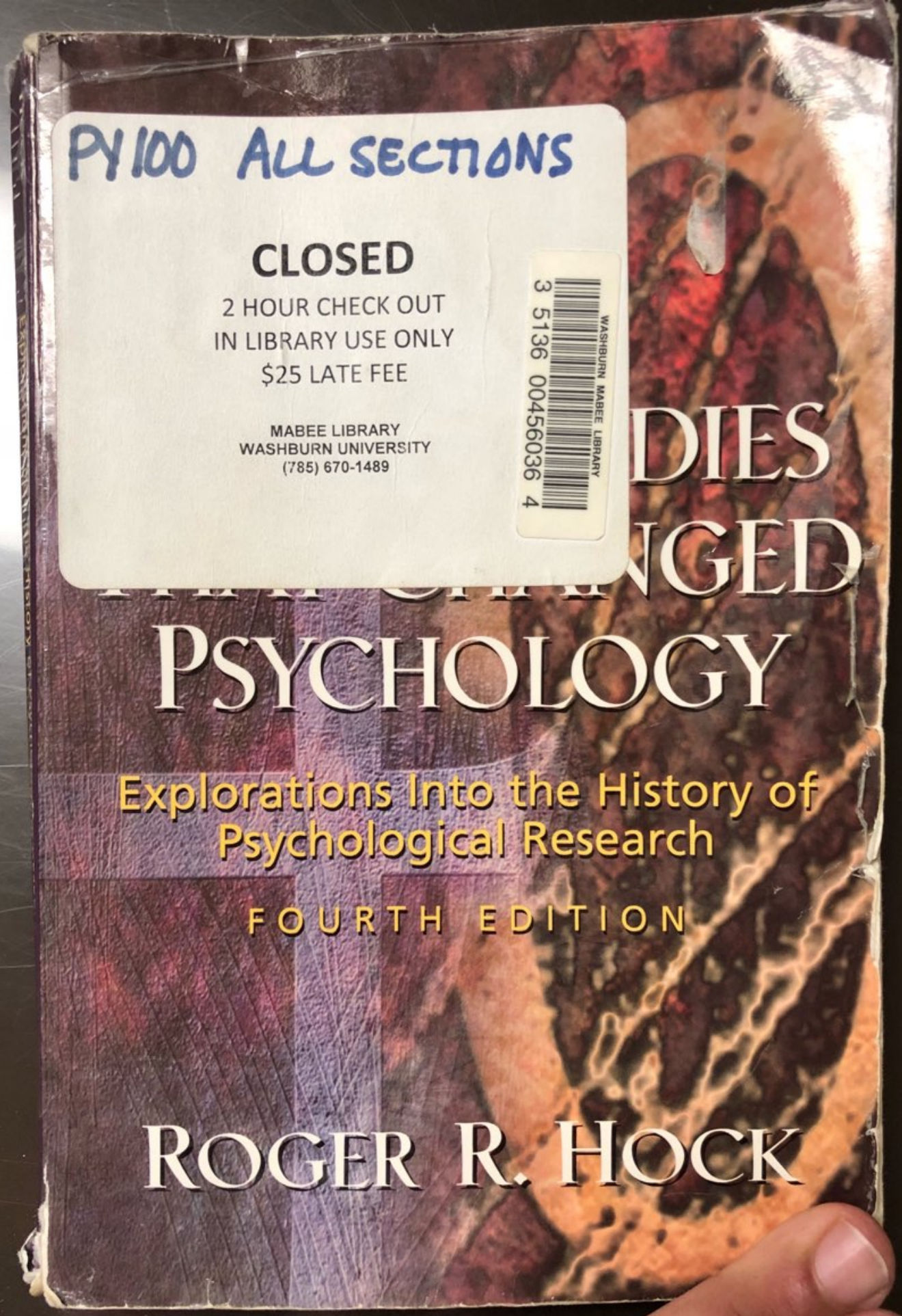
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Explorations Into the History of Psychological Research
FOURTH EDITION
ROGER R. HOCK

3 LEARNING AND CONDITIONING

The area of psychology concerned with learning and conditioning has produced a rather well-defined body of literature explaining how animals and humans learn. Some of the most famous names in the history of psychology have devoted their entire careers to this research—names that are widely recognized even outside the behavioral sciences, such as Pavlov, Watson, Skinner, and Bandura. Picking a few of the most influential studies from this branch of psychology and from these researchers is no easy task, but the articles selected can be found in nearly every introductory psychology textbook and are representative of the mammoth contributions of these scientists.

For Pavlov, we take a journey back nearly 100 years to review his work with dogs, metronomes, salivation, and the discovery of the conditioned reflex. Second, Watson, known for many contributions, is probably most famous (notorious?), for his torturous experiment with Little Albert, which demonstrated for the first time how emotions are a product of experience. For the third study in this section, we discuss Skinner's famous explanation and demonstration of superstitious behavior in a pigeon and how humans become superstitious in exactly the same way. Finally comes an examination of the well-known "Bobo Doll Study," in which Bandura established that aggressive behaviors could be learned by children through their modeling of adult violence.

IT'S NOT JUST ABOUT SALIVATING DOGS!

Pavlov, I. P. (1927). ***Conditioned reflexes.*** **London: Oxford University Press.**

Have you ever walked into a medical building where the odor of the disinfectant made your teeth hurt? If you have, it was probably because the odor triggered an association that had been conditioned in your brain between that smell and your past experiences at the dentist. When you hear "The Star Spangled Banner" played at the Olympic Games, does your heart beat a little faster? This happens to most Americans. Does the same thing happen when you hear the Italian national anthem? Unless you were raised in Italy, most likely it does not, because you have been conditioned to respond

RECENT APPLICATIONS

A citation of Spanos's 1982 article appeared in a 1997 article offering a *new* theory to explain the idea that subjects perform behaviors involuntarily under hypnosis (Lynn, 1997). This researcher contended that highly hypnotizable individuals perceive their behaviors while *under* as involuntary for several reasons. First, such people enter hypnosis with the *intention* to do what the hypnotist suggests. Second, they strongly *expect* that hypnosis has the power to mold their behavior whether they voluntarily cooperate or not. And third, "the intention to cooperate with the hypnotist as well as the expectation to be able to do so, create a heightened readiness to experience these actions as involuntary" (Lynn, 1997, p. 239). It is not surprising that this researcher relied on Spanos's work on hypnosis in that the theory mirrors and endorses the ideas set forth the article that is the subject of this reading.

On the other hand, several recent articles have refuted Spanos's position and added support for Hilgard's findings on hypnosis and pain reduction discussed above (e.g., Kihlstrom, 1998, 1999; Miller & Bowers, 1993; Montgomery, DuHamel, & Redd, 2000).

Finally, researchers in Spain attempted to stake out some territory in the middle of this debate by suggesting that it may be possible to *condition* people to respond to hypnosis (Diaz & Alvarez, 1997). Using a methodology developed by Skinner called *shaping* (see the discussion on Skinner in the next section), 10 subjects who tested very low on hypnotic suggestibility were given a series of exercises designed to teach them to respond to hypnotic-type suggestions. As subjects correctly completed each exercise, they were reinforced (rewarded) by the therapist. After conditioning, 6 of the 10 subjects responded to hypnotic suggestions, while none showed any suggestibility before the conditioning began. The authors concluded that "these results confirm the importance of situational variables in suggestibility or hypnotic susceptibility" (p. 167).

Clearly the debate goes on. Spanos continued his research until his untimely death in a plane crash in June 1994 (see McConkey & Sheehan, 1995). A summary of his early work on hypnosis can be found in his 1988 book, *Hypnosis: The Cognitive-Behavioral Perspective.* Nicholas Spanos was a prolific and well-respected behavioral scientist who will be missed greatly by his colleagues and by all those who learned and benefitted from his work (see Baker, 1994, for a eulogy to Nick Spanos). And, clearly, his research legacy will be carried on by others. His work on hypnosis changed psychology in that he offered a recent, experimentally-based alternative explanation for an aspect of human consciousness and behavior that was virtually unchallenged for nearly 200 years.

Baker, R. (1994). In memoriam: Nick Spanos. *Skeptical Inquirer, 18*(5), 459.
Diaz, A., & Alvarez, M. (1997). Transformations of the instructions in suggestions using operant procedures. *Psicothema, 9*(1), 167–174.

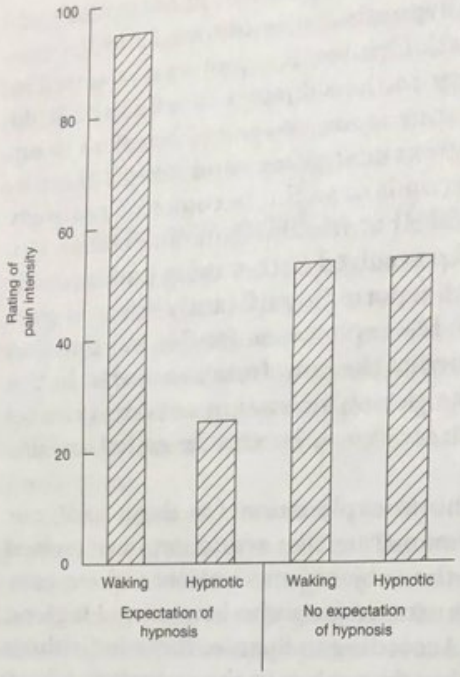

FIGURE 1 Waking versus hypnotic analgesia: Expectation versus no expectation.

accepted among most behavioral scientists that people cannot be hypnotized against their will. Furthermore, under hypnosis, subjects will not engage in acts they believe are antisocial, and they are not able to perform feats of superhuman strength or endurance. In this article, Spanos has demonstrated how many of the more subtle aspects of hypnosis may be explained in less mysterious and more straightforward ways than that of the *hypnotic trance.*

What would be the implications of accepting Spanos's contention that hypnosis does not exist? The answer to this question is, "perhaps none." Whether the effects of hypnosis are produced by an altered state of awareness or by increased motivation does not change the fact that hypnosis is often a useful method of helping people improve something in their lives. One reason that there continues to be such widespread and unquestioning acceptance of the power of the hypnotic trance may be that humans need to feel that there is a way out, a last resort to solve their problems if all else fails—something so omnipotent that they can even change against their own resistance to such change.

Whether or not hypnosis is an altered state of consciousness remains a highly controversial issue. But whatever hypnosis is, it is not the panacea most people would like to find. Several studies have shown that hypnosis is no more effective than other methods of treatment to help people stop abusing alcohol and tobacco, improve their memory, or lose weight (see Lazar & Dempster, 1981, for a review of this research).

The third and perhaps most interesting demonstration of hypnosis addressed by Spanos was the claim that hypnosis can cause people to become insensitive to pain (the analgesia effect). One way that pain can be tested in the laboratory without causing damage to the subject is by using the "cold pressor test." If you are a subject in such a study, you would be asked to immerse your arm in ice water (zero degrees centigrade) and leave it there as long as you could. After the first 10 seconds or so this becomes increasingly painful, and most people will remove their arm within a minute or two. Hilgard (1978) reported that subjects who received both waking and hypnotic training in analgesia (pain reduction) reported significantly less cold-pressor pain during the hypnotized trials. His explanation for this was that during hypnosis, a person is able to dissociate the pain from awareness. In this way, Hilgard contended, a part of the person's consciousness experiences the pain, but this part is hidden from awareness by what he called an "amnesic barrier."

