INTERACT WITH PSYCHOLOGY 2

FIFTH EDITION

Volume 2 of a personalized instructional system for introductory psychology, developed by the Northeastern University Psychology Department

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Contents

Introduction ................................................................. vii

1 Some Contributions of Psychology to Education I
   The Technology of Teaching ........................................ 1

2 Some Contributions of Psychology to Education II
   The Personalized System of Instruction ......................... 35

3 Brain and Behavior ..................................................... 63

4 Individual Behavior Disorders ....................................... 107

5 Self-Control .................................................................. 151

6 Personal Behavior Problems and Self-Control .................. 193

7 Social Behavior Disorders ............................................. 229

8 Visual Perception and Behavior ....................................... 267

9 Physiological Psychology and Visual Perception .............. 303

10 Ethology* .................................................................... 333

Multiple-Choice Self-Test Answer Keys ......................... 377

Index ........................................................................ 379

*The word ethology may be unfamiliar to you. It refers to a method of investigating animal behavior, usually in the animal’s natural environment.
CHAPTER 3

BRAIN AND BEHAVIOR

With the exception of study and review questions and occasional explanatory material, the following material was taken from the indicated sources.

PART 1: Behavior and the two halves of the brain


Some of this material also reflects studies of aphasic patients conducted by M' Sidman, L.T. Stoddard, J.P. Mohr, P.B. Rosenberger, and J. Leicester.

What people do is related not only to the world around them but to the world within them as well. Correlated with our external behavior are the activities of sense organs, muscles, glands, nerves, and other body organs. Our brain, because of its complexity and its obvious involvement in almost everything we do, has challenged our curiosity for centuries. Chapter 3 will introduce some basic and particularly interesting relations between brain and behavior.

Some of the most startling discoveries about the way the brain influences human behavior have occurred as the result of work done by Sperry and Gazzaniga with patients who underwent a particular type of brain surgery. In Part 1, Sidman describes the techniques used by these investigators and some of the conclusions they were able to draw from their studies. In Part 2, Sidman discusses one of the most human of all types of behavior, language, and relates some aspects of a behavioral formulation of language to the kinds of language disturbances produced by brain damage. This is an area in which many unsolved problems still exist. By interweaving behavioral principles, investigative techniques, and experimental findings, we hope to provide you with some of the tools for understanding and evaluating work in this area of psychology, and perhaps to provide some of you with the incentive to go more deeply into the subject.

PART 1: BEHAVIOR AND THE TWO HALVES OF THE BRAIN—

M. SIDMAN

Behavior is directly observable and, with appropriate recording techniques, quantifiable—exactly measurable. So are the discriminative and reinforcing stimuli that control behavior. But the brain, locked in the skull, is rarely available for direct observation. How is it possible to find out anything about the relations between brain and behavior?

Nonhuman animals have been a major source of information about the structure and function of the brain. Implanted electrodes can deliver tiny electric currents to the brain of animals, and this technique has yielded the fascinating discovery that stimulation of certain parts of the brain is reinforcing. In addition to stimulating the brain, it is also possible with those same electrodes to record the electrical activity in portions of the animal's brain, and thereby to find out what regions are active during certain kinds of stimulation, and while the animal is performing certain kinds of behavior. It is also possible to stimulate the brain of lower animals with chemicals, and thereby gain additional understanding of the processes that change as behavior changes.

Another avenue of approach is surgery. It is possible to remove, or ablate, selected portions of the brain, or to disconnect one area from the rest. In living animals, behavioral testing before and after surgery has provided the largest body of knowledge about relations between brain and behavior. Autopsy—surgery after the animal has died—has taught us much about the way the brain is constructed.

1. What are five basic techniques for obtaining information from lower animals about the structure and function of the brain?
How can we possibly learn anything about the human brain and its relation to behavior? Most of our information about human brain-behavior relations has come from studies of brain-damaged people. Human brain damage arises from two general sources. One major source involves events like strokes (blocking of blood vessels that nourish the brain, or excessive bleeding), tumors, blows to the head, inherited malfunctions, and failure of parts of the brain to grow properly. Some of these problems are treatable by surgery, drugs, radiation, and other methods, but often they are untreatable because of the narrow scope of our understanding of brain function, because of the limited techniques available for diagnosis, and because it is difficult to get at certain parts of the brain without damaging other important regions. The second major source of human brain damage is surgical operation, performed to remove tumors of the brain, to cure epilepsy and other convulsive disorders, to stop hemorrhages (excessive bleeding), to remove foreign bodies (bullets and such), and, when the patient's grave condition warrants the risk, to identify visually the cause of that condition.

Because of our incomplete understanding of brain function, and the primitive state of our techniques, the occurrence of brain disease or its attempted alleviation through surgery often leaves us with a feeling of hopeless compassion for the sufferer. Yet, because of our inadequate knowledge, each person who suffers brain damage, whatever its source, is in a position to contribute to our understanding by participating as a subject in research. The opportunity to study one will permit us to help others. What follows is a description of some of the ways such unfortunate sufferers of brain damage have made important contributions to our understanding of some particularly human brain-behavior relations.

Before looking at some of the things we have learned from brain-damaged people, you should know a few facts about the human brain. First, we do not have just one brain—we have two. Both are situated within the same skull, but one is on the left side and the other is on the right—the left and right cerebral hemispheres. Although structural differences are beginning to be recognized, the two cerebral hemispheres are for all practical purposes mirror images of each other. Each structure on the left side has its counterpart on the right, just like our arms, legs, eyes, and ears. Normally, however, the two brains are not independent. They are connected to each other by bundles of nerve fibers, or tracts, which transmit information from one hemisphere to the other.

Although the two sides look alike, they do not function in exactly the same way in controlling our movements and in receiving information from our environment. For example, certain "motor areas" in our left hemisphere control the movements of our right arm and leg; corresponding areas in the right hemisphere control our left arm and leg. This is also true of lower animals. How do we know this is true in people? One source of information has been through direct electrical stimulation of the human brain during brain surgery. Fortunately, we feel no pain when the surface of our brain is touched, stimulated electrically, or even cut. Once the skin and outer membranes have been anesthetized—made insensitive to pain—it is possible to carry out brain surgery on conscious, fully awake patients. Thus, in the course of necessary surgery, it becomes possible also to gain additional information about the way the brain works.

When the surgeon stimulates a specific place on the surface, or cortex, of the left side of the brain, he observes a movement on the patient's right side; likewise, if he stimulates the cortex of the brain on the right side, movements occur on the left side of the body. This is called contralateral control; each half of the brain controls movements on the opposite, or contralateral, side of the body.
Evidence for contralateral control in people also comes from certain instances of brain damage. For example, if a major blood vessel that normally nourishes the motor area in the left hemisphere is blocked, the person will be paralyzed on the right side of his body. Paralysis on the left side occurs when motor areas in the right hemisphere are destroyed. Thus, movement on one side of the body can be produced by stimulating the contralateral side of the brain, or such movement can be prevented by destruction of the appropriate area on the contralateral side of the brain.

A similar relation exists between the brain and certain kinds of environmental stimulation. For example, when we touch something with our left hand, signals are sent to our right hemisphere. Similarly, information about things we touch and feel with our right hand travels to our left hemisphere.

The situation is more complex with respect to vision. Here, it is not the two eyes that send information to separate halves of the brain. Rather, the environment is sorted out into halves, or fields, each of which stimulates its own half of the brain. For example, if we stare straight ahead at a small fixation point, everything at the left of that fixation point registers in our right hemisphere, and everything at the right of the fixation point registers in our left hemisphere. Information about the left visual field, even though it stimulates both eyes, goes to the contralateral, or right side of the brain; information about the right visual field goes to the left half of the brain.

Thus, people who have suffered destruction of the visual sensory area in their left hemisphere will find themselves in the peculiar situation of reacting only to the left half of the world in front of them. They will not respond to anything that lies at the right of whatever they are viewing directly. And what kind of blindness will occur if the visual sensory area in the right hemisphere is destroyed? Then, of course, the person will be blind to objects in the left visual field, but will respond to those in the right visual field.

Write your answers to the Study Questions in the spaces provided below.

1. 

2. 

6. What is a second source of evidence for contralateral control? Give examples of motor and sensory contralateral control.

7. What does the term visual field mean? How do stimuli in one visual field stimulate the eyes? Which cerebral hemisphere receives information from (a) the left visual field, and (b) the right visual field?

