduct of this experiment and of classical experiments in this field which have also used arbitrary sequences. First no effort was made to conceal the nature of the subject's task. He knew that his job was to find out the "correct concept." He knew what a concept was: a grouping of instances in terms of common properties. He knew what properties of instances were worth considering. And he knew, finally, that what he was seeking was a conjunctive concept, and that only one concept was to be attained in each problem.

* We are particularly indebted to Mrs. Mary Crawford Potter for aid in designing and executing this experiment as well as devising techniques of analysis for it.

In these respects, the procedure differed from the procedure originally introduced by Hull (1920). In the Hull procedure, the subject was *not* told what his task was. Rather the task was presented as a study in rote learning. The subject had the task of learning to associate names or nonsense syllables with instances that were presented to him. There might, for example, be five different concepts, illustrated by an array of instances; and the subject's task was to "learn" that particular cards were labeled "DAX," others "CIV," etc. If he did not figure it out for himself, he might never realize that "DAX" cards were so labelled because they shared certain common attribute values. The test of whether the subject had attained the concept was, at least in Hull's study, whether the nonsense syllables could be applied to a series of new cards that illustrated the various concepts but which had not been presented before. In sum, *incidental* concept attainment was being studied. William James urged that the psychology of religion begin with the investigation of "the most religious man in his most religious moment." We wanted at the outset to see concept attainment at its best.

There is one other crucial difference between our procedure here and earlier ones, a difference whose importance has already been lucidly remarked upon by Hovland (1952). In studies inspired by Hull's procedure, it was not made clear to the subjects what it was about the instances presented to them that might be relevant. The different attributes and their values were, in short, left uncontrolled. Thus, Hull used a set of pseudo-Chinese characters, a particular radical of which was the defining attribute of the correct concept. It is apparent that the number of attributes a subject might consider as possibly relevant are close to limitless: any component stroke, angularity, or curvedness of components, thickness of strokes, crowdedness of strokes, number of right angles, number of strokes, number of disconnected lines, width, length, and symmetry of characters, predominance of vertical or horizontal strokes, "movement" or "stillness" of the arrangement of strokes.

So long as the experimenter does not know to which and to how many component attributes the subject is attending, it is impossible to control or understand the amount of information being presented to the subject by any one instance or combination of instances. One cannot know when the subject has had an informationally adequate series of instances—adequate to eliminate all but one, the correct concept. Nor is it possible to study the effect of the number of defining attributes in the concept as compared to the number of noisy irrelevant attributes. To be sure, the use of such characters in concept-attain-