Again, Spanos rejected a hypnotic explanation for these analgesic findings and offered evidence to demonstrate that reduction in perceived pain during hypnosis is a result of the subjects' motivation and expectations. All of the research on hypnosis uses subjects who have scored high on measures of hypnotic susceptibility. According to Spanos, these individuals "have a strong investment in presenting themselves in the experimental setting as good hypnotic subjects" (p. 208). These subjects know that a waking state is being compared to a hypnotic state and want to demonstrate the effectiveness of hypnosis. Spanos performed a similar study involving cold-pressor pain, but with one major difference: Some subjects were told that they would first use waking analgesia techniques (such as self-distraction) and would then be tested using hypnotic pain-reduction methods, but other subjects were not told of the later hypnotic test.

Figure 1 summarizes what Spanos found. When subjects expected the hypnosis condition to follow the waking trials, they rated the analgesic effect lower in order to, as Spanos states, "leave room" for improvement under hypnosis. Spanos claimed that this demonstrated how even the hypnotic behavior of pain insensitivity could be attributed to the subjects' need to respond to the demands of the situation rather than automatically assuming a dissociated state of consciousness.

The most important question concerning all these findings reported by Spanos is whether we should reevaluate the phenomenon called hypnosis. And what does it mean if we were to decide that hypnosis is not the powerful mind-altering force that popular culture, and many psychologists, have portrayed it to be?

IMPLICATIONS OF THE FINDINGS

In evaluating Spanos's research, you should remember that his goal was not to prove that hypnosis does not exist, but rather to demonstrate that what we call *hypnotic behaviors* are the result of highly motivated, goal-directed social behavior, not an altered and unique state of consciousness. It is well

imagined scenario, the higher the absorption rating, the more likely they were to interpret their related behavior as occurring involuntarily. Spanos also noted that a person's susceptibility to hypnosis correlates with his or her general tendency to become absorbed in other activities such as books, music, or daydreaming. Consequently, these individuals are more likely to willingly cooperate with the kind of suggestions involved in hypnosis.

Creation of Expectations in Hypnotic Subjects

Spanos claims that the beliefs most people have about hypnosis are adequate in themselves to produce what is typically seen as hypnotic behavior. He further contends that these beliefs are strengthened by the methods used to induce and study hypnosis. He cites three examples of research that demonstrated how people might engage in certain behaviors under hypnosis because they think they should, rather than because of an altered state of awareness.

First, Spanos referred to a study in which a lecture about hypnosis was given to two groups of students. The lectures were identical except that one group was told that arm rigidity was a spontaneous event during hypnosis. Later both groups were hypnotized. In the group that had heard the lecture including the information about arm rigidity, some of the subjects exhibited this behavior *spontaneously,* without any instructions to do so. However, among the subjects in the other group, not one arm became rigid. According to Spanos, this demonstrated how people will enact their experience of hypnosis according to how they believe they are supposed to behave.

The second hypnotic event that Spanos used to illustrate his position involved research findings that hypnotized subjects claim the visual imagery they experienced under hypnosis was more intense, vivid, and real than similar imaginings when not hypnotized. Here, in essence, is how these studies typically have been done. Subjects are asked to imagine scenes or situations in which they are performing certain behaviors. Then, these same subjects are hypnotized and again asked to visualize the same or similar situations (the hypnotized and nonhypnotized trials can be in any order). These subjects generally report that the imagery in the hypnotized condition was significantly more intense. Spanos and his associates found, however, that when two different groups of subjects are used, one hypnotized and one not, their average intensity ratings of the visual imagery are approximately equal. Why the difference? The difference in the two methods is probably explained by the fact that when two different groups are tested, the subjects do not have anything to use for comparison. However, when the same subjects are used in both conditions, they can compare the two experiences and rate one against the other. So, since subjects nearly always rate the hypnotic imagery as more intense, this supports the idea that hypnosis is really an altered state, right? Well, if you ask Spanos, he would say, "Wrong!" In his view, the subjects who participate in both conditions expect the ritual of hypnosis to produce more intense imagery and, therefore, they rate it accordingly.

understand that they must voluntarily do something to initiate the suggested behavior and instead simply wait for their arms or body to begin to move. Other subjects respond to the suggestion, but are aware that they are behaving voluntarily. Finally, there are those subjects who agree to both requests; they respond to the suggestion and interpret their response as beyond their control.

Spanos suggested that whether subjects interpret their behavior to be voluntary or involuntary depends on the way the suggestion is worded. In one of his studies, Spanos put two groups of subjects through a hypnosis induction procedure. Then to one group he made various behavior suggestions, such as, "your arm is very light and is rising." To the other group he gave direct instructions for the same behaviors, such as, "raise your arm." Afterward he asked the subjects if they thought their behaviors were voluntary or involuntary. The subjects in the suggestion group were more likely to interpret their behaviors as involuntary than were those in the direct instruction group.

Right now, while you are reading this page, hold your left arm straight out and keep it there for a couple of minutes. You will notice that it begins to feel heavy. This heaviness is not due to hypnosis; it's due to gravity! So if you are *hypnotized* and given the suggestion that your outstretched arm is becoming heavy, it would be very easy for you to attribute your action of lowering your arm to involuntary forces (you want to lower it anyway!). But what if you are given the suggestion that your arm is light and rising? If you raise your arm, it should be more difficult to interpret that action as involuntary, because you would have to ignore the contradictory feedback provided by gravity. Spanos tested this idea and found that such an interpretation was more difficult. Subjects who believed they were hypnotized were significantly more likely to define as involuntary their behavior of arm-lowering than that of arm-raising. In the traditional view of hypnosis, the direction of the arm in the hypnotic suggestion should not make any difference; it should always be considered involuntary.

Suggestions made to hypnotic subjects often ask them to imagine certain situations in order to produce a desired behavior. If you were a subject, you might be given the suggestion that your arm is rigid and you cannot bend it. To reinforce this suggestion, it might be added that your arm is in a plaster cast. Spanos believed that some people may become absorbed in these *imaginal strategies* more than others, which could have the effect of leading them to believe that their response (the inability to move their arm) was involuntary. His reasoning was that if you are highly absorbed, you will not be able to focus on information that alerts you to the fact that the fantasy is not real. The more vividly you imagine the cast, its texture and hardness, how it got there, and so on, the less likely you are to remember that this is only your imagination at work. If this deep absorption happens, you might be more inclined to believe that your rigid-arm behavior was involuntary when actually it was not. In support of this, Spanos found that when subjects were asked to rate how absorbed they were in a suggested

great deal of meaning. Subjects expect to relinquish control over their own behavior, and as the process of hypnotic induction develops, they begin to believe that their voluntary acts are becoming automatic, involuntary events. An example of this that Spanos offers is that early in the hypnotic procedure, voluntary instructions are given to the subject, such as, "relax the muscles in your legs," but later these become involuntary suggestions, such as, "your legs feel limp and heavy."

In collaboration with various colleagues and associates, Spanos devoted nearly a decade of research prior to this 1982 article demonstrating how many of the effects commonly attributed to hypnotic trances could be explained just as easily (or even more easily) in less mysterious ways.

METHOD

This article does not report on a specific experiment, but rather summarizes numerous studies made by Spanos and others prior to 1982, which were designed to support his position against Hilgard's contention (and the popular belief) that hypnosis is a unique state of consciousness. Most of the findings reported were taken from 16 studies in which Spanos was directly involved, and that offered alternate interpretations of hypnotically produced behavior. Therefore, as in the previous article on dream research, results and the discussion of them will be combined.

RESULTS AND DISCUSSION

Spanos claimed that there are two key aspects of hypnosis that lead people to believe it is an altered state of consciousness. One is that subjects interpret their behavior as being caused by something other than the self, thus making the action seem involuntary. The second aspect is the belief discussed previously that the hypnosis ritual creates expectations in the subject which in turn motivate the subject to behave in ways that are consistent with the expectations. The research Spanos reports in this article focuses on how these frequently cited claims about hypnosis have been drawn into question.

The Belief That Behavior Is Involuntary

As subjects are being hypnotized, they are usually asked to take various *tests* to determine if a hypnotic state has been induced. Spanos claimed that these tests are often carried out in such a way as to invite the subjects to convince themselves that something out of the ordinary is happening. Hypnotic tests involve suggestions such as, "your arm is heavy and you cannot hold it up"; your hands are being drawn together by some force and you cannot keep them apart; your arm is as rigid as a steel bar and you cannot bend it; or your body is so heavy that you cannot stand up. Spanos interpreted these test suggestions as containing two interrelated requests. One request asks subjects to do something, and the other asks them to interpret the action as having occurred involuntarily. Some subjects fail completely to respond to the suggestion. Spanos claimed that these subjects do not

disorders were a result of imbalances in a universal magnetic fluid present in the body. During strange gatherings in his laboratory, soft music would play, the lights would dim, and Mesmer, clothed like a sorcerer, would take iron rods from bottles of various chemicals and touch parts of the afflicted patients' bodies. He believed that this would transmit what he called the *animal magnetism* in the chemicals into the patients and provide relief from their symptoms. Interestingly, history has recorded that in many cases this treatment appeared to be successful. It is from Mesmer that we acquired the word *mesmerize,* and many believe that his treatment included some of the techniques we now associate with hypnosis.

Throughout the history of psychology, hypnosis (named after Hypnos, the Greek god of sleep) has played a prominent role, especially in the treatment of psychological disorders, and it was a major component in Freud's psychoanalytic techniques. Ernest Hilgard has been at the forefront of modern researchers who support the position that hypnosis is an altered psychological state (Hilgard, 1978). His and others' descriptions of hypnosis have included characteristics such as increased susceptibility to suggestion, involuntary performance of behaviors, improvements in recall, increased intensity of visual imagination, dissociation (the ability to be aware of some conscious events while being unaware of others), and analgesia (lowered sensitivity to pain). Until recently, the idea that hypnosis is capable of producing thoughts, ideas, and behaviors that would otherwise be impossible that it is an altered state of consciousness has been virtually undisputed.

However, it is the job of scientists to look upon the status quo with a critical eye and, whenever they see fit, to debunk common beliefs. Just as Hobson and McCarley proposed a new view of dreaming that was radically different from the prevailing and popular one, social psychologist Nicholas Spanos has suggested that the major assumptions underlying hypnosis, as set forth by Hilgard and others, should be questioned. In this article Spanos wrote, "The positing of special processes to account for hypnotic behavior is not only unnecessary, but also misleading. . . . Hypnotic behavior is basically similar to other social behavior and, like other social behavior, can be usefully described as strategic and goal-directed" (p. 200). In other words, Spanos contended that hypnotized subjects are actually engaging in voluntary behavior designed to produce a desired consequence. He further maintained that while such behavior may result from increased motivation, it does not involve an altered state of consciousness.