8. If a person suffers damage to the visual sensory area in one cerebral hemisphere, what objects will he be able to see?
These facts about contralateral control of movement and sensory input provide us with important tools for analyzing the functions of each half of the human brain. For example, when certain areas of our brain are destroyed, we lose the power of speech; we become mute, or our speech becomes garbled and unintelligible to others. Or we may be able to speak, but be unable to understand the speech of others. When brain damage interferes with the ability to produce or understand speech or language, we describe it with the term, aphasia. A person whose speech, understanding of speech, or understanding of printed words has been affected by brain damage is called aphasic. Aphasia can take many forms, each of which may have its own name. When reading, for example, has been affected, the disability is called dyslexia, and the person is said to be dyslexic. Brain damage that causes aphasia is frequently quite extensive, and causes other kinds of problems as well. For example, aphasic patients often suffer paralysis of the right side of their body. When this happens, we can tell immediately which side of his brain has been damaged. When paralysis does accompany aphasia, it is almost always the right side of the body that the patient is unable to move. This pairing of aphasia with right-sided paralysis tells us which side of the brain is most intimately involved in language. It must, of course, be the left hemisphere.

This is a major difference between our brain and the brain of nonhuman animals. The left side of the human brain is usually dominant for speech and language behavior. No reliable evidence for any kind of hemispheric dominance has been found in nonhuman animals. Cerebral dominance seems to be a purely human trait, and it is appropriate that this shows up most clearly in a most human form of behavior—language.

Write your answers to the Study Questions in the spaces provided below.

1. Define aphasia and aphasic. When paralysis accompanies aphasia, which side of the body is usually paralyzed? Which cerebral hemisphere is, therefore, most intimately involved in language?

2. What is cerebral dominance? In which form of behavior does it show up most clearly? In which species has cerebral dominance been found?
Let us now turn to some experiments that demonstrate in a rather spectacular way just how completely dominant the left hemisphere is for speech. The experiments were done with patients who suffered epileptic seizures, in which the body is convulsed and consciousness is lost or clouded, so intensely and so frequently that the patients were practically incapacitated, unable to carry on a reasonably normal life. In an attempt to cure the seizures, the left and right halves of the brain were separated by cutting the fiber tracts that join them. The surgery accomplished its main purpose, reducing the frequency and the severity of the patients' seizures considerably, and no lasting ill effects appeared. It looked as though the patients could function just as well with a "split brain" as they could when the two hemispheres were still joined together. In fact, on the day after the operation, when one of the patients was asked how he felt, he joked, "I have a splitting headache."

But even though the split-brain patients behaved normally for all practical purposes, subtle behavioral tests revealed some remarkable facts about the ways the two hemispheres function independently of each other, particularly with respect to speech. For example, in one experiment the patient was asked simply to name small objects placed, unseen, in his left or right hand. If an object was placed in his left hand, he was unable to name it. But when the object was shifted to his right hand, he was immediately able to give its correct name. The split-brain patient could name the objects only when he felt them with his right hand — when information about the objects was received in his left hemisphere.

What about visual stimuli? To test these, the patient was asked to fix his gaze on a central point between two small projection screens. When his eyes were properly centered, a visual stimulus was flashed for a tenth of a second or less, too fast for the eye to shift its gaze from the central fixation point. The stimuli were pictures of objects, colors, arrows pointing in different directions, lines, dots, and so on. When a single picture at a time was flashed into either the patient's right or left visual field, he described and named normally only those pictures that appeared in the right visual field — on the screen to the right of his fixation point. When a picture flashed in the left visual field, the patient said that he saw nothing, or "just a flash."

Sometimes two pictures were flashed at the same time, one to the left visual field and one to the right visual field; for example, a picture of a pencil on the left and of a knife on the right. This means, of course, that the pencil image was projected to the right hemisphere and the knife image to the left hemisphere. On the basis of the previous results, it should be possible to guess what happened. In hundreds of such experiments, the patient asserted that he saw the knife only, and he never mentioned the pencil.

Write your answers to the Study Questions in the spaces provided below.

1. What is a split-brain patient? Why was split-brain surgery performed on these patients?

2. In the experiment described here, what were the two stimulus conditions and what was the response? To which stimulus condition could the patient respond correctly? Which hemisphere had to receive information about the stimulus in order for him to respond correctly?

3. In the experiments described here, what were the stimulus conditions and what were the responses? Which visual field and hemisphere had to receive information before the patient could respond correctly?
Experiments like those just described seem to demonstrate quite clearly that split-brain patients are able to speak only about things they see in their right visual field, or feel with their right hand; verbal expression is possible only with respect to information that goes to the left hemisphere. The left half of the brain appears to be dominant for speech.

Are these experiments conclusive? Not yet. Before we assert that stimuli to the isolated right hemisphere cannot set the occasion for speech, we have to demonstrate that stimuli from the left visual field, or from the left hand, actually do reach the disconnected right hemisphere. Perhaps that patient's inability to talk about such stimuli means simply that the right hemisphere is not even being stimulated. If this were so, we would not expect him to be able to respond with speech or in any other way. To control for this possibility, we must devise an experimental situation to find out whether stimuli to the right hemisphere can control responses other than speech. If we can show this, we would have to conclude that the left hemisphere is dominant specifically for speech.

Matching to sample (described in chapter 1) is a most useful technique for accomplishing this. Instead of naming the picture or the felt object, the patient is asked to reach underneath a shield with one hand and to find blindly, by touch, an object that correctly matches the object pictured in the screen or previously felt with his hand. The simple apparatus used in this experiment is shown in figure 3.1. In this diagram, the patient is staring at the central fixation point, and a picture is about to be flashed on the screen, to the left or right of the fixation point. A group of objects are out of sight, and his task will be to pick out the object that matches the picture. With this procedure, it is possible to find out whether stimuli projected to the left and right hemispheres, particularly the latter, can control nonverbal responses—in this instance, selecting the object that matches the picture.

With the matching-to-sample procedure, the patient responded correctly regardless of which field, left or right, contained the stimuli. He picked out the pencil, scissors, or any other object that matched the picture even when the picture was projected in the left visual field and, therefore, in the right hemisphere. Furthermore, responses to the left visual field were correct even though the patient denied having seen anything. After being urged and prodded to put his hand out and give it a try,
he then came up with the correct object. Clearly, then, the right hemisphere was receiving stimulation; the objects could be matched even though they could not be named. Stimuli projected to the left hemisphere could be both matched and named. These experiments demonstrated that only stimuli projected to the left hemisphere can control speech. Stimuli projected to the disconnected right hemisphere are received there, and can be matched, but the information has no way to cross over to the dominant speech areas in the left hemisphere.

Note that the experiments just described involved both sight and touch, and an important factor was not taken into account. This was the combination of visual field stimulated, and hand used to identify the matching object. There are, of course, four such combinations, as indicated in Table 3.1. When pictures were flashed in the left visual field, the patient was sometimes required to identify the object with his left hand and sometimes with his right hand. With stimuli presented to the right visual field the patient also had to find the object sometimes with one hand and sometimes with the other.

TABLE 3.1

The Four Possible Combinations of Visual Field into Which an Object is Projected and Hand Used to Identify the Object

<table>
<thead>
<tr>
<th>Visual Field Containing Stimulus</th>
<th>Hand Used for Matching</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Left</td>
<td>Left</td>
</tr>
<tr>
<td>2. Left</td>
<td>Right</td>
</tr>
<tr>
<td>3. Right</td>
<td>Right</td>
</tr>
<tr>
<td>4. Right</td>
<td>Left</td>
</tr>
</tbody>
</table>

4. What two senses were involved in the matching-to-sample procedure just described? What are the four possible combinations of visual field into which the object is projected and hand used to identify the object?
When these four combinations of hand and visual field were taken into account, the matching-to-sample procedure yielded an even more dramatic demonstration that the two hemispheres had actually been disconnected and were functioning independently in some ways. As one might expect, the patient could accurately use his left hand to identify items flashed in his left visual field, and his right hand to identify objects seen in his right visual field, but cross combinations did not work. The patient was lost if he tried to use his right hand to match a picture flashed in his left visual field, or to use his left hand to match a picture that projected in his right visual field. These results are summarized in Table 3.2.

**TABLE 3.2**

Responses of Split-Brain Patients to the Four Possible Combinations of Visual Field and Hand Used to Identify Objects in Matching-to-Sample Procedures

<table>
<thead>
<tr>
<th>Visual Field Containing Stimulus</th>
<th>Hand Used for Matching</th>
<th>Patient's Response Correct or Not?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Left</td>
<td>Left</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Left</td>
<td>Right</td>
<td>No</td>
</tr>
<tr>
<td>3. Right</td>
<td>Right</td>
<td>Yes</td>
</tr>
<tr>
<td>4. Right</td>
<td>Left</td>
<td>No</td>
</tr>
</tbody>
</table>

This is an excellent illustration of the separation between the two hemispheres in split-brain patients. Stimuli from the left visual field and from the left hand—both projecting to the right hemisphere—could combine to control matching-to-sample behavior. The same was true for vision and touch projecting to the left hemisphere. Stimulus control over nonverbal behavior was intact within each half of the brain, but not between the two halves.

Write your answers to the Study Questions in the spaces provided below.

1. 

2. 

3. 