THEORETICAL PROPOSITIONS

Spanos theorized that all of the behaviors commonly attributed to a hypnotic trance state are within the normal, voluntary abilities of humans. He maintained that the only reason people define themselves as having been hypnotized is that they have interpreted their own behavior *under hypnosis* in ways that are consistent with their expectations about being hypnotized. Spanos views the process of hypnosis as a ritual that in Western culture carries a

"meaningless bursts of neural static," why do these meaningless bursts consistently fail to activate any flashes of three-R activity?

CONCLUSION

Whether or not you are willing to accept the rather less romantic view of dreaming developed by Hobson and McCarley's research, this is an excellent example of how psychologists or scientists in any field need to remain open to new possibilities even when the *established order* has existed for decades. There is no doubt that the activation-synthesis model of dreams has changed psychology. This does not mean that we have solved all the mysteries of sleep and dreaming, and perhaps we never will. But it's bound to be a fascinating journey.

Foulkes, D. (1985). *Dreaming: A cognitive-psychological analysis.* Hillsdale, NJ: Erlbaum.
Hartmann, E. (2000). We do not dream the 3 R's: Implications for the nature of dreaming memtation. *Dreaming, 10*(2), 103–110.
Hobson, J. A. (1989). *Sleep.* New York: Scientific American Library.
Kahan, T., LaBerge, S., Levitan, L., & Zimbardo, P. (2000). Similarities and differences between dreaming and waking cognition: An exploratory study. *Consciousness and Cognition, 6*(1), 132–147.
Mancia, M. (1999). Psychoanalysis and the neurosciences: A topical debate on dreams. *International Journal of Psychoanalysis, 80*(6), 1205–1213.

ACTING AS IF YOU ARE HYPNOTIZED

Spanos, N. P. (1982). Hypnotic behavior: A cognitive, social, psychological perspective. *Research Communications in Psychology, Psychiatry, and Behavior, 7,* 199–213.

The alterations in consciousness with which we are all most familiar are related to sleep and dreaming. The previous three articles have focused on several highly influential studies relating to these topics. Another phenomenon relating to altered states of consciousness is hypnosis. Hypnosis is usually seen as a mysterious and powerful process of controlling a person's mind. The phrases and words that surround hypnosis, such as *going under* and *trance,* indicate that it is commonly considered to be a separate and unique state of awareness, different from both waking and sleep. And many psychologists agree with this view. Nicholas Spanos, however, has led the opposing view that hypnosis is, in reality, nothing more than an increased state of motivation to perform certain behaviors and can be fully explained without resorting to trances or altered states.

The beginnings of hypnosis are usually traced back to the middle of the eighteenth century, a time when mental illness was first recognized as resulting from psychological rather than organic causes. One of the many fascinating characters who helped bring psychology out of the realm of witchcraft was Franz Anton Mesmer (1733–1815). He believed that *hysterical*

And the research continues. Many studies seek to challenge Hobson and McCarley's conceptualization of the origin and function of dreams. One such study compared subjects' cognitions (thoughts) and emotional perceptions of their recent waking and dreaming experiences (Kahan, LaBerge, Levitan, & Zimbardo, 2000). The findings may surprise you. The researchers discovered that "dreaming cognition is more similar to waking cognition than previously assumed and that the differences between dreaming and waking cognition are more quantitative than qualitative" (Kahan et al., 2000, p. 132). In other words, the authors contend, your experience of past dreaming events is pretty much the same as your experience of past waking events; therefore, they are asking by implication, How could dreams possibly involve only random bursts of electrical brain activity?

Yet another study demonstrated how the controversy among sleep and dream theorists lives on. The Freudian-based, psychoanalytic community continues to express their annoyance that Hobson and McCarley's theories leave little room for the view that is central to their reason for being: Dreams are messages from the unconscious. In a journal devoted to Freudian psychoanalysis, Mancia (1999) demonstrates the differences between the psychoanalytic notion of dreaming and the theory proposed by Hobson and McCarley, often referred to as the "neuroscientific" approach. Mancia describes the clash between these two fundamental views with great clarity:

> Whereas the neuroscientists are interested in the structures involved in dream production and in dream organization and narratability; psychoanalysis concentrates on the meaning of dreams and on placing them in the context of the analytic relationship [with the analyst] in accordance with the affective [emotional] history of the dreamer. . . . The brain structures and functions of interest to the neurosciences . . . are irrelevant to their psychoanalytic understanding (Mancia, 1999, p. 1205).

Of course, Hobson and McCarley very likely would reply that there is no psychoanalytic understanding possible, because there is no such thing as an unconscious in the Freudian conceptualization of it. That debate, while worth having, must be saved for another time and place.

Finally, a fascinating study took a new look at what types of behaviors people dream about most frequently (Hartmann, 2000). The goal of the study was to see if people dream about the "Three Rs"—reading, writing, and arithmetic—that are such a central part of most people's waking lives. The researchers analyzed 456 written dream reports and asked 240 "frequent dreamers" to complete a survey about how frequently they dreamed about reading, writing, and calculating. Out of the 456 descriptions of dreams, there were no instances of reading and writing, and only one report of calculating. Moreover, among the participants in the survey portion of the study, 90% reported that they "never" or "hardly ever" dreamed about any of these activities even though they spent an average of 6 hours per day reading, writing, or calculating. These results offer a provocative challenge to Hobson and McCarley's model expressed in this reading. If dreams are made up of

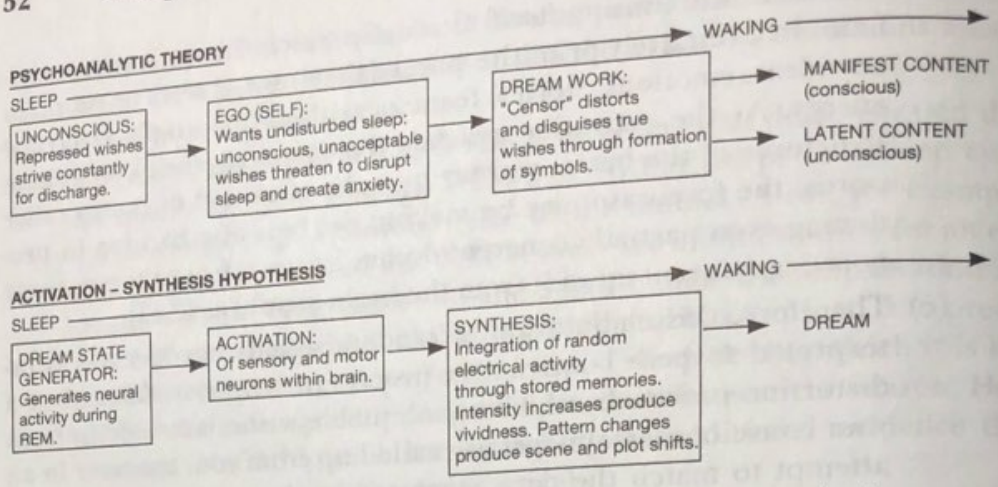

FIGURE 1 Psychoanalytic theory and activation-synthesis hypothesis compared (adapted from p. 1346).

And, he allows, dreams are not devoid of meaning, but should be interpreted in more straightforward ways. Hobson states his somewhat more compromising view as follows:

> For all their nonsense, dreams have a clear import and a deeply personal one. Their meaning would stem, I assert, from the necessity in REM sleep for the brain-mind to act upon its own information and according to its own lights. Thus, I would like to retain the emphasis of psychoanalysis upon the power of dreams to reveal deep aspects about ourselves, but without recourse to the concept of disguise and censorship or to the now famous Freudian symbols. My tendency, then, is to ascribe the nonsense to brain-mind dysfunction and the sense to its compensatory effort to create order out of chaos. That order is a function of our own personal view of the world, our current preoccupations, our remote memories, our feelings, and our beliefs. That's all. (Hobson, 1989, p. 166)

Another dream researcher took Hobson's sentiments a step further. Foulkes (1985), a leading researcher on daydreaming, also subscribes to the notion that night dreams are generated by spontaneous brain activity during sleep. He has suggested that while dreams do not contain hidden unconscious messages, they may provide us with a great deal of psychological information. Foulkes maintains that the way your cognitive system places form and sense onto the random impulses in your brain reveals information about the importance of certain of your memories and provides insight into your thinking processes. He also believes that dreams serve several useful purposes. One of these arises from dreams you have about experiences that have not actually happened to you. These dreams may assist in preparing you to encounter new or unexpected events; something like a cognitive rehearsal, or "What would I do if . . .?" Foulkes suggests that another possible function of dreams is that, since your dreams are usually about yourself, they may offer opportunities for you to increase your knowledge of who you are.

instead it is activating itself internally. Since this activation originates in a relatively primitive part of the brain, it does not contain any ideas, emotions, stories, fears, or wishes. It is simple electrical energy. As the activation reaches the more advanced, cognitive structures of the brain, you try to make sense out of it. "In other words, the forebrain may be making the best of a bad job in producing even partially coherent dream imagery from the relatively noisy signals sent up to it from the brain stem" (p. 1347).

(c) Therefore, this elaboration of random signals into dreams is interpreted to be a constructive process, a synthesis, instead of a distortion process by which unacceptable wishes are hidden from your consciousness. Images are called up from your memory in an attempt to match the data generated by the brain stem's activation. It is precisely because of the randomness of the impulses, and the difficult task of the brain to try to inject them with some meaning, that dreams are often bizarre, disjointed, and seemingly mysterious.

(d) Freud's explanation for our forgetting dreams was repression. He believed that when the content of a dream is too disturbing for some reason, you are motivated to forget it. Hobson and McCarley, acknowledging that dream recall is poor (at least 95% of all dreams are not remembered), offered a pure physiological explanation that was concordant with the rest of their activation-synthesis hypothesis. They claimed that when we awaken, there is an immediate change in the chemistry of the brain. Certain brain chemicals necessary for converting short-term memories into long-term ones are suppressed during REM sleep. So unless a dream is particularly vivid (meaning that it is produced by a large amount of activation) and you awaken during or immediately after it, the content of the dream will not be remembered.

Figure 1 illustrates Hobson and McCarley's comparison between the psychoanalytic view of the dream process and their activation-synthesis model.

IMPLICATIONS AND RECENT APPLICATIONS

Hobson and McCarley have continued to conduct research in support of their revolutionary hypothesis of dreaming. Their new conceptualization has not been universally accepted, but no psychological discussion of dreaming would be considered complete without its inclusion.

Twelve years after the appearance of Hobson and McCarley's original article on the activation-synthesis model, Allan Hobson published his book called, simply, *Sleep*. In this work, he explains his theory of dreaming in expanded and greatly simplified terms. He also elaborates on his view about what impact the theory may have on the interpretation of dream content.

person's psyche. Instead, the D state appeared to Hobson and McCarley to be a preprogrammed event in the brain that functions almost like a neurobiological clock.