5. What were the results of matching-to-sample procedures involving all four combinations of hand and visual field?

6. What did the matching-to-sample experiment indicate about the degree to which behavior was intact (a) within each half of the brain, and (b) between the two halves?
These experiments have demonstrated clearly that in order for stimuli to control oral speech, they must be projected to the person's left hemisphere. Normally, of course, even stimuli projected to the right hemisphere can control speech, because tracts of nerve fibers connect it to the left hemisphere. In the split-brain patient, however, communication between the two halves of the brain is no longer possible. But although the disconnected right hemisphere may be thought of as being "mute," must we conclude that it is also stupid? Too often we tend to assume that a person who lacks speech also lacks understanding. People with aphasia are sometimes considered to be retarded, or even schizophrenic, by others who do not know the history of their disease. How can we find out whether a split-brain patient is capable of understanding stimuli that are presented to his right, or "nonspeaking," hemisphere?

The question here is one of speech versus comprehension. A little thought will make it apparent that speech does not necessarily imply understanding. A person can learn to say the names of pictures, and even to read words aloud, without understanding what he is saying. Comprehension must be demonstrated in some other way, and in the case of the "silent" right hemisphere, it is necessary to test for stimulus control over some behavior other than speech. One kind of language comprehension is auditory comprehension, or the understanding of oral speech. A person may be said to display auditory comprehension when he successfully matches appropriate objects to words that are spoken to him.

Using this matching-to-sample technique, split-brain patients were tested for their understanding of spoken words. They were asked to reach into a group of hidden objects, and find the one that the experimenter named aloud. As one might guess, the patients had no problem doing this with their right hand. The interesting finding was that they could do just as well with their left hand. The right hemisphere, which is incapable of mediating speech production, can mediate auditory comprehension.

1. Why do stimuli projected to the right hemisphere control speech for a normal person but not for a split-brain patient? Which hemisphere is the "nonspeaking" one?

2. What does speech tell us about comprehension? What is auditory comprehension? How can a person display auditory comprehension without speaking?

3. In the experiment described here, what were the stimuli and the responses? What was the outcome? What does this outcome tell us about the functions of the right hemisphere?
1. What mediating response can the split-brain patient make to objects in his right visual field that will enable him to match these objects using his left hand? Which hemisphere governs the production of this mediating response? Which hemisphere receives the response-produced stimulus as a signal to use in controlling the matching response of the left hand?

2. Distinguish between oral reading and reading comprehension. How can reading comprehension be demonstrated?
or written text by saying the words aloud. Too often, we take this also as an indication that the person is understanding the words he is reading out loud, but this is not necessarily so. One can name (read) printed words without knowing what they mean. An appropriate test for reading comprehension, like auditory comprehension, involves matching to sample. If a person can match printed words to appropriate objects, he demonstrates a form of reading comprehension. He understands printed text.

It will come as no surprise that the split-brain patient was able to read printed words aloud when they were flashed in his right visual field. This performance is little different in principle from picture naming. Somewhat more interesting, but still not surprising, was the split-brain patient's ability to find the correct object with his right hand in response to printed words flashed in his right visual field. In other words, his left hemisphere was capable of mediating both oral reading and reading with comprehension. But what happened when the printed words were flashed in the left visual field, and the patient was required to locate the matching object with his left hand? He was able to do this task just as well. He understood the printed words even when the stimuli projected exclusively to his right hemisphere. Absence of speech did not mean absence of comprehension. This answers our original question: The right hemisphere, although mute, is not stupid.

Write your answers to the Study Questions in the spaces provided below.

1.  

2.  

3.  

PART 2: BRAIN DAMAGE AND LANGUAGE DEFICIT — M. SIDMAN

We have seen that study of the diseased brain has much to teach us about relations between the normal brain and behavior. Let us now approach this topic more systematically. How does brain damage affect behavior in general, and verbal behavior in particular?

We already know some important things about normal behavioral processes—about the environmental variables controlling the particular way a person will behave in a given situation. When a person's brain is damaged, and his behavior
changes, our analysis leads us to search for the ways in which one or more of these environmental variables has changed its control over behavior. Just what relations between behavior and its controlling variables does brain damage change, and what kinds of changes take place?

**Behavior and Its Consequences**

The most powerful principle we have learned is that consequences govern behavior. We are likely to repeat responses that have produced reinforcing consequences, and we are unlikely to repeat responses that have removed or prevented reinforcement. Behavior that is not reinforced will not change (no learning will take place) or will decrease in frequency (extinction). We diagram the relation between behavior and a reinforcing consequence as follows:

\[ R \rightarrow S^R \]

The ability of any reinforcer \((S^R)\) to increase the frequency of behavior \((R)\) will depend on at least two modulating, or regulating, factors. One is the schedule of reinforcement. A schedule of reinforcement is a rule which specifies when a reinforcer is to be delivered. For example, reinforcement could occur after every ten responses, on the average of every minute since the previous reinforcement, or after ten seconds of no responding. Schedules of reinforcement strongly affect both the rate and pattern of an organism's responding. A second factor is the extent to which the organism has been deprived of the reinforcer, that is, how long the organism has gone since last receiving that particular reinforcer. For example, food and water can be effective reinforcers for organisms that have been deprived of those reinforcers, but not for organisms that have been satiated with them.

Brain damage may affect behavior by changing the influence of variables that normally modulate the action of reinforcement. For example, after one kind of brain damage a person may lose his appetite. The behavioral observation is that he no longer eats, no matter how long he has gone without food. Brain damage has destroyed the controlling relation between behavior and food deprivation; food is no longer a reinforcer. Different brain damage may actually lead to quite the opposite effect! A person may eat continually, indicating that satiation no longer reduces the effectiveness of food reinforcement.

Typically, any response is controlled by more than one consequence (reinforcer), each with its own modulating factors, as diagrammed below. Brain damage need not destroy the relation between a response and all its consequences, but may act selectively. For example, the verbal response, “I’m cold,” may sometimes produce a blanket and sometimes an embrace. A person who has suffered brain damage may be observed to say “I’m cold,” much less often than usual, but the brain damage may not have affected the response, “I’m cold,” directly. It may have made just one of its reinforcers, warmth, ineffective.

1. Which responses are we likely to repeat? Which are we unlikely to repeat?

2. What are two factors that may modulate the effectiveness of a reinforcer? How?

3. What are two ways in which brain damage may affect behavior?

4. How many consequences typically control a response? How can brain damage affect response-reinforcer relations? What happens when control by all reinforcers is destroyed?
Brain damage, then, can selectively destroy behavioral control by a particular kind of reinforcement—sex, warmth, food, or any other. In the extreme instance, brain damage may completely destroy control by all kinds of reinforcement. Then, consequences will no longer affect the person's behavior; he may end up behaviorless, like a vegetable.

Write your answers to the Study Questions in the spaces provided below.

1. 

2. 

3. 

4. 

Chaining, Conditioned Reinforcement, and Language

Actually, consequences like food, water, sex, or physical warmth reinforce only a small part of our own behavior. Most of our behavior consists of long chains of stimuli and responses, as shown in the paradigm in Figure 3.2A.

In the paradigm, the chain ends with a terminal reinforcer (SR). Each intermediate stimulus (S₁, S₂, S₃) serves as a discriminative stimulus (Sᵢ) for the response (R) that follows it. A discriminative stimulus in a chain that eventually leads to terminal reinforcement is also a reinforcer for the response that comes before it. For example, S₃ᵢ is a discriminative stimulus for response R₃, but at the same time this stimulus reinforces R₁. Stimuli that link responses together into a chain become

**Figure 3.2A.** \( \cdots S^P_3 \rightarrow R_3 \rightarrow S^P_2 \rightarrow R_2 \rightarrow S^P_1 \rightarrow R_1 \rightarrow S^R \)

**Figure 3.2B.** \( \cdots R_3 \rightarrow S^*_3 \rightarrow R_2 \rightarrow S^*_2 \rightarrow R_1 \rightarrow S^R \)

1. What is the name of the final stimulus in a behavioral chain? What two functions does each intermediate stimulus fulfill? What is the paradigm for a behavioral chain?
reinforcers in their own right and are called *conditioned reinforcers*. Each $S^0$, then, might also be symbolized as $S'$, a conditioned reinforcer. In Figure 3.2B, we identify the intermediate stimuli in the behavioral chain as $S'$, corresponding to the $S^0$s in Figure 3.2A.

Here, then, is another way for brain damage to affect behavior. Brain damage may destroy or reduce behavioral control by discriminative stimuli and conditioned reinforcers. Our main reason for bringing up the topic of conditioned reinforcement in this part is to point out the close relations between certain kinds of conditioned reinforcers and verbal behavior. Language, as we all know, involves communication. What does it mean *behaviorally* to say that we communicate? It means that our behavior has an effect on someone else's behavior. Changes in the behavior of other people are important consequences—reinforcers—of our own behavior:

$$R \xrightarrow{our\ behavior} S' \xrightarrow{change\ in\ someone\ else's\ behavior}$$

When we produce a desired effect on someone else's behavior (the changes in his behavior reinforce ours), we say that we have "achieved communication." When we produce an undesirable effect (his behavior fails to reinforce ours) we talk about "a failure of communication." Language is a social process: by this we mean that the major sources of reinforcement are the responses of other people.

Most responses of other people are conditioned reinforcers, which were created by their participation in the stimulus–response chains that eventually lead to terminal reinforcement. One of the simplest forms of language is the cry of a hungry child. When her child cries after a long time without food, the conscientious mother springs into action. She turns on lights, opens and closes the refrigerator, fills a pot with water to warm the bottle, changes the baby's diaper while the bottle is heating, and so on. At first, the baby continues to cry throughout all this activity. But later, the stimuli arising from the mother's actions take on a new significance for the child. As soon as the mother begins, the baby stops crying.

Can we analyze this interaction between mother and baby behaviorally? The baby's cry is a discriminative stimulus that sets the occasion for a long chain of behavior by the mother. The chain ends when she reinforces the baby's cry by feeding him; the end of the baby's crying is the terminal reinforcer for the mother's behavior. After several repetitions of this sequence, stimuli that consistently precede feeding—the appearance of the mother with the bottle—become discriminative stimuli for the baby to stop crying. Through backward chaining earlier stimuli in the chain then become $S^0$s for the baby to stop crying, until he eventually stops at the first sounds of the mother's preparations. But those first sounds also become conditioned reinforcers for the original cry. Thus, the baby's cry is a discriminative stimulus for the mother's behavior; stimuli arising from her behavior reinforce the baby's cry, and at the same time set the occasion for him to stop crying; his silence reinforces the mother's behavior; and so on. Baby and mother have learned to communicate with each other:

2. What two types of behavioral control may brain damage reduce or destroy? In behavioral terms, what is meant by saying that: (a) we have "achieved communication"; (b) we have "failed to achieve communication"; and (c) language is a "social process"?

3. By what process do the responses of other people come to function as conditioned reinforcers? Explain this process as it relates to the behavior of a mother preparing a bottle for her crying baby.
Generalized Reinforcers

Conditioned reinforcement that comes from the behavior of other people is a characteristic of verbal behavior. Language development goes hand in hand with the development of conditioned reinforcers. The very beginnings of the process involve simple interactions of the sort we have just described between mother and child. From such simple beginnings, conditioned reinforcement eventually becomes quite complex. A particular conditioned reinforcer usually serves as an intermediate consequence not just in one chain of behavior but in many, each of which may lead to a different terminal reinforcer. Money is such an intermediate consequence; it is a common element in behavioral pathways to many terminal reinforcers, as indicated in the simplified paradigm shown below.

\[
\begin{align*}
R_1 & \rightarrow S^R (\text{food}) \\
& \rightarrow S^R (\text{money}) \rightarrow R_2 \\
& \rightarrow S^R (\text{shelter}) \\
& \rightarrow S^R (\text{physical comfort})
\end{align*}
\]

A conditioned reinforcer that leads only to one terminal reinforcer, for example, to food, will increase or decrease in effectiveness as food deprivation increases or decreases. On the other hand, a person may be satiated with food, drink, and sex, yet money will remain an effective reinforcer because it can still lead to various comforts, amusements, privileges, and so on. For this reason, behavioral consequences like money are called generalized conditioned reinforcers or more simply, generalized reinforcers. Because their reinforcing power does not depend on any single modulating influence like food deprivation or physical discomfort, generalized reinforcers like money or social approval are likely to remain powerful determiners of behavior under a wide variety of conditions.

Most human behavior—almost all verbal behavior—is governed by generalized reinforcers. For this reason, brain damage that destroys the strength of just one reinforcer may appear to have little effect on verbal behavior; generalized reinforcers will still remain powerful.

Stimulus Control

The most dramatic effects of brain damage on human language show themselves not in the response-reinforcement relation, but in disturbances of stimulus control. None of our behavior produces reinforcement at all times and in all places. A response is usually reinforced only when particular stimuli are present; in the absence of appropriate stimuli, the response usually goes unreinforced. This is what we mean when we talk about the stimulus control of behavior. Speech usually comes under a particular kind of stimulus control. Spoken sounds cannot by themselves change the environment. Speech cannot literally move mountains, but people who operate power shovels and bulldozers can do so in response to our orders. Thus, the reinforcement for speech usually has to be mediated through the behavior of other people, and we learn to speak only when another person \(S^p\) is present. In the absence of other people \(S^p\) our speech is not usually reinforced. The basic stimulus-response relations are diagrammed below.

4. What is the critical difference between generalized reinforcers and other types of conditioned reinforcers? What two examples of generalized reinforcers are given here?

5. Which class of behavior is especially maintained by generalized reinforcers? How does such a response-reinforcer relation affect verbal behavior following brain damage?

6. What is stimulus control, and what is the basic paradigm for this kind of control? What are two examples of verbal behavior under defective stimulus control?
"Thinking out loud" is, of course, a special case in which the reinforcement comes from a change in our own behavior. In this instance, both the speaker and the listener are the same person. But for the most part, people who go around "talking to themselves" demonstrate a breakdown of the usual stimulus control over their speaking behavior—it is no longer governed by the presence or absence of other people. Many factors can cause such a breakdown—a thirsty man may cry "Water!" even though he is alone in the desert—or brain damage may be accompanied by logorrhea—uncontrollable and incoherent talkativeness. In the absence of other people (S^d) our speech is not usually reinforced. People who go around "talking to themselves" demonstrate defective stimulus control of their speaking behavior; such a breakdown may accompany brain disease.

Instead of causing behavior to occur under inappropriate circumstances (S^d), defective stimulus control may cause behavior to be absent under appropriate circumstances (S^p); the person may never talk, even when it is advantageous for him to do so, and even when the relations between reinforcement and nonverbal responses are still intact. Such mutism is another type of defective stimulus control that characterizes certain forms of aphasia. (Again, mutism may also come about in other ways.)

Write your answers to the Study Questions in the spaces provided below.

1.

2.

3.
Mands and Tacts

We have already noted that verbal behavior—communication—occurs when a change in another person's behavior constitutes reinforcement. People are the most important sources of reinforcement for other people. Language, at least in its most common forms, always involves an interaction between at least two people. Depending on the direction of their interaction at any moment, one of these people may be characterized as a "speaker," and the other as a "listener." This treatment of language as an interpersonal (or social) process led Skinner to describe two large classes of verbal behavior, which differ in their significance depending on whether one is acting as speaker or as listener.

One of the two large classes of verbal behavior is called the mand, a term that resembles "command" and "demand." Skinner has described the mand as follows:

"In a given verbal community, certain responses are characteristically followed by certain consequences. 'Wait!' is followed by someone's waiting and 'Sh-h!' by silence. Much of the verbal behavior of young children is of this sort. 'Candy!' is characteristically followed by the receipt of candy, and 'Out!' by the opening of a door. These effects are not inevitable, but we can usually find one consequence of each response which is commoner than any other . . . When a response is characteristically reinforced in a given way, its likelihood of appearing in the behavior of the speaker is a function of the deprivation associated with that reinforcement. The response 'Candy!' will be more likely to occur after a period of candy deprivation, and least likely after candy satiation. The response 'Quiet!' is reinforced through the reduction of an aversive condition, and we can increase the probability of its occurrence by creating such a condition—that is, by making a noise." (from Verbal Behavior, page 35)

Verbal responses that we call mands have a characteristic consequence and are controlled by factors, like deprivation or aversive stimulation, that modulate that particular consequence. The hungry baby's cry, reinforced by food, is a primitive stage in the development of our repertoire of mands. Because mands are controlled by specific consequences, they tend to operate primarily for the benefit of the speaker rather than the listener. Whether or not a mand is reinforced will

1. In behavioral terms, how is communication defined? What terms may be used to characterize two people involved in a verbal interaction?

2. Name a basic class of verbal behavior. What two common English words does mand resemble? What examples of mands are described here? What consequence typically follows mands?

3. Define mand. For whose benefit do mands primarily operate? What is the behavioral function of words like "please," used in conjunction with a mand?
depend on whether the listener is disposed to provide the specified reinforcement. Words like “please,” “if you don’t mind,” and so on, function to increase the probability that the listener will reinforce.

Mands eventually do come under stimulus control:

The community provides the specific consequences that reinforce mands, but it provides them only under appropriate circumstances. A particular mand is likely to be controlled by any of several different discriminative stimuli, but only by one reinforcer and its associated deprivation. The controlling relations are diagrammed below. For example, we may say “water” in the presence of a faucet, an empty glass, a waiter in a restaurant, or an oasis in the desert, but these stimuli will occasion the mand only if we have been deprived of water.