4. The researchers pointed to findings by others that demonstrated that all mammals cycle through REM and NREM sleep. This sleep cycle varies according to the body size of the animal. A rat, for example, will shift between REM and NREM every six minutes, while for an elephant a single cycle takes two-and-a-half hours! One explanation for this difference may be that the more vulnerable an animal is to predators, the shorter are its periods of sound sleep during which it is less alert and thus in greater danger of attack. Whatever the reason, Hobson and McCarley took these findings as additional evidence that dreaming sleep is purely physiological.
5. Hobson and McCarley claimed to have found the trigger, the power supply, and the clock of the "dream state generator" in the brain. They reported this to be the pontine brain stem, located in the back and near the base of the brain. Measurements of neural activity (the frequency of firing of neurons) in this part of the brain in cats found significant peaks in activity corresponding to periods of REM sleep. When this part of the brain was artificially inhibited, the animals went for weeks without any REM sleep. Furthermore, reducing the activity of the pontine caused the length of time between periods of D state sleep to increase. Conversely, stimulation of the brain stem caused REM sleep to occur earlier and increased the length of REM periods. Such increases in REM have been attempted through conscious behavioral techniques, but these have been mostly unsuccessful. The authors' interpretation of these findings was that since a part of the brain completely separate from the pontine brain stem is involved in consciousness, dreaming cannot be driven by psychological forces.
6. The first five points summarized from Hobson and McCarley's research focused on the *activation* portion of their theory. They maintained that the *synthesis* of this activation is what produces your experience of dreaming. The psychological implications of their theory were detailed by the authors in four basic tenets:
   (a) "The primary motivating force for dreaming is not psychological but physiological, since the time of occurrence and duration of dreaming sleep are quite constant, suggesting a preprogrammed, neurally determined genesis" (p. 1346). They did allow that dreams may have psychological meaning, but suggested that this meaning is much more basic than the psychoanalytic view imagines it to be. They further contended that dreaming should no longer be considered to have purely psychological significance.
   (b) During dreaming, the brain stem is not responding to sensory input or producing motor output based on the world around you;

sure. (You may believe your pet dreams, but has your dog or cat ever told you what the dream was about?) However, all mammals experience stages of sleep similar to those in humans. Hobson and McCarley went one step further and claimed that there is no significant difference between humans and other animals in the physiology of dreaming sleep. So they chose cats for their experimental subjects. Using various laboratory techniques, they were able to stimulate or inhibit certain parts of the animals' brains and record the effect on dreaming sleep.

RESULTS AND DISCUSSION

The various findings detailed by Hobson and McCarley were used to demonstrate different aspects of their theory. Therefore, their results will be combined with their discussion of the findings here. The evidence generated by the researchers in support of their theory can be summarized in the following points:

1. The part of the brain in the brain stem that controls physical movement and incoming information from the senses is at least as active during dreaming sleep (which they called the *D state*) as it is when you are awake. However, while you are asleep, sensory input (information coming into your brain from the environment around you) and motor output (voluntary movement of your body) are blocked. Hobson and McCarley suggest that these physiological processes, rather than a psychological censor, may be responsible for protecting sleep.

   You will remember from the previous article that you are paralyzed during dreaming, presumably to protect you from the potential danger of acting out your dreams. Hobson and McCarley reported that this immobilization actually occurs at the spinal cord and not in the brain itself. Therefore, the brain is quite capable of sending motor signals, but the body is not able to express them. The authors suggested that this may account for the strange patterns of movement in dreams, such as your inability to run from danger or the perception that you are moving in slow motion.
2. The main exception to this blocking of motor responses is in the muscles and nerves controlling the eyes. In part, this explains why rapid eye movement occurs during D state, and may also explain how visual images are triggered during dreaming.
3. Hobson and McCarley pointed out another aspect of dreaming that emerged from a physiological analysis of the D state and that could not be explained by a psychoanalytic interpretation. This was that the brain enters REM sleep at regular and predictable intervals during each night's sleep and remains in that state for specific lengths of time. There is nothing random about this sleep cycle. The authors interpreted this to mean that dreaming cannot be a response to waking events or unconscious wishes, because this would produce dreaming at any moment during sleep, according to the whims and needs of the

your sensory and motor abilities are shut down, but this part of your brain is not. It continues to generate what Hobson and McCarley regarded as meaningless bursts of neural static. Some of these impulses reach other parts of your brain, responsible for higher functions such as thinking and reasoning. When this happens, your brain tries to synthesize and make some sort of sense out of the impulses. To do this, you sometimes create images, ideas, and even stories with plots. If we awaken and remember this cognitive activity, we call it a dream and invest it with all kinds of significance which, according to Hobson and McCarley, was never there to begin with.

Hobson and McCarley's original article, upon which this discussion is based, is a highly technical account of the neurophysiology of sleep and dreaming. While their work can be found in nearly all textbooks that include information about dreaming, very little of the detail is offered there, due to the complex nature of the researchers' reporting. We will explore their article in significantly greater detail, although for clarity and understanding, considerable distillation and simplification is unavoidable.

THEORETICAL PROPOSITIONS

Hobson and McCarley believed that modern neurophysiological evidence "permits and necessitates important revisions in psychoanalytic dream theory. The activation-synthesis hypothesis . . . asserts that many formal aspects of the dream experience may be the obligatory and relatively undistorted psychological concomitant of the regularly recurring and physiologically determined brain state called 'dreaming sleep' " (p. 1335). What they meant by this was simply that dreams are triggered automatically by basic physiological processes, and there is no *censor* distorting the true meaning to protect you from your unconscious wishes. Moreover, they contend that the strangeness and distortions often associated with dreams are not disguises, but the results of the physiology of how the brain and mind work during sleep.

The most important part of their theory was that the brain becomes activated during REM sleep and generates its own original information. This activation is then compared with stored memories in order to synthesize the activation into some form of dream content. In other words, Hobson and McCarley claim that what is referred to as REM sleep actually causes dreaming, instead of the opposing popular view that dreams produce REM sleep.

METHOD

In their article, Hobson and McCarley incorporated two methods of research. One method was to study and review previous work by many researchers in the area of sleep and dreaming. In this single article, the authors cite 37 references that pertain to their hypothesis, including several earlier studies of their own. The second method they used was research on the sleep and dreaming patterns of animals. They did not try to claim that nonhuman animals dream, since this is something no one can know for

UNROMANCING THE DREAM . . .

Hobson, J. A., & McCarley, R. W. (1977). The brain as a dream-state generator: An activation-synthesis hypothesis of the dream process. *American Journal of Psychiatry, 134,* 1335–1348.

The work of Aserinsky and Dement explored the apparent need for dreaming sleep in humans. Cartwright's research led to an examination of the reasons why you dream and some of the functions dreaming might serve. The history of research on dreaming has been dominated by the belief that dreams reveal something about yourself; that they are products of your inner psychological experience of the world. This view can be traced back to Sigmund Freud's psychoanalytic theories of human nature.

You'll recall that Freud believed that dreams are the expression of unconscious wishes for things we are unable to have while awake. Therefore, dreams offer insights into the unconscious that are unavailable in waking thought. However, the psychoanalytic approach also contends that many of these wishes are unacceptable to the conscious mind and, if expressed openly in dreams, would disrupt sleep and create anxiety. Thus, to protect the individual, the true desires contained in the dream are disguised in the dream's images by a hypothetical censor. Consequently, the theory asserts the true meaning of most dreams lies hidden beneath the dream's outward appearance. Freud called this surface meaning of a dream the *manifest content* and the deeper, true meaning the *latent content.* In order to reveal the meaningful information of a dream, the manifest content must be interpreted, analyzed, and penetrated.

While the validity of a great portion of Freud's work has been drawn into serious question by behavioral scientists over the past 50 years, his conceptualization of dreams remains widely accepted by psychologists and Western culture in general. (See the reading on Anna Freud for a discussion of other enduring aspects of Freud's theories.) Almost everyone has had the experience of remembering an unusual dream and thinking, "I wonder what it really means!" We believe that our dreams have deep meaning about conflicts that are hidden in the unconscious parts of our psyches.

In the late 1970s, Allan Hobson and Robert McCarley, both psychiatrists and neurophysiologists at Harvard's medical school, published a new theory of dreaming that shook the scientific community so deeply that the tremors are still being felt today. What they said, in essence, was that dreams are nothing more than your attempt to interpret random electrical impulses produced automatically in your brain during REM sleep.

They proposed that while you are asleep there is a part of your brain, located in the brain stem, that is periodically activated and produces electrical impulses. This part of your brain is related to physical movement and the processing of input from your senses while you are awake. When you are asleep,

for the phenomenon known as *delirium tremens* (DTs), which usually involve terrible and frightening hallucinations (Greenberg & Perlman, 1967).

Dement spent decades following up on his early preliminary findings regarding the behavioral effects of dream deprivation. In his later work, he deprived subjects of REM for much longer periods of time and found no evidence of harmful changes. He concluded that "A decade of research has failed to prove that substantial ill effects result even from prolonged selective REM deprivation" (Dement, 1974).

Finally, research with its origins in Dement's early work reported here suggests that there is a greater synthesis of proteins in the brain during REM sleep than during NREM sleep. Some believe that these chemical changes may represent the process of integrating new information into the memory structures of the brain and may even be the organic basis for new developments in personality (Rossi, 1973).

RECENT APPLICATIONS

It is generally accepted by experts in the field of sleep and dreaming that Aserinsky discovered REM. Most studies relating to sleeping, dreaming, or sleep disorders attribute that basic fact to him. Consequently, his early work with Kleitman is frequently cited in many recent scientific articles.

Dement's extension of Aserinsky's work continues to be cited frequently in a wide range of research articles relating to sleep patterns. One such recent study found that REM sleep plays a role in people's ability to improve their performance on a newly learned task while they sleep (Stickgold, Whidbee, Schirmer, Patel, & Hobson, 2000). Another provocative article citing Dement's research in the journal, *New Ideas in Psychology*, proposed that REM sleep is an adaptive survival mechanism that has evolved to ensure social bonding between infant mammals and their mothers, and between sexual partners (McNamara, 1996). The author claims that this bonding hypothesis is supported by consideration of the biological attachment of infants, the physiological characteristics of REM sleep, an examination of which animals exhibit REM sleep and which do not, and the typical content of human dreams. Predictably, proponents of Freudian psychoanalytic psychology have latched onto these new findings about attachment as evidence of Freud's ultimate wisdom in proposing that repression and dream analysis are central to an understanding the human psyche (Zborowski & McNamara, 1998).

Dement, W. C. (1974). *Some must watch while some must sleep*. San Francisco: Freeman.
Greenberg, R., & Perlman, C. (1967). Delirium tremens and dreaming. *American Journal of Psychiatry, 124*, 133–142.
McNamara, P. (1996). REM-sleep: A social bonding mechanism. *New Ideas in Psychology, 14*(1), 35–46.
Rossi, E. I. (1973). The dream protein hypothesis. *American Journal of Psychiatry, 130*, 1094–1097.
Stickgold, R., Whidbee, D., Schirmer, B., Patel, V., & Hobson, J. (2000). *Journal of Cognitive Neuroscience, 12*(2), 246–254.
Zborowski, M. J., & McNamara, P. (1998). Attachment hypothesis of REM sleep: Toward an integration of psychoanalysis, neuroscience, and evolutionary psychology and the implications for psychopathology research. *Psychoanalytic Psychology, 15*(1), 115–140.

There were several interesting additional discoveries made in this brief yet remarkable article. If you return to the table for a moment, you'll see that two subjects, as mentioned before, did not show a significant REM-rebound (subjects 3 and 7). It is always important in research incorporating a relatively small number of subjects to attempt to explain these exceptions. Dement found that the small increase in subject 7 was not difficult to explain: "His failure to show a rise on the first recovery night was in all likelihood due to the fact that he had imbibed several cocktails at a party before coming to the laboratory, so the expected increase in dream time was offset by the depressing effect of the alcohol" (p. 1706).