Mands such as “Water!” and “Water, please!” are controlled by a state of water deprivation, made more or less probable by the presence of certain discriminative stimuli, and reinforced by the presentation of water. Must we, therefore, conclude that the word “water” is a mand? Far from it. A mother teaching her child to talk may point to water in a cup, water in a pan, water running from a faucet, water in a lake or an ocean. While doing so she may mand the child’s verbal response by saying “What is this?” When the child replies “Water,” she may reinforce him with a hug, a smile, or the word, “right!” In this case, the child’s response, “water,” is not controlled by a state of deprivation or of aversive stimulation, and it is not reinforced by the presentation of water. Thus, it is not a mand. The response belongs to a second large class of verbal behavior, the tact.

The term tact resembles the word “contact” in the sense of making contact with, or describing something about, the environment. The controlling relations for tacts are diagrammed below.

4. Describe the discriminative, deprivational, and reinforcement functions associated with mands. What is the paradigm for the controlling relations of the mand?

5. What is a second basic class of verbal behavior? What common English word does tact resemble? Describe the discriminative, deprivational, and reinforcement functions associated with tacts. What is the paradigm for the controlling relations of the tact?
The probability of a tact does not depend on any particular deprivation but, instead, on the presence of one particular discriminative stimulus or set of stimulus properties. For example, the SDs in our tact paradigm are all forms of water—they share the stimulus properties of the substance we call “water.” The stimulus control of the tact is limited when compared with that of the mand.

Furthermore, the quite specific response-reinforcer relation that characterizes the mand is in marked contrast to that of the tact. The tact (“water,” for example) is controlled by several different kinds of reinforcers. Many of these are expressions of thanks or approval for our appropriate tacting behavior, as when we give directions to a stranger or answer a question correctly in class. These are generalized reinforcers for the tact.

No word, taken out of context, can be classified as a mand or a tact. These classifications depend upon the prevailing stimulus-response-reinforcer (and deprivation) relations. When the thirsty speaker says, “Give me a glass of water,” the word “water” functions as a mand. When, in response to the question, “What are you drinking?” he replies “Water,” the word “water” functions as a tact. To clarify the mand/tact distinction for yourself, think of a few situations in which the word “pancakes”—already described in a mand function—may function as a tact.

Unlike mands, which benefit the speaker, tacts are particularly useful to the listener. The tact may be said to tell the listener something that is to his advantage to know. This does not, of course, mean that a speaker gets no reinforcement for his tacting behavior. Without reinforcement, tacts would never have arisen and would certainly not persist. When a child, learning to talk, says “mama” appropriately, he gets a hug; when a student gives the correct facts in an examination, he gets an “A”; when a person gives us road directions, we say, “thank you.” These are all generalized reinforcers. Tacts do not require specific consequences, and, therefore, are independent of specific deprivations or aversive stimulation. It is possible, then, to make generalized reinforcement for a tact contingent on a particular stimulus. SDs, rather than deprivations, come to control their probability of occurrence.

Because the reinforcing community (the listeners) provides generalized reinforcers for tacts, rather than reinforcers that are specific for each tact, the major source of control shifts from consequences to discriminative stimuli. This process is crucial for any community. None of us know or learn everything through direct experience. We must depend on other people for valid reports and descriptions of things and events. We must be able to trust the relation between people’s verbal behavior and reality. “The boy who cried wolf” is a case of a tact gone wrong.

6. What factors determine the classification of words as mands or tacts?

7. Distinguish between mands and tacts in terms of: (a) dependence upon specific deprivations or aversive stimulation, (b) discriminative stimulus control, (c) type of reinforcement contingencies and (d) which participant in the verbal interaction is likely to benefit from each.

8. Why does the source of control shift from consequences to discriminative stimuli in the case of tacts? How do tacts benefit the verbal community? How can a statement that sounds like a tact function as a mand?
Because the response was so often emitted in the absence of the appropriate SD (wolf), the verbal community came to recognize it as a mand rather than a tact, stopped attending to it, and eventually failed to respond when it was emitted as a tact under appropriate stimulus control. A politician seeking to remain in office may make statements that sound like tacts but are actually mands. For example, when he tells us, "The economy is healthy," we wonder whether his verbal behavior is actually controlled by the state of the economy or whether his words are controlled by the voter's behavior at the polls. If he is describing the true situation, he is tacting the stimuli; if his behavior is controlled solely by our votes, he is manding reinforcement. In science, we expect (but do not always get) the ideal situation. We expect the behavior of the scientist to be entirely controlled by the "facts" and not by any personal gain he may achieve, even a gain in reputation. We expect the scientist to tact his data accurately, even if they prove his theories to be wrong.

Mands are likely to be extremely strong, for the community reinforces them directly with characteristic consequences. But tacts are likely to be much less predictable. Their probability depends on the community's skill in providing generalized reinforcement for accurate reporting. Since the reinforcing community does not always detect the controlling stimuli, the tact relation easily becomes distorted. Consider the response, "My tooth hurts." The listener has no access to the controlling stimuli, and "My tooth hurts" may not be a tact at all; it may, instead, be a mand to be excused from school.

When someone shouts "Fire!" in response to the smell of smoke and the sight of flames, the word "fire" functions both as a mand and as a tact. As a tact, "Fire!" names the discriminative stimulus that controls it. In effect, it says to the verbal community: "There is a fire." As a mand, "Fire!" is controlled by a specific state of aversive stimulation—the imminence of being burned, of seeing others burned, or of seeing property destroyed. In effect, it says to the verbal community: "Run from the fire! Bring help to put out the fire!" As a mand, "Fire!" is reinforced by specific consequences, that is, by the reduction of a specific state of aversive stimulation—by helping others to escape from the fire and by bringing help to put out the fire. The response of pulling a fire alarm serves the same double mand-tact function as shouting "Fire!" In some cases, shouting "Fire!" or pulling the fire alarm may not be determined by stimuli from an actual fire, but instead by the highly specific reinforcements that the sight and sounds of fire engines provide. Distortions of the tact relation can be pleasing and even beautiful, and we encourage this in poetry. But when the consequences of such distortions are harmful, the community calls it "lying" and punishes it.

Brain damage often makes a clear distinction between mand and tact. The most dramatic cases occur when a mand and a tact both have the same form. For example, if we hold a glass of water in front of a person and ask him what it is, he will say, "glass of water." This is a tact; the response is under specific stimulus control. He may also say, "glass of water," when he is thirsty, even though no glass is visible. The response is now a mand, under the control of a specific deprivation. The two responses, mand and tact, sound exactly the same, but their sources of control are quite different. Brain damage can interfere with one source of control without touching the other. An aphasic patient may be unable to answer correctly when you hold up a glass of water and ask him what it is. He might give no answer at all, or he might say something like, "a bottle of ink," or "a piece of matter." Stimulus control here is quite deficient. But when the physician gives him a pill to take, he may say quite clearly and without hesitation, "glass of water." The mand relation is still intact in such a patient. Although the form of the response, "glass of water," is exactly the same in both mand and tact, brain damage has destroyed one source of control and not the other.
Write your answers to the Study Questions in the spaces provided below.

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Brain Damage and the Tact Relation

A single form of response can be either a mand or a tact, depending on the source of control, and particular responses or controlling stimuli can be involved in many different tact relations. Language is characterized by sets of interlocking tact relations, with some tacts sharing the same response, and others sharing the same stimulus.

Let us examine some tact relations in which the stimulus, clock, is a component. Table 3.3 lists some forms of this stimulus and some appropriate tacting responses.

<table>
<thead>
<tr>
<th>Stimulus: Clock</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual objects</td>
<td>Oral pronunciation</td>
</tr>
<tr>
<td>Pictures</td>
<td>Oral spelling</td>
</tr>
<tr>
<td>Visual word, upper case</td>
<td>Oral synonym</td>
</tr>
<tr>
<td>Visual word, lower case</td>
<td></td>
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<tr>
<td>Visual word, script</td>
<td></td>
</tr>
<tr>
<td>Auditory word, pronounced</td>
<td></td>
</tr>
<tr>
<td>Auditory word, spelled</td>
<td></td>
</tr>
<tr>
<td>Palpated object</td>
<td>Written naming, upper case</td>
</tr>
<tr>
<td>Palpated word, upper case</td>
<td></td>
</tr>
<tr>
<td>Palpated word, lower case</td>
<td></td>
</tr>
<tr>
<td>Palpated word, script</td>
<td></td>
</tr>
<tr>
<td>Matching to visual or palpated word, upper case, lower case, or script</td>
<td></td>
</tr>
<tr>
<td>Matching to auditory word pronounced or spelled</td>
<td></td>
</tr>
<tr>
<td>Matching to visual or palpated objects</td>
<td></td>
</tr>
<tr>
<td>Matching to pictures</td>
<td></td>
</tr>
</tbody>
</table>

This seemingly simple stimulus may take several forms, some of which are listed on the left side of Table 3.3. It can be an actual clock that one experiences visually; it can be a picture of a clock; it can be the visual word, clock, composed of upper-case, lower-case, or script letters. It need not be a visual stimulus at all, but may be the word pronounced or spelled aloud—two kinds of auditory stimuli. Or it may be a stimulus that one feels with hands and fingers (palpates) without seeing or hearing it, as a blind man might feel an actual clock or might feel raised upper-case, lower-case, or script letters that spell the word, clock.