Subject 3, however, was more difficult to reconcile. Although he showed the largest increase in the number of awakenings during deprivation (from 7 to 30), he did not have any REM rebound on any of his five recovery nights. Dement acknowledged that this subject was the one exception in his findings and theorized that perhaps he had an unusually stable sleep pattern that was resistant to change.

Finally, the eight subjects were monitored for any behavioral changes that they might experience due to the loss of REM sleep. All the subjects developed minor symptoms of anxiety, irritability, or difficulty concentrating during the REM interruption period. Five of the subjects reported a clear increase in appetite during the deprivation, and three of these gained three to five pounds. None of these behavioral symptoms appeared during the period of control awakenings.

SIGNIFICANCE OF THE FINDINGS AND SUBSEQUENT RESEARCH

More than 30 years after this preliminary research by Dement, we know a great deal about sleeping and dreaming. Some of this knowledge was discussed briefly earlier in this chapter. We know that most of what Dement reported in his 1960 article has stood the test of time. We all dream, and if we are somehow prevented from dreaming one night, we dream more the next night. There does indeed appear to be something basic in our need to dream. In fact, the REM-rebound effect can be seen in many animals.

One of Dement's accidental findings, one that he reported only as a minor anecdote, now has greater significance. One way that people may be deprived of REM sleep is through the use of alcohol or other drugs such as amphetamines and barbiturates. While these drugs increase your tendency to fall asleep, they suppress REM sleep and cause you to remain in the deeper stages of NREM for greater portions of the night. It is for this reason that many people are unable to break the habit of taking sleeping pills or alcohol in order to sleep. As soon as they stop, the REM-rebound effect is so strong and disturbing that they become afraid to sleep and return to the drug to avoid dreaming. An even more extreme example of this problem occurs with alcoholics who may have been depriving themselves of REM sleep for years. When they stop drinking, the onset of REM rebound may be so powerful that it can occur while they are *awake!* This may be an explanation

subject. In fact, the amount of variation among the dreamers was only plus or minus 7 minutes!

Now, the main point of this study was to examine the effects of being deprived of dreaming, or REM, sleep. The first finding to address this was the number of awakenings required to prevent REM sleep during the dream-deprivation nights. As you can see in Table 1 (column 3a), on the first night, the experimenter had to awaken the subjects between 7 and 22 times in order to block REM. However, as the study progressed, subjects had to be awakened more and more often in order to prevent them from dreaming. On the last deprivation night, the number of forced awakenings ranged from 13 to 30 (column 3b). On average, there were twice as many attempts to dream at the end of the deprivation nights.

The next and perhaps most revealing result was the increase in dreaming time after the subjects were prevented from dreaming for several nights. The numbers in Table 1 (column 4) reflect the first recovery night. The average total dream time on this night was 112 minutes, or 26.6% (compared with 80 minutes and 19.5% during baseline nights in column 1). Dement pointed out that there were two subjects who did not show a significant increase in REM (subjects 3 and 7). If they are excluded from the calculations, the average total dream time is 127 minutes, or 29%. This is a 50% increase over the average for the baseline nights.

While only the first recovery night is reported in Table 1, it was noted that most of the subjects continued to show elevated dream time (compared with baseline amounts) for five consecutive nights.

"Wait a minute!" you're thinking. Maybe this increase in dreaming has nothing to do with REM deprivation at all. Maybe it's just because these subjects were awakened so often. Well, you'll remember that Dement planned for your astute observation. Six of the subjects returned after several days of rest and repeated the procedure exactly except they were awakened between REM periods (the same number of times). This produced no significant increases in dreaming. The average time spent dreaming after the control awakenings was 88 minutes, or 20.1% of the total sleep time (column 5). When compared to 80 minutes, or 19.5%, in column 1, no significant difference was found.

DISCUSSION

Dement tentatively concluded from these findings that we need to dream. When we are not allowed to dream, there seems to be some kind of pressure to dream that increases over successive dream-deprivation nights. This was evident in his findings from the increasing number of attempts to dream following deprivation (column 3a vs. column 3b) and in the significant increase in dream time (column 4 vs. column 1). He also notes that this increase continues over several nights so that it appears to make up in quantity the approximate amount of lost dreaming. Although Dement did not use the phrase at the time, this important finding has come to be known as the *REM-rebound* effect.

Following the nights of dream deprivation, subjects entered the *recovery phase* of the experiment. During these nights (which varied from one to six), the subjects were allowed to sleep undisturbed throughout the night. Their periods of dreaming continued to be monitored electronically and the amount of dreaming was recorded as usual.

Next, each subject was given several nights off (something they were very glad about, no doubt!). Then six of them returned to the lab for another series of interrupted nights. These awakenings "exactly duplicated the dream-deprivation nights in number of nights and number of awakenings per night. The only difference was that the subject was awakened in the intervals between eye-movement (dream) periods. Whenever a dream period began, the subject was allowed to sleep on without interruption and was awakened only after the dream had ended spontaneously" (p. 1706). Finally, subjects again had the same number of recovery nights as they did following the dream-deprivation phase. These were called *control recovery*, and were included to eliminate the possibility that any effects of dream deprivation were not due simply to being awakened many times during the night, whether dreaming or not.

RESULTS

Table 1 summarizes the main findings reported. During the baseline nights, when subjects were allowed to sleep undisturbed, the average amount of sleep per night was 6 hours and 50 minutes. The average amount of time the subjects spent dreaming was 80 minutes, or 19.5% (see Table 1, column 1). Dement discovered in these results from the first several nights that the amount of time spent dreaming was remarkably similar from subject to

TABLE 1 Summary of Dream-Deprivation Results

SUBJECT	1. PERCENT DREAM-TIME BASELINE	2. NUMBER OF DREAM DEPRIVATION NIGHTS	3a. NUMBER OF AWAKENINGS FIRST NIGHT	3b. NUMBER OF AWAKENINGS LAST NIGHT	4. PERCENT DREAM-TIME RECOVERY	5. PERCENT DREAM-TIME CONTROL
1.	19.5	5	8	14	34.0	15.6
2.	18.8	7	7	24	34.2	22.7
3.	19.5	5	11	30	17.8	20.2
4.	18.6	5	7	23	26.3	18.8
5.	19.3	5	10	20	29.5	26.3
6.	20.8	4	13	20	29.0	—
7.	17.9	4	22	30	19.8 (28.1)*	16.8
8.	20.8	3	9	13	— **	—
Average	19.5	4.38	11	22	26.6	20.1

*Second recovery night.

**Subject dropped out of study before recovery nights.

(adapted from p. 1707)

giving us this wealth of information on sleeping and dreaming is William Dement. Beginning around the time of Aserinsky's findings, Dement was interested in studying the basic function and significance of dreaming.

THEORETICAL PROPOSITIONS

What struck Dement as most significant was the discovery that dreaming occurs every night in everyone. As Dement states in his article, "Since there appear to be no exceptions to the nightly occurrence of a substantial amount of dreaming in every sleeping person, it might be asked whether or not this amount of dreaming is in some way a necessary and vital part of our existence" (p. 1705). This led him to ask some obvious questions: "Would it be possible for human beings to continue to function normally if their dream life were completely or partially suppressed? Should dreaming be considered necessary in a psychological sense or a physiological sense or both?" (p. 1705).

Dement decided to try to answer these questions by studying subjects who had somehow been deprived of the chance to dream. At first he tried using depressant drugs to prevent dreaming, but the drugs themselves produced too great an effect on the subjects' sleep patterns to allow for valid results. So, he decided on "the somewhat drastic method" of waking subjects up every time they entered REM sleep during the night.

METHOD

This article reported on the first eight subjects in an ongoing sleep and dreaming research project. The subjects were all males ranging in age from 23 to 32. A participant would arrive at the sleep laboratory around his usual bedtime. Small electrodes were attached to the scalp and near the eyes to record brain-wave patterns and eye movements. As in the Aserinsky study, the wires to these electrodes ran into the next room so that the subject could sleep in a quiet, darkened room.

The procedure for the study was as follows: For the first several nights, the subject was allowed to sleep normally for the entire night. This was done to establish a baseline for each subject's usual amount of dreaming and overall sleep pattern.

Once this information was obtained, the next step was to deprive the subject of REM or dream sleep. Over the next several nights (the number of consecutive deprivation nights ranged from three to seven for the various subjects), the experimenter would awaken the subject every time the information from the electrodes indicated that he had begun to dream. The subject was required to sit up in bed and demonstrate that he was fully awake for several minutes before being allowed to go back to sleep.

An important point mentioned by Dement was that the subjects were asked not to sleep at any other times during the dream study. This was because if subjects slept or napped, they might dream, and this could contaminate the findings of the study.

sleep could be monitored. The subjects were then allowed to fall asleep normally (subjects participated on more than one night each). During the night, subjects were awakened and *interrogated,* either during periods of eye activity or during periods when little or no eye movement was observed. The idea was to wake the subjects and ask them if they had been dreaming and if they could remember the content of the dream. The results were quite revealing.

For all of the subjects combined, there were a total of 27 awakenings during periods of sleep accompanied by rapid eye movements. Of these, 20 reported detailed visual dreams. The other seven reported "the feeling of having dreamed," but could not recall the content in detail. During periods of no eye movement, there were 23 awakenings; in 19 of these instances, the subjects did not report any dreaming, while in the other four, the participants felt vaguely as if they might have been dreaming, but were not able to describe the dreams. On some occasions, subjects were allowed to sleep through the night uninterrupted. It was found that they experienced between three and four periods of eye activity during the average of 7 hours of sleep.

While it may not have seemed so remarkable at the time, Aserinsky had discovered what is very familiar to most of us now: REM (rapid eye movement) sleep, or dreaming sleep. From his discovery grew a huge body of research on sleep and dreaming that continues to expand. Over the years, as research methods and physiological recording devices have become more sophisticated, we have been able to refine Aserinsky's findings and unlock many of the mysteries of sleep.

For example, we now know that after you fall asleep, you sleep in four stages, beginning with the lightest sleep (Stage 1) and progressing into deeper and deeper stages. After you reach the deepest stage (Stage 4), you begin to move back up through the stages; your sleep becomes lighter and lighter. As you approach Stage 1 again, you enter a very different kind of sleep called REM. It is during REM that you do most of your dreaming. However, contrary to popular belief, it has been found scientifically that you do not move around very much during REM. Your body is immobilized by electrochemical messages from your brain that actually paralyze your muscles. This is a survival mechanism that prevents you from acting out your dreams and possibly injuring yourself or worse!

Following a short period in REM, you proceed back into the four stages of sleep called non-rapid-eye-movement sleep (NON-REM or NREM for short). During the night, you cycle between NREM and REM about five or six times (your first REM period comes about 90 minutes after falling asleep), with NREM becoming shorter and REM becoming longer (thereby causing you to dream more toward morning). And, by the way, everyone dreams. While there is a small percentage of individuals who never remember dreams, research has determined that we all have them.

All of this knowledge springs from the discovery of REM by Aserinsky in the early 1950s. And one of the leading researchers who followed Aserinsky in

Finally, what is perhaps most indicative of Turnbull's ongoing influence in the field of psychology is the observation that his 1961 article and his related book (Turnbull, 1962), continue to be cited and quoted in most general psychology texts as demonstrations of environmental influences on human perceptual development (e.g., Morris, 1996; Plotnik, 1999). Colin Turnbull died in 1994 at the age of 70. He was one of the most famous and most unconventional anthropologists in the history of the field. If you are interested in learning more about the details of his life, an excellent, well-reviewed biography has been published recently, titled *In the Arms of Africa: The Life of Colin M. Turnbull* (Grinker, 2000).

Adams, R. J. (1987). An evaluation of color preference in early infancy. *Infant Behavior and Development, 10,* 143–150.
Blakemore, C., & Cooper, G. F. (1970). Development of the brain depends on physical environment. *Nature, 228,* 227–229.
Fisher, J., & Strickland, H. (1989). Ethnoarchaeology among the Efe Pygmies, Zaire: Spacial organization of campsites. *American Journal of Physical Anthropology, 78,* 473–484.
GalaniMoutafi, V. (2000). The self and the other: Traveler, ethnographer, tourist. *Annals of Tourism Research, 27*(1), 203–224.
Grinker, R. (2000). *In the arms of Africa: The life of Colin M. Turnbull.* New York: St Martins Press.
Morris, C. (1996). *Understanding psychology* (2nd ed.). Englewood Cliffs, NJ: Prentice Hall.
Plotnik, R. (1999). *Introduction to psychology* (5th ed.). Pacific Grove, CA: Brooks/Cole.
Turnbull, C. (1962). *The forest people.* New York: Simon & Schuster.

TO SLEEP, NO DOUBT TO DREAM . . .

Aserinsky, E., & Kleitman, N. (1953). Regularly occurring periods of eye mobility and concomitant phenomena during sleep. *Science, 118,* 273–274.
Dement, W. (1960). The effect of dream deprivation. *Science, 131,* 1705–1707.

As you can see, this section is somewhat different from the others in that there are two articles being discussed. The first study discovered a basic phenomenon about sleeping and dreaming that made the second study possible. The primary focus is William Dement's work on dream deprivation, but to prepare you for that, Aserinsky's findings must be addressed first.

In 1952, Eugene Aserinsky, while a graduate student, was studying sleep. Part of his research involved observing sleeping infants. He noticed that as these infants slept, there were periodic occurrences of active eye movements. During the remainder of the night, there were only occasional slow, rolling eye movements. He theorized that these periods of active eye movements might be associated with dreaming. However, infants could not tell him whether they had been dreaming or not. So, in order to test this idea, he expanded his research to include adults.

Aserinsky and his coauthor, Nathaniel Kleitman, employed 20 normal adults to serve as subjects. Sensitive electronic measuring devices were connected by electrodes to the muscles around the eyes of these subjects. The leads from these electrodes stretched into the next room where the subjects'

In regard to size constancy, Turnbull's observational study may offer us an explanation for why this ability is learned rather than innate. Certain perceptual skills may be necessary for our survival, but we do not all develop and grow in the same situation. Therefore, to maximize our survival potential, some of our skills are allowed to unfold over time in ways that are best suited to our physical environment.

SIGNIFICANCE OF FINDINGS AND RECENT APPLICATIONS

Turnbull's work fueled the fire of behavioral scientists who address the question of the relative influence of biology versus environment (learning) on our behavior: the "nature-nurture" controversy. Turnbull's observations of Kenge's perceptions points strongly to the nurture or environmental side of the issue. In a fascinating series of studies by Blakemore and Cooper (1970), kittens were raised in darkness except for exposure to either vertical or horizontal stripes. Later, when the cats were taken out of the dark environment, the ones who had been exposed to vertical lines responded to the vertical lines on objects in the environment, but ignored horizontal lines. Conversely, the cats exposed to horizontal lines during development later appeared to recognize only the presence of horizontal figures. The cats' ability to see was not damaged, but some specific perceptual abilities had not developed. These particular deficits appeared to be permanent.

Other research, however, has suggested that some of our perceptual abilities may be present at birth; that is, given to us by nature without any learning needed. For example, one study (Adams, 1987) exposed newborn infants (only 3 days old) to squares of various colors of light (red, blue, green) and to squares of gray light at the exact same brightness. All these very young infants spent significantly more time looking at the colorful squares than at the gray ones. It is unlikely that infants had the opportunity to learn that preference in 3 days, so these findings provide evidence that some of our perceptual abilities are innate.

The overall conclusion from research in this area is that there is not a single definitive answer regarding the source of our perceptual abilities. Turnbull and Kenge clearly demonstrated that some are learned, but others may be innate or part of our "factory-installed standard equipment." The one sure point here is that this area of research is bound to be pursued far into the future.

It should be noted that this article by Turnbull, even though it appeared in a psychology journal, has made lasting contributions to Turnbull's own field of anthropology and has helped to illustrate important crossovers between the two fields. Psychologists have continually been informed about the underlying causes of human behavior by studying it across cultural borders and ethnic boundaries. Conversely, anthropologists have broadened their scope of study through an awareness of the psychological underpinnings of human behavior in societal and cultural settings (e.g., see Fisher & Strickland, 1989; GalaniMoutafi, 2000).

Looking out across the plain, Kenge saw a herd of buffalo grazing several miles away. Remember that at such a distance, the image (the sensation) of the buffalo cast onto the retinas of Kenge's eyes was very small. Kenge turned to Turnbull and asked what kind of insect they were! Turnbull replied that they were buffalo even bigger than the forest buffalo Kenge had seen before. Kenge just laughed at what he considered to be a stupid story and asked again what those insects were. "Then he talked to himself, for want of more intelligent company, and tried to liken the distant buffalo to the various beetles and ants with which he was familiar" (p. 305).

Turnbull did precisely what you or I would do in the same situation. He got back into the car and drove with Kenge to the grazing buffalo. Kenge was a very courageous young man, but as he watched the animals steadily increase in size, he moved over next to Turnbull and whispered that this was witchcraft. Finally, as they approached the buffalo and he could see them for the size they truly were he was no longer afraid, but he was still unsure as to why they had been so small before, and wondered if they had grown larger or if there was some form of trickery going on.

A similar event occurred when the two men continued driving and came to the edge of Lake Edward. This is quite a large lake, and there was a fishing boat two or three miles out. Kenge refused to believe that the distant boat was something large enough to hold several people. He claimed that it was just a piece of wood, until Turnbull reminded him of the experience with the buffalo. At this, Kenge just nodded in amazement.

During the rest of the day spent outside the jungle, Kenge watched for animals in the distance and tried to guess what they were. It was apparent to Turnbull that Kenge was no longer afraid or skeptical, but was working on adapting his perceptions to these entirely new sensations. And he was learning fast. The next day, however, he asked to be returned to his home in the jungle and again remarked that this was bad country: no trees.

DISCUSSION

This brief research report dramatically illustrates how we acquire our *perceptual constancies*. Not only are they learned as a result of experience, but these experiences are influenced by the culture and environment in which we live. In the jungle where Kenge had spent his entire life, there were no long-range views. In fact, vision was usually limited to about a hundred feet. Therefore, there was no opportunity for the BaMbuti to develop size constancy and, if you stop to think about it, there was no need for them to do so. Although it has not been directly tested, it is possible that these same groups of Pygmies may have a more highly developed ability for figure-ground relationships. The logic here is that it is extremely important for the BaMbuti to distinguish those animals (especially the potentially dangerous ones) that are able to blend into the surrounding background vegetation. This perceptual skill would seem less necessary for people living in a modern industrialized culture.

BaMbuti Pygmies. Because he was an anthropologist, Turnbull's primary method of research was naturalistic observation; that is, observing behavior as it occurs in its natural setting. This is an important method of research for psychologists as well. For example, differences in aggressive behavior between young boys and girls during play could be studied through observational techniques. Examining the social behavior of nonhuman primates, such as chimpanzees, would also require a method involving naturalistic observation. Such research is often expensive and time consuming, yet some behavioral phenomena cannot be properly researched in any other way.

Turnbull, on one excursion, was traveling through the forest from one group of Pygmies to another. He was accompanied by a young man (about 22 years old) named Kenge, who was from one of the local Pygmy villages. Kenge always assisted Turnbull in his research as a guide and introduced Turnbull to groups of BaMbuti who did not know him. Turnbull's observations that constitute this published report began when he and Kenge reached the eastern edge of a hill that had been cleared of trees for a missionary station. Because of this clearing, there was a distant view over the forest to the high Ruwenzori Mountains. Since the Ituri Forest is extremely thick, it was highly unusual to see views such as this.

RESULTS

Kenge had never in his life seen a view over great distances. He pointed to the mountains and asked if they were hills or clouds. Turnbull told him that they were hills, but they were larger than any Kenge had seen before in his forest. Turnbull asked Kenge if he would like to take a drive over to the mountains and see them more closely. After some hesitation—Kenge had never left the forest before—he agreed. As they began driving, a violent thunderstorm began and did not clear until they had reached their destination. This reduced visibility to about 100 yards, which prevented Kenge from watching the approaching mountains. Finally, they reached the Ishango National Park, which is on the edge of Lake Edward at the foot of the mountains. Turnbull writes:

> As we drove through the park the rain stopped and the sky cleared, and that rare moment came when the Ruwenzori Mountains were completely free of cloud and stood up in the late afternoon sky, their snow-capped peaks shining in the afternoon sun. I stopped the car and Kenge very unwillingly got out. (p. 304)

Kenge glanced around and declared that this was bad country because there were no trees. Then he looked up at the mountains and was literally speechless. The life and culture of the BaMbuti were limited to the dense jungle and, therefore, their language did not contain words to describe such a sight. Kenge was fascinated by the distant snow caps and interpreted them to be a type of rock formation. As they prepared to leave, the plain stretching out in front of them also came clearly into view. The next observation makes up the central point of this article and this chapter.

would be if all objects were perceived differently each time your angle of vision changed.

Another one of these techniques is size constancy. This is the perceptual facility that is most related to Turnbull's article. Size constancy enables you to perceive a familiar object as being the same size, regardless of its distance from you. If you see a school bus two blocks away, the image projected onto your retina is the same as that of a small toy bus seen close up. Nevertheless, you perceive the distant bus to be its large, normal size. Likewise, if you are looking at two people standing in a field, one 10 feet from you and the other 100 feet in the distance, your sensation of the more distant person is of someone three feet tall. The reason you perceive that person to be of normal size is due to your ability of size constancy.

Your perceptions using any of these strategies can be tricked. This is how visual (optical) illusions work. A film director can shoot a scene in which a ship is being tossed about in a terrible storm. Even though the camera is filming a two-foot-long model ship in a special effects tank, we perceive the ship as full size because of size constancy and the lack of any comparison objects to offer cues as to its true size. In the 1980 film spoof *Airplane,* we see a room shot from a low angle directly behind a telephone on a desk (therefore, we know this phone is about to ring with important information). The phone is so close to the camera lens that it appears huge on the screen, but we see it as a normal-size phone due to our ability of size constancy. The perceptual surprise comes when the phone rings and the actor crosses the room to answer. The phone he picks up turns out to really be as huge as it looked: about three feet across!