The right column of Table 3.3 lists some of the appropriate tacting responses to the stimulus, clock—various types of oral naming, written naming, and matching to sample. One may respond to any of the listed stimuli by pronouncing or spelling...
clock aloud, or by saying another word that means the same thing, for example, timepiece; one may respond by writing clock or its synonym in upper-case, lower-case, or script letters; or one may select a matching stimulus out of several non-matching alternatives, and the correct matching stimulus may be either seen, heard, or felt.

No single one of these stimulus-response relations can be accepted as evidence for language: A parrot can repeat pronounced words; a dog can learn to do many of the matching tasks; a person who speaks only French can copy the printed English word, even without understanding it. But when each of the stimuli can give rise appropriately to all the responses, we have an interlocking set of tact relations that is characteristic of language.

Within this interlocking set, any single stimulus controls many responses, and any single response is controlled by many stimuli. Brain damage need not break down all tact relations in which a particular stimulus or response participates. Indeed, it turns out that brain damage respects behavioral subdivisions of stimulus control within the tact relation. To illustrate this, let us look at the results of some experimental analyses of aphasic behavior.

Patient 1—R.W.

R.W., a 14-year-old boy, had just finished running the 100-yard dash in a school track meet in the late afternoon of May 15, 1964. He sat down on the ground, clapped his hand to the left side of his forehead, collapsed, and had a seizure. He was immediately taken to the emergency ward of a local hospital, where he was found to be dazed, confused, and completely unable to speak. X-ray studies showed that a large artery in the left side of his brain had been blocked, cutting off the flow of blood to some of the major areas involved in language behavior. He had suffered a "stroke." Three weeks later, R.W.'s physical condition had improved so much that he could leave the hospital, but he was left with a complete paralysis of the right side of his body and was still almost speechless. Physical therapy and a leg brace soon made it possible for him to walk, but his right arm remained useless. R.W. was eager to participate in experiments that might shed some light on his difficulties and perhaps help others in the same situation.

The experiments were carried out in a well-ventilated room with sound-resistant walls and door to reduce unwanted stimulation. R.W. sat facing a square panel of nine translucent windows onto which stimuli could be projected. Touching a window activated a switch and delivered a signal to electronic programming and recording devices. The experiments were designed to pinpoint aspects of R.W.'s language behavior that his brain damage had changed, and to identify aspects left unaffected. A number of simple tact relations were explored, including oral naming, written naming, and matching to sample.

Oral naming was tested as follows: Simple three-letter picture names, like boy, box, pie, pig, cat, car, cow, and so on, were projected one at a time onto the middle window, as illustrated below. R.W. was asked simply to read each word aloud. If he did so correctly, an automatic device delivered a nickel to him; if he was unable to name the word correctly, he received no reinforcement, and after a brief pause another picture was projected.

3. How can brain damage affect tact relations?

4. Which areas of R.W.'s brain were damaged? What were the physical symptoms of this damage?

5. What experimental apparatus was used to test R.W.'s behavior? What was the purpose of this experimental testing?

6. Which behavior was tested first? Which three tests were used?
In other tests, the picture itself, instead of the picture name, was projected on the center window, and R.W. again had to say the picture name aloud. A third type of test did not use visual stimuli at all; instead, a tape recorder dictated the picture name, and R.W. had to repeat the auditory word—the word he heard over the loudspeaker.

These tests involve three kinds of tact relations, illustrated below. In each of them, the responses are the same—saying the words aloud—but the controlling stimuli are different.

All three tests confirmed the clinical observations. R.W. was unable to speak the words in response to any of the different kinds of stimuli. At best, he could only grunt. These data permitted us to ask some additional questions. First, did R.W. fail in these tests simply because he could not speak, or was he unable to discriminate the stimuli—to identify them? In other words, was his problem on the response side or on the stimulus side of the oral naming paradigm shown above? Were all tact relations involving these three types of stimuli deficient, or only those tact relations that involved oral naming?

How might one answer such a question? The reasoning might go as follows: If R.W.'s problem was in stimulus discrimination, he would be unable to respond appropriately in any way to the three types of stimuli; if his problem was only with oral naming, then he would be able to tact the stimuli by some other kind of response.

To answer this question, tests of written naming were carried out. The stimuli remained the same, printed words, pictures, and dictated words. R.W. had to write or print the name of the word or picture that was presented to him. On each trial, he had a new piece of paper, so that earlier stimuli would not interfere. As before, he received a nickel for each correct response. The three kinds of tact relations in these tests are diagrammed below, which is exactly the same as the oral naming paradigm except for the form of response—written instead of oral naming.

R.W. went through the writing tests with almost no errors, and thus earned many more nickels than in the oral naming tests. His problem in tacting the stimuli by oral naming, then, had not arisen from an inability to discriminate the stimuli; he was able to tact those same stimuli by writing the names. Brain damage interacted differently with the different tact relations.
Write your answers to the Study Questions in the spaces provided below.

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Patient 1 R.W.—(Continued)

R.W.'s brain damage left written naming while destroying his ability to say the same names aloud. A second question now arises: Could R.W. understand the written words? His ability to copy them tells us nothing about his understanding; a child who has not yet learned to read may still be able to copy words. R.W.'s ability to write the words to dictation could also have been done without understanding them; it is possible to transform sounds into written characters without being able to understand either the sounds or the writing, as an English-speaking person might write down sounds made by a person who is speaking French. R.W.'s ability to write the appropriate words in response to pictures, however, did indicate that he could understand the words he was writing. But even here, one might wonder whether he could understand those same written words if he himself had not done the writing.

How could we test R.W.'s comprehension of spoken and written words without asking him either to speak or to write? This was where the matching-to-sample technique became useful. As before, a word or picture was projected on the center window, or a spoken word sounded over the loudspeaker. These stimuli were the samples, and one was presented on each trial. R.W.'s task was, first, to respond to the sample stimulus by pressing the center window. This caused words or pictures to be projected on the eight outer windows. One of these eight stimuli corresponded to the sample; the other seven did not. Examples appear in Figure 3.4A and 3.4B.

In Figure 3.4A, a sample picture is to be matched to the appropriate word; other tests presented a word on the center window, and pictures on the outer windows. In Figure 3.4B, a dictated word is to be matched to the appropriate printed word; in other tests, pictures appeared on the outer windows, R.W. had to press the one that corresponded to the sample. If he chose correctly a nickel was automatically delivered. Incorrect responses caused the windows to be darkened briefly, and then a new sample was presented to begin the next trial.

![Figure 3.4A](cat boy hen)

![Figure 3.4B](hoe axe)

With the same three types of stimuli we have been using all along, it was possible to test R.W.'s performance on six kinds of matching-to-sample tasks. These are diagrammed below.

1. What question did the experimenters ask next? Which tests of written naming indicated understanding, and which did not? Why?

2. What was tested next? What technique was used? Why was this technique used? How were the stimuli presented? What responses were required of the subject? What were the contingencies for correct and incorrect responding?

3. How many types of stimuli were used in the matching-to-sample tests? How many types of responses were required? What were they? How many matching-to-sample tasks did these stimulus-response combinations yield? How do these tasks differ from those used to test oral and written naming?
The results of R.W.'s naming and matching-to-sample tests are summarized in Figure 3.5. The numbers in the upper left-hand corners of the blocks indicate the task numbers of the matching-to-sample tests.

Two of these tasks merely confirmed what we already know, that R.W. could discriminate the stimuli: In Task 1, he had only to match identical printed words to each other, and in Task 4, he had only to match identical pictures. Both of these could be done without any understanding of the stimuli, and, as expected, R.W. did them perfectly. Similarly, he could match dictated to printed words (Task 5) without understanding either the words he heard or those he saw. At least, this indicated only a limited kind of comprehension—an understanding of the correspondence between letters and their sounds. Of greater interest was his performance on the other tasks. His nearly perfect scores in matching printed-word samples to pictures

<table>
<thead>
<tr>
<th>SAMPLE STIMULI</th>
<th>RESPONSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRINTED WORDS</td>
<td>Oral Naming</td>
</tr>
<tr>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>0</td>
<td>75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PICTURES</th>
<th>Matching to printed words</th>
<th>Matching to pictures</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Task 1</td>
<td>Task 2</td>
</tr>
<tr>
<td>75</td>
<td>Task 3</td>
<td>Task 4</td>
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<tr>
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<td>Task 6</td>
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<td>Task 6</td>
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</table>

<table>
<thead>
<tr>
<th>DICTATED WORDS</th>
<th>Matching to printed words</th>
<th>Matching to pictures</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Task 1</td>
<td>Task 2</td>
</tr>
<tr>
<td>75</td>
<td>Task 3</td>
<td>Task 4</td>
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<tr>
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<td>25</td>
<td>Task 6</td>
<td>Task 6</td>
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<tr>
<td>0</td>
<td>Task 6</td>
<td>Task 6</td>
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</tbody>
</table>

Figure 3.5. Summary of results for R.W. on tests of naming and matching-to-sample.