The last important point that must be made before turning to this chapter's study concerns whether these perceptual abilities are learned or inborn. Research with individuals who were blind at birth and who later gain their sight has suggested that our ability to perceive figure-ground relationships is, at least in part, innate; that is, present from birth. Perceptual constancies, on the other hand, are a product of experience. When young children (age 5 and under) see cars or trains in the distance, they perceive them as toys and sometimes will ask quite adamantly to have one. By the time children reach age 7 or 8, size constancy has developed and they are able to judge sizes correctly over varying distances.

Psychologists have asked the question: What kinds of experiences allow us to acquire these abilities? And could a situation exist in which a person might grow to adulthood and not possess some of these perceptual talents? Well, Turnbull's brief report published 30 years ago shed a great deal of light on these questions.

METHOD

As mentioned at the beginning of this chapter, Turnbull is not a psychologist, but rather an anthropologist. In the late 1950s and early 1960s, he was in the dense Ituri Forest in Zaire (now Congo) studying the life and culture of the

perception. Sensations are the raw materials for perception. Your brain's perceptual processes are involved in three general activities: (1) selecting the sensations to pay attention to as discussed in the previous paragraph; (2) organizing these into recognizable patterns and shapes; and (3) interpreting this organization to explain and make judgments about the world. In other words, perception refers to how we take this jumble of sensations and create meaning. Your visual sensations of the page you are reading are nothing more than random black shapes on a white background. This is what is projected onto the retinas of your eyes and sent to the visual fields of your brain. However, you pay attention to them, organize them, and interpret them so that they become words and sentences that contain meaning.

Your brain has many tricks or strategies available to assist in organizing sensations in meaningful and understandable ways. To put Turnbull's study in proper perspective, let's take a look at several of these. The perceptual strategy you probably use the most is called *figure-ground.* A well-known example of the figure-ground relationship is pictured in Figure 1. When you look at the drawing, what do you see immediately? Some of you will see a white vase, while others will see two profiles facing one another. As you study this drawing, you will be able to see either one and you will be able to switch back and forth between seeing the vase and seeing the profiles. You'll notice that if you look at the vase (figure), the profiles (ground) seem to fade into the background. But focus on the profiles (figure) and the vase (ground) becomes the background. We appear to have a natural tendency to divide sensations into figure and ground relationships. If you think about it, this makes the world a much more organized place. Imagine trying to spot someone in a crowd of people. Without your figure-ground abilities, this task would be impossible. When soldiers wear camouflaged clothing, the distinction between figure and ground is blurred so that it becomes difficult to distinguish the figure (the soldier) from the ground (the vegetation).

Other organizational strategies we use routinely to create order and meaning out of those chaotic sensations are called *perceptual constancies.* These refer to our ability to know that the characteristics of objects stay the same even though our sensations of them may change drastically. One of these, for example, is shape constancy. If you stand up and walk around a chair, the image of that chair projecting onto your retina (the sensation) changes with every step you take. However, you perceive the shape of the chair to be unchanged. Imagine how impossibly confusing your world

FIGURE 1 Figure-ground relationship—a reversible figure. From Charles G. Morris, *Understanding Psychology,* 7th ed., p. 101. Copyright 1990. Reprinted by permission of Prentice Hall.

hypnotized people are no different from awake people; they are just a bit more motivated.

WHAT YOU SEE IS WHAT YOU'VE LEARNED

> Turnbull, C. M. (1961). Some observations regarding the experiences and behavior of the BaMbuti Pygmies. *American Journal of Psychology, 74,* 304–308.

This study is a somewhat unusual one to appear in this book. Turnbull did not have any specific theoretical propositions, there was no clear scientific method used, and the author is not a psychologist. Nevertheless, this short article has been frequently and widely cited to demonstrate some important psychological concepts relating to your ability to perceive the world around you. Before reaching the point where Turnbull's observations can be placed in the proper context, a considerable amount of conceptual explanation is necessary. Keep in mind that we will get to the study itself, even though we may seem to be taking the long way around. Let's begin by filling in the theory behind Turnbull's discoveries, which the brevity of his article did not allow him to do.

THEORETICAL PROPOSITIONS

Two large and important fields of study within psychology are those of sensation and perception. These are fundamentally separate areas, but they are highly related. Sensation refers to the information you are constantly receiving from your environment through your senses. You are bombarded with a huge amount of sensory data every minute of every day. If you just stop and think about it for a minute, frequencies of light are reflecting off all the objects around you wherever you look, near or far. There are probably a multitude of sounds entering your ears at any moment, parts of your body are in contact with various objects, and several tastes and smells are often present. If you take your attention off this book for a moment (I know this is difficult!) and focus on each sense, one at a time, you'll begin to get some idea of the amount of "sensory input" that was beneath your level of awareness. In fact, if I do this right now I become aware of the hum from my computer, a car going by outside, a door slamming somewhere, a painting on the wall, a partly cloudy sky, the light from my desk lamp, the feel of my elbows resting on the arms of the chair, the taste of the apple I just finished eating, and so on. However, just a few seconds ago, I was not aware of any of these sensations. We are continuously filtering all this available input and using only a small percentage of it. If your sensory filtering mechanisms were suddenly to fail, the world would become so intensely confusing that you would be overwhelmed, and probably you would not be able to survive it.

The fact that the sensory world (what you see, hear, touch, taste, and smell) usually appears to you in an organized way is due to your abilities of

2 PERCEPTION AND CONSCIOUSNESS

The study of perception and consciousness is of great interest to psychologists because they define and reveal your psychological interaction with your environment. Think for a moment about how your senses are bombarded constantly by millions of pieces of information from the combined stimuli that surround you at any given moment. It is impossible for your brain to process all of it. So, your brain organizes this barrage of sensory data into units that yield form and meaning. That's what psychologists refer to as *perception*.

Clearly, your level of *consciousness,* also commonly referred to as your *state of awareness,* governs to a large extent what you perceive and how your brain organizes it. As you go through your day, your night, your week, your year, and your life, you experience many and varied states of awareness: You concentrate (or not), you daydream, you fantasize, you sleep, you dream, maybe you've been hypnotized at some point, maybe you've used psychoactive drugs (even caffeine and nicotine count!). These conditions are all altered states of consciousness that produce various changes in your perceptions of the world and that, in turn, influence your behavior.

Within the research areas of perception and consciousness, some of the most influential and interesting studies have focused on vision, sleep, dreams, and hypnosis. This section begins with a famous and influential study which, takes us to a far-away culture to reveal how our perceptions of the world around us are shaped by a lifetime of specific sensory input. The article was published in a psychology journal, but written by an anthropologist, who discovered an amazing phenomenon in his research in the Ituri Forest in what is now the nation of Congo, about how our brains learn to see and interpret the world around us. The second reading in this section contains two articles that changed psychology because they (1) discovered REM (rapid eye movement) sleep and (2) revealed the relationship between REM and dreaming. Third is an influential and controversial study proposing that dreams are not mysterious messages from your unconscious, as Freud and others would have it, but that they consist of purely physical and random electrical impulses in your brain while you sleep. And fourth is one of many studies that has influenced traditional psychological thinking by arguing *against* the widespread belief that hypnosis is a unique and powerful state of consciousness. This last study offers evidence suggesting that

system that incorporates virtual reality to help autistic children safely explore and interact with the world around them. Autism is a serious childhood disorder marked by a lack of interaction with others, disrupted speech development, varying degrees of mental retardation sometimes accompanied by streaks of genius, and an intense desire to avoid any environmental changes (remember Dustin Hoffman's wonderful depiction of Raymond Babbitt in *Rain Man?*). Often these children pose a danger to themselves because their perceptions are either distorted or not fully developed. So, for example, an autistic child might not perceive drop-offs such as those represented by the visual cliff and, therefore, be prone to dangerous falls. According to Strickland, however, through virtual reality it is possible to design custom programs that allow each individual child to gain valuable experience without danger of physical injury.

CONCLUSION

Through the inventiveness of Gibson and Walk, behavioral scientists have been able to study depth perception in a clear and systematic way. The question of whether this and other perceptual abilities are innate or learned continues to be debated. The truth may lie in a compromise that proposes an interaction between nature and nurture. Perhaps, as various studies have indicated, depth perception is present at birth (even in the Campos et al. study, the interest generated by the very young infants demonstrates perception of something), but fear of falling and avoidance of danger is learned through experience, after the infant is old enough to crawl around and get into trouble.

But whatever the questions are, it is the methodological advances such as the visual cliff that allow us to begin to find the answers.

Adolph, K., & Eppler, M. (1998). Development of visually guided locomotion. *Ecological Psychology, 10*(3–4), 303–321.

Campos, J., Hiatt, S., Ramsay, D., Henderson, C., & Svejda, M. (1978). The emergence of fear on the visual cliff. In M. Lewis & L. A. Rosenblum (Eds.), *The development of affect.* New York: Plenum Press.

Sorce, J., Emde, R., Campos, J., & Klinnert, M. (1985). Maternal emotion signaling: Its effect on the visual cliff behavior of 1-year-olds. *Developmental Psychology, 21,* 195–200.

Strickland, D. (1996). A virtual-reality application with autistic children. *Presence-Teleoperators and Virtual Environments, 5*(3), 319–329.

cliff, they had already learned to avoid such situations. A later study placed younger infants, ages 2 to 5 months, on the glass over the deep side of the visual cliff. When this happened, all of the babies showed a decrease in heart rate. Such a decrease is thought to be a sign of interest, not fear, which is accompanied by heart rate increases (Campos, Hiatt, Ramsay, Henderson, & Svejda, 1978). This indicates that these younger infants had not yet learned to fear the drop-off and would learn the avoidance behavior somewhat later. These findings argued against Gibson and Walk's position.

It is important to notice, however, that while there was and still is controversy over just when we are able to perceive depth (the nativists vs. the empiricists), much of the research that is done to find the answer incorporates the visual cliff apparatus developed by Gibson and Walk. Additionally, other related research using the visual cliff has turned up some fascinating findings.

One example is the work of Sorce, Emde, Campos, and Klinnert (1985). They put 1-year-old infants on a visual cliff for which the drop-off was neither shallow nor deep but in between (about 30 inches). As a baby crawled toward the cliff, it would stop and look down. On the other side, as in the Gibson and Walk study, the mother was waiting. Sometimes the mother had been instructed to maintain an expression of fear on her face while other times the mother looked happy and interested. When infants saw the expression of fear, they refused to crawl any further. However, most of the infants who saw their mother looking happy checked the cliff again and crawled across. When the drop-off was made flat, the infants did not check with the mother before crawling across. This method of nonverbal communication used by infants in determining their behavior is called *social referencing.*

RECENT APPLICATIONS

Gibson and Walk's ground-breaking invention of the visual cliff still exerts a major influence on current studies of human development, perception, emotion, and even mental health.

A recent study by Adolph and Eppler cited Gibson and Walk's early study in their research on how toddlers acquire the abilities to navigate variations in terrain as they progress from crawling to walking (Adolph & Eppler, 1998). You may have noticed that toddlers are virtually driven to engage in exploratory behaviors, especially over novel surfaces such as stones, beach sand, or (the best one) mud. Well, Adolph and Eppler contend that this is precisely how the human visual system *learns* about the effect such surface irregularities have on our balance and, consequently, how we learn to compensate for changes under our feet. That is why, according to their theory, we eventually, and conveniently, stop falling down so much!