4. How well did R.W. perform on each of the six matching-to-sample tasks? Which tasks could be performed correctly without understanding the stimuli? Which tasks measured (a) reading comprehension and (b) auditory comprehension?
(Task 2) and in matching picture samples to the appropriate printed words (Task 3) showed that he could understand the printed words. He was still able to grasp the relation between printed words and other kinds of objects in his environment. His reading comprehension was intact, even though he could not say the words aloud, and even when he had not written the words himself. He was also nearly errorless in Task 6, matching dictated sample words to pictures. This performance demonstrated auditory comprehension; he could understand the spoken words even though he could not speak them himself, and even when he had not written them himself.

Does R.W. resemble the split-brain patients we described earlier? They had shown that only the left hemisphere was capable of supporting speech behavior. R.W. had suffered damage only to his left hemisphere, and his intact right hemisphere was clearly incapable of supporting oral speech. But the split-brain patients could do written naming and matching to sample even when the responses were controlled by their isolated right hemisphere. Remember, R.W.'s right side was paralyzed, so that he had to do all his writing and matching with his left hand. His performances and the split-brain patients' were almost identical. We cannot be sure, but it is possible that R.W.'s intact performances were also mediated by his right hemisphere.

In discussing the tests carried out with R.W. and with the split-brain patients, we have consistently stated that some procedures tested only the subject's ability to discriminate the stimuli, while others also tested his ability to comprehend or understand the stimuli. The distinction between discrimination and comprehension, although often quite useful, is not really as clear-cut as we have implied.

When we talk about tests that do not measure comprehension, we are on fairly safe ground. Consider, for example, the nonsense syllable ZUB. If you saw this printed, you could surely copy it (written naming of printed words), and you could select the printed stimulus ZUB from a group of printed stimuli such as ZUT, BUZ, and so forth (matching printed words to printed words). Furthermore, if someone said “ZUB” to you, you could select the printed stimulus ZUB from a similar group (matching printed words to auditory stimuli). In response to the auditory stimulus “ZUB,” you could most likely respond by writing the letters Z-U-B (written naming of an auditory stimulus). You could, of course, do all these things without understanding or comprehending what ZUB means: it doesn’t “mean” anything. If these tests can successfully be completed by responding to a nonsense syllable (which, by definition, is incomprehensible); then the tests clearly do not tell us anything about the subject's comprehension, even when a “meaningful” word such as CAT is the stimulus.

We have, however, said that certain tests, such as matching printed or dictated words to pictures, measure comprehension. What do we mean by this? Well, it's important to remember that comprehension isn't a thing. It is simply a word that we use to describe some behaviors, but not others. If a person can, for example, match the printed word c-a-t to a picture of a cat, and if he can write or say “cat” when we point to a real or pictured cat, we are likely to say that he comprehends or understands the word c-a-t. If, however, he can match the printed word to the dictated word, but not to the picture, we are unlikely to credit him with comprehension. If the opposite is true, and he can match the printed word to the picture, but not to the dictated word, we are still likely to credit him with comprehension. The consequences of these abilities are different. They permit different kinds of interaction with the physical and social environment, and our language takes this into account.

5. To what extent does R.W.'s tactual behavior resemble that of the split-brain patients described in Part I?

6. How can we differentiate between tests that measure only discrimination and those that measure comprehension? What is comprehension?
Write your answers to the Study Questions in the spaces provided below.

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Patient 2—J.L.P.

This patient, J.L.P., was a 62-year-old sheet metal worker, who spent most of his evenings at a local gymnasium training and managing fighters. Unlike R.W., who suffered a sudden stroke, J.L.P.'s symptoms gradually worsened over a period of about a week. He first noted moderate weakness of his right arm and the right side of his face. The weakness gradually spread to his right leg and continued to get worse until he was unable to move the right side of his body. He did not lose his speech completely, but found himself having great trouble "finding" the words he wanted to say. For example, when asked whom he was going to visit on his vacation, he answered, "Well, ah, up in Vermont, wrote last week, three kids." But he could not say who they were. His pronunciation was good. In addition to his right-sided paralysis and his speech problem, J.L.P. was also found to be blind to objects in his right visual field. All these observations, of course, indicated damage to his left hemisphere. X-ray examination revealed a complete blockage of a large artery which supplied areas in the left hemisphere, and perhaps some parts of the right hemisphere as well. He was eventually able to walk with the aid of a leg brace and a three-legged cane, but his right arm remained useless, and his speech problems persisted. He, too, was eager to participate in experimental studies. J.L.P. was given the same tests as those administered to R.W. The results of J.L.P.'s tests are shown in Figure 3.6.

1. Which specific types of paralysis, blindness, and speech difficulty did J.L.P. display? Which hemisphere is implicated as being damaged? How does J.L.P. differ from R.W.?

2. By comparing Figures 3.5 and 3.6, how do J.L.P.'s results differ from R.W.'s?
To summarize: Each of the four types of response was involved in at least one good performance, demonstrating that none of the poor scores could be attributed to an inability to perform the required responses. Also, each of the three types of stimuli was involved in at least one good performance, demonstrating that none of the poor scores could be attributed to an inability to discriminate the stimuli. All the behavior required in these tests was available to J.L.P., and all the stimuli were capable of controlling some behavior. His brain damage had interacted not with the stimuli or responses alone, but with specific stimulus-response relations.

The four tasks in which J.L.P. did best share an important feature. Since they involve only repeating, copying, or matching identical stimuli, they can be done even by a person who has never learned to read, write, or understand words. Oral naming of dictated words can be done simply by repeating sounds; written naming of printed words can be done simply by copying forms; matching identical printed words to each other, or identical pictures to each other, can be done on the basis of physical similarities, even by a person completely unfamiliar with the words and pictures. These performances, therefore, do not necessarily tell us anything about the behavioral control exerted by language forms—by words. This is probably why J.L.P. was able to do them so well. All his deficient performances were on tasks that required him to make use of his learned experience with printed and spoken words.

Can we draw any conclusions about the particular kinds of tact relations that were affected by J.L.P.'s brain damage? There are several interesting comparisons. First, all the deficient performances (scores from zero to 70 percent) involved visual (printed) or auditory (spoken) words, either on the stimulus or on the response side of the tact relation. Clearly, his problems were with language forms. But we can specify the deficits even more sharply. For example, although J.L.P. was completely unable to name printed words orally—to read them aloud—he did much better (60 percent) when he had to say those same names in response to pictures. His picture naming, although disturbed, was considerably better than his printed-word naming. This comparison suggests that visual text was particularly troublesome to J.L.P.

Other comparisons confirm the suggestion that visual text was a special problem for J.L.P. For example, although he scored 60 percent in naming pictures aloud, he was completely unable to name them correctly in writing. Visual words were involved in this writing task, not as sample stimuli, but as products of the writing itself. Common sense suggests that it is difficult to write meaningfully, as this task demanded, if one cannot understand what one is writing. Proof that J.L.P. could understand few of the printed words came from two other tests—matching picture samples to printed words (30 percent), and matching printed-word samples to pictures (10 percent). These poor scores were clear evidence of his disturbed reading comprehension.

J.L.P.'s poorest performances (zero to 30 percent correct) all involved visual words. The remaining four tasks, on which he was less deficient (40 to 70 percent correct), involved relations between auditory and visual words or did not involve visual words at all. Writing to dictation (40 percent) and matching printed to dictated words (55 percent), although deficient, were less seriously disturbed than were those same responses to pictures. The relations between printed words and other visual stimuli were more impaired than were the relations between printed and dictated words.

Least disturbed of all were two tasks that did not involve visual words: Oral naming of pictures (60 percent), and matching dictated words to pictures (70 percent). Of the three tasks involving dictated words, matching them to pictures was the only one that did not involve visual words at all, and J.L.P. scored highest on this one of the three.
In summary: J.L.P.'s brain damage disrupted only those tact relations that required the use by naming or understanding of words; within the disrupted set of tact relations, the most severely affected were those that involved visual words; less severely affected were tact relations that involved auditory words; and least affected were tact relations that involved no visual words at all. J.L.P.'s brain damage had caused a clearly definable reading deficiency.

Write your answers to the Study Questions in the spaces provided below.

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9. Summarize the effect of J.L.P.'s brain damage upon his tact relations. How does this pattern compare to R.W.'s and to that obtained with split-brain patients?
1. Name five techniques for obtaining information about the structure and function of the brains of lower animals.

2. Define cerebral hemisphere and cortex.

3. Describe what is meant by contralateral control. Give motor and sensory examples. Cite two sources of evidence for contralateral control.
4. Define *visual field*, and explain how the external visual environment stimulates the brain.

5. Define *aphasia* and list its behavioral characteristics. State which hemisphere is most intimately involved in language. What is the supporting evidence?

6. Define *cerebral dominance*. In which human behavior is it most clearly evident? In which species has cerebral dominance been found?

7. Describe the *split-brain* patient.

8. Describe the experiments with split-brain patients which used tactile and visual non-word stimuli. What were the results? What do they tell us about hemispheric functions? Are we left with a definitive conclusion about right hemisphere functions? Why (or why not)?
9. Describe the matching-to-sample technique and how it is used to test cerebral hemisphere functions in the split-brain patient.

10. List the four possible combinations of *visual field* and *hand* used in the matching-to-sample experiment. Which tests could the patients perform successfully? What does this result show about these patients' brains?

11. What is *auditory comprehension*? How was it tested in the split-brain patients? What were the results and what do they tell us about the functions of the hemispheres?

12. State how the "vocal" left hemisphere can communicate with the "silent" right hemisphere in the split-brain patient.

13. Distinguish between *oral reading* and *reading comprehension*. What is an appropriate test of reading comprehension?
14. What were the results of the oral reading and reading comprehension experiments with the split-brain patients? What do these results tell us about the functions of the left and the right hemispheres?

15. Summarize the functions of the right and the left cerebral hemispheres with respect to speech production and comprehension of verbal stimuli (including spoken and printed words).

Part 2: Brain Damage and Language deficit—M. Sidman

1. Name two variables that may modulate the effectiveness of a reinforcer. Describe how brain damage can affect response-reinforcer relations.

2. Describe a behavior chain (including the stimuli that maintain it) and draw the paradigm.

3. State, in behavioral terms, what is meant by saying: (a) we have “achieved communication”; (b) we have “failed to achieve communication”; and (c) language is a “social process.”

4. Distinguish between generalized reinforcers and other types of conditioned reinforcers. What are two examples of generalized reinforcers?
5. Define *stimulus control*. Give some examples of defective stimulus control following brain damage.

6. Name the two basic classes of verbal behavior. What common English words do these two terms resemble?

7. Distinguish between mands and tacts in terms of: (a) which participant in a verbal interaction is likely to benefit from them; (b) their dependence on specific states of deprivation or aversive stimulation; (c) discriminative stimulus control; and (d) the kinds of reinforcers that maintain them.

8. Draw the paradigms for mands and tacts, and give some examples of each.

9. How does the strength of mands and tacts differ? Why?
10. Describe how the same word can function both as a mand and a tact. Give an example.

11. Describe how brain damage can distinguish between mand and tact relations. Give an example, stating which relation has been disrupted and which has been left intact.

12. Define language in terms of tact relations.

13. List the tests that were used to analyze the disturbed tact relations of the two brain-damaged patients, R.W. and J.L.P. State whether each of these tests measured discrimination only, or comprehension as well as discrimination.

14. Summarize the results and conclusions based on the testing of R.W. and J.L.P. Compare the performances of R.W. and J.L.P. to each other and to the results obtained with the split-brain patients.
CHAPTER 3: MULTIPLE-CHOICE SELF-TEST

Instructions: Answer these questions by circling your responses in the answer space provided at the end of the test. When you have answered all questions, check your responses against the answer key at the end of the text (page 377).

1. If a person suffers extensive damage to the visual sensory area in the left hemisphere, that person will not be able to see objects in:
   a. the left visual field.
   b. the right visual field.
   c. half of each visual field.
   d. either visual field.

2. Aphasic patients almost always suffer paralysis of the ______ side of the body, leading to the conclusion that the ______ hemisphere is most intimately involved in language.
   a. left; right
   b. left; left
   c. right; left
   d. right; right

3. Split-brain patients can correctly orally name objects felt with the ______ hand or viewed in the ______ visual field.
   a. left; right
   b. left; left
   c. right; left
   d. right; right

4. In one of the matching-to-sample tests with the split-brain patients, pictures of objects were projected to the left visual field. In this case the patient:
   a. correctly matched using his left hand.
   b. correctly matched using his right hand.
   c. correctly matched using either hand.
   d. could not perform correctly.

5. In the split-brain patient, auditory comprehension can be mediated by:
   a. the right hemisphere only.
   b. the left hemisphere only.
   c. both the right and the left hemispheres.
   d. neither the right nor the left hemisphere.

6. In one of the matching-to-sample tests with split-brain patients, in which words were flashed to the patient's right visual field, he:
   a. could read the word aloud, as well as match correctly using his right hand.
   b. could not read the word aloud, but could match correctly using his right hand.
   c. could read the word aloud, as well as match correctly using his left hand.
   d. could not read the word aloud, but could match correctly using his left hand.

7. A conclusion of the research on split-brain patients would be that:
   a. both hemispheres mediate speech production as well as language comprehension.
   b. while the left hemisphere mediates both speech production and language comprehension, the right hemisphere mediates only language comprehension.
   c. while the left hemisphere mediates only speech production, the right hemisphere mediates both speech production and language comprehension.
   d. while the left hemisphere mediates only language comprehension, the right hemisphere mediates both speech production and language comprehension.
8. Brain damage may affect drinking behavior in two quite distinct ways. In one case a person may refuse to drink no matter how long he has gone without water. For this person, brain damage has destroyed the controlling relation between drinking behavior and ____________, so that water ____________ a reinforcer.
   a. satiation; is
   b. deprivation; is
   c. satiation; is not
   d. deprivation; is not

9. Brain damage that destroys the strength of one particular reinforcer may have little effect upon verbal behavior, because:
   a. most verbal behavior is under the control of generalized reinforcers.
   b. the strength of verbal behavior does not depend on reinforcement.
   c. most verbal behavior is under the control of specific reinforcers and their associated deprivations.
   d. most verbal behavior is under the control of discriminative stimuli, not reinforcers.

10. Which of the following statements about mands is false? Mands:
   a. function mainly for the benefit of the speaker.
   b. are controlled by states of deprivation or aversive stimulation.
   c. are typically controlled by only one reinforcer.
   d. are controlled by one discriminative stimulus.

11. Suppose that you go shopping around for a used car, and bring along a friend who works part-time as an auto mechanic. You meet the salesman (whose commission is a percentage of the price of each car he sells), and he shows you a variety of cars. Consider the statement, “This car is a great buy. Its engine is in fine shape.” If your friend makes this statement, it is likely to be a ____________, controlled mainly by specific ____________. If the salesman makes this statement, it is likely to be a ____________, controlled mainly by specific ____________.
   a. mand; S^R's and associated deprivations/tact; S^R's from the car's engine
   b. mand; S^R's from the car's engine/tact; S^R's and associated deprivations
   c. tact; S^R's from the car's engine/mand; S^R's and associated deprivations
   d. tact; S^R's and associated deprivations/mand; S^R's from the car's engine

12. Suppose that a brain-damaged patient can say “Blanket, please,” when he is cold, but cannot name a blanket or calls it a “balloon” when someone points to a blanket and asks him what it is. In this case, brain damage has destroyed the controlling relation between the _________ “blanket” _________ and its usual controlling _________; but has left the response “blanket” ____________ in its _________ relation and its usual controlling _________.
   a. mand; S^R's/tact; S^R's
   b. tact; S^R's/mand; S^R's
   c. mand; S^R's/tact; S^R's
   d. tact; S^R's/mand; S^R's

13. In the testing of R.W. and J.L.P., some tests measured only discrimination, while others measured comprehension. Which of the following is a test of comprehension?
   a. matching printed words to printed words
   b. matching dictated words to pictures
   c. matching dictated words to printed words
   d. matching pictures to pictures

14. The results of R.W.’s tests show that:
   a. while he could not name verbal stimuli orally, he could understand verbal stimuli.
   b. brain damage had caused a clearly definable reading deficiency.
   c. while he could copy printed words and match printed words to printed words, he could not understand them.
   d. while he could repeat dictated words, he could not match dictated words to objects.
15. In comparing the results of R.W.'s and J.L.P.'s tests, it is apparent that:
   a. the language of both patients was affected similarly by brain damage.
   b. for J.L.P. only one response category was affected, while for R.W. several tact relations were affected.
   c. for R.W. only one response category was affected, while for J.L.P. several tact relations were affected.
   d. R.W. had most difficulty with auditory verbal stimuli, while J.L.P. had most difficulty with visual verbal stimuli.

Circle your answers below.
1. a b c d
2. a b c d
3. a b c d
4. a b c d
5. a b c d
6. a b c d
7. a b c d
8. a b c d
9. a b c d
10. a b c d
11. a b c d
12. a b c d
13. a b c d
14. a b c d
15. a b c d