Another recent and very topical study looked at the possibilities of using virtual reality to help developmentally disabled children learn to deal safely with the physical environment around them. Strickland (1996) developed a

highly developed. Since it is nocturnal, a rat locates food by smell and moves around in the dark using cues from the stiff whiskers on its nose. So when a rat was placed on the center board, it was not fooled by the visual cliff because it was not using vision to decide which way to go. To the rat's whiskers, the glass on the deep side felt the same as the glass on the shallow side and, thus, the rat was just as likely to move off the center board to the deep side as to the shallow side.

You might expect the same results from kittens. They are basically nocturnal and have sensitive whiskers. However, cats are predators, not scavengers like rats. Therefore, they depend more on vision. And, accordingly, kittens were found to have excellent depth perception as soon as they were able to move on their own: at about 4 weeks.

Although at times this research article (and this discussion) risks sounding like a children's animal story, it has to be reported that the species with the worst performance on the visual cliff was the turtle. The baby turtles chosen to be tested were of the aquatic variety, because the researchers expected that since the turtles' natural environment was water, they might prefer the deep side of the cliff. However, it appeared that the turtles were smart enough to know that they were not in water, and 76% of them crawled off onto the shallow side. But 24% went "over the edge." "The relatively large minority that chose the deep side suggests either that this turtle has poorer depth perception than other animals, or its natural habitat gives it less occasion to 'fear' a fall" (p. 67). Clearly, if you live your life in water, the survival value of depth perception, in terms of avoiding falls, would be diminished.

Gibson and Walk pointed out that all of their observations were consistent with evolutionary theory. That is, all species of animals, if they are to survive, need to develop the ability to perceive depth by the time they achieve independent movement. For humans, this does not occur until around 6 months of age; but for chickens and goats, it is nearly immediate (by one day); and for rats, cats, and dogs, about 4 weeks of age. The authors conclude, therefore, that this capacity is inborn, because to learn it through trial and error would cause too many potentially fatal accidents.

So, if we are so well prepared biologically, why do children take so many falls? Gibson and Walk explained that the human infants' perception of depth had matured sooner than had their skill in movement. During testing, many of the infants supported themselves on the deep side of the glass as they turned on the center board, and some even backed up onto the deep side as they began to crawl toward the mother across the shallow side. If the glass had not been there, some of the children would have fallen off the cliff!

CRITICISMS AND SUBSEQUENT RESEARCH

The most common criticism of the researchers' conclusions revolves around the question of whether they really proved that depth perception is innate in humans. As mentioned earlier, by the time infants were tested on the visual

many answers are found through the development of new methods for studying the questions. And the results of Gibson and Walk's early study provide an excellent example of this.

RESULTS AND DISCUSSION

Nine children in the study refused to move off the center board. This was not explained by the researchers, but perhaps it was just infant stubbornness. When the mothers of the other 27 called to them from the shallow side, all the infants crawled off the board and crossed the glass. Only three of them, however, crept, with great hesitation, off the brink of the visual cliff when called by their mothers from the deep side. When called from the cliff side, most of the children either crawled away from the mother on the shallow side or cried in frustration at being unable to reach the mother without moving over the cliff. There was little question that the children were perceiving the depth of the cliff. "Often they would peer down through the glass of the deep side and then back away. Others would pat the glass with their hands, yet despite this tactile assurance of solidity would refuse to cross" (p. 64).

Do these results prove that humans' ability to perceive depth is innate rather than learned? Well, obviously it does not, since all the children in this study had at least six months of life experience in which to learn about depth through trial and error. However, human infants cannot be tested prior to 6 months of age because they do not have adequate locomotor abilities. It was for this reason that Gibson and Walk decided to test various other animals as a comparison. As you know, most nonhuman animals gain the ability to move about much sooner than humans. The results of the animal tests were extremely interesting, in that the ability of the various animals to perceive depth developed in relation to when the species needed such a skill for survival.

For example, baby chickens must begin to scratch for their own food soon after hatching. When they were tested on the visual cliff at less than 24 hours of age they never made the mistake of stepping off onto the deep side.

Kids and lambs are able to stand and walk very soon after birth. From the moment they first stood up, their response on the visual cliff was as accurate and predictable as that of the chicks. Not one error was made. When one of the researchers placed a one-day-old baby goat down on the deep side of the glass, it became frightened and froze in a defensive posture. If it was then pushed over toward the shallow side, it would relax and jump forward onto the seemingly solid surface. This indicated that the visual sense was in complete control and that the animals' ability to feel the solidity of the glass on the deep side had no effect on the response.

For the rats, it was a different story. They did not appear to show any significant preference for the shallow side of the table. Why do you suppose this difference was found? Before you conclude that rats are just stupid, consider Gibson and Walk's much more likely explanation: A rat does not depend very much on vision to survive. In fact, its visual system is not

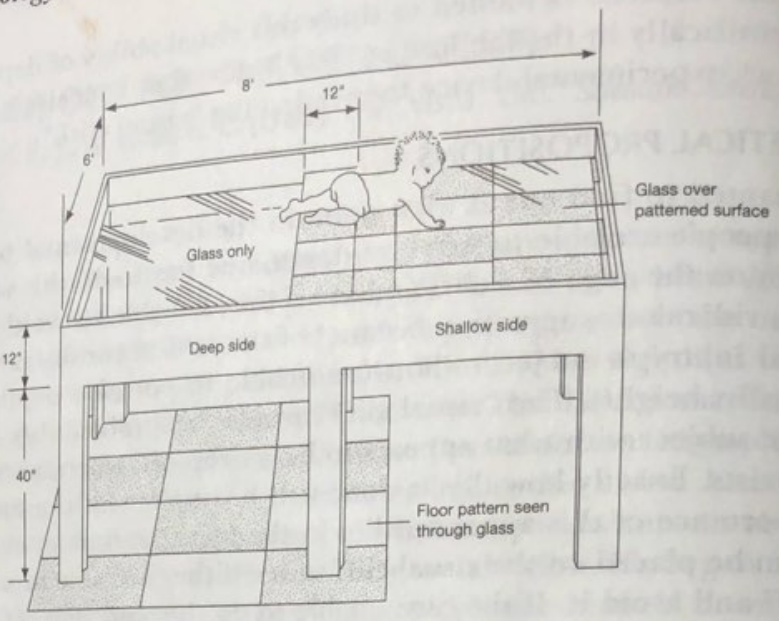

FIGURE 1 Gibson and Walk's visual cliff. From *Introduction to Child Development, 5th edition,* by J. Dworetzky © 1993. Reprinted with permission of Wadsworth, an imprint of the Wadsworth Group, a division of Thomson Learning. Fax (800) 730-2215.

between the shallow and deep sides and avoid stepping off "the cliff." You can imagine the rather unique situation in the psychology labs at Cornell University when the various baby animals were brought in for testing. They included chicks, turtles, rats, lambs, kids (baby goats, that is), pigs, kittens, and puppies. One has to wonder if they were all tested on the same day!

Remember, the goal of this research was to examine whether depth perception is learned or innate. What makes this method so ingenious is that it allowed that question to at least begin to be answered. After all, infants, whether human or animal, cannot be asked if they perceive depth, and, as mentioned above, they cannot be tested on real cliffs. In psychology,

FIGURE 2 The visual cliff in testing situation. From E. J. Gibson and R. D. Walk. "The visual cliff," *Scientific American,* April 1960, 65. Photo by William Vandivert.

These researchers wanted to study this visual ability of depth perception scientifically in the laboratory. To do this, they conceived of and developed an experimental device they called the "visual cliff."

THEORETICAL PROPOSITIONS

If you wanted to find out at what point in the developmental process animals or people are able to perceive depth, one way to do this would be to put them on the edge of a cliff and see if they are able to avoid falling off. This is a ridiculous suggestion because of the ethical considerations of the potential injury to subjects who were unable to perceive depth (or more specifically, height). The "visual cliff" avoids this problem because it presents the subject with what appears to be a drop-off, when no drop-off actually exists. Exactly how this is done will be explained in a moment, but the importance of this apparatus lies in the fact that human or animal infants can be placed on the visual cliff to see if they are able to perceive the drop-off and avoid it. If they are unable to do this and step off the "cliff," there is no danger of falling.

Gibson and Walk took a "nativist" position on this topic, which means that they believed that depth perception and the avoidance of a drop-off appear automatically as part of our original biological equipment and are not, therefore, products of experience. The opposing view, held by empiricists, contends that such abilities are learned. Gibson and Walk's visual cliff allowed them to ask these questions: At what stage in development can a person or animal respond effectively to the stimuli of depth and height? And do these responses appear at different times with animals of different species and habitats?

METHOD

The visual cliff consisted of a table about four feet high with a top made from a piece of thick, clear glass (Figures 1 and 2). Directly under half of the table (the shallow side) is a solid surface with a red-and-white checkered pattern. Under the other half is the same pattern, but it is down at the level of the floor underneath the table (the deep side). At the edge of the shallow side, then, is the appearance of a sudden drop-off to the floor although, in reality, the glass extends all the way across. Between the shallow and the deep side is a center board about a foot wide. The process of testing infants using this device was extremely simple.

The subjects for this study were 36 infants between the ages of 6 months and 14 months. The mothers of the infants also participated. Each infant was placed on the center board of the visual cliff and was then called by the mother first from the deep side and then from the shallow side.

In order to compare the development of depth perception in humans with that in other baby animals, the visual cliff allowed for similar tests with other species (without a mother's beckoning, however). These animals were placed on the center board and observed to see if they could discriminate

WATCH OUT FOR THE VISUAL CLIFF!

Gibson, E. J., & Walk, R. D. (1960). The "visual cliff." *Scientific American, 202,* 67–71.

One of the most often told anecdotes in psychology concerns a man called S. B. (initials used to protect his privacy). S. B. had been blind his entire life until the age of 52, when a newly developed operation (the now-common corneal transplant) was performed on him and his sight was restored. However, S. B.'s new ability to see did not mean that he automatically perceived what he saw the way the rest of us do. One important example of this became evident soon after the operation, before his vision had cleared completely. S. B. looked out his hospital window and was curious about the small objects he could see moving on the ground below. He began to crawl out on his window ledge, thinking he would lower himself down by his hands and have a look. Fortunately, the hospital staff prevented him from trying this. He was on the fourth floor, and those small moving things were cars! Even though S. B. could now see, he was not able to perceive depth.

Our visual ability to sense and interpret the world around us is an area of interest to experimental psychologists. And within this lies the central question of whether such abilities are inborn or learned. As you will recall from the previous article, Turnbull addressed this issue in his report of the BaMbuti Pygmy Kenge's inability to perceive the true size of objects at great distances. Kenge had the ability to perceive depth per se, but because his life had been spent in dense jungle, he did not have the experiences necessary to develop the capacity for the visual skill of size constancy. While Turnbull's discoveries were enlightening to the scientific community, the observational nature of his work did not allow for the systematic study of visual perception. In order to determine accurately if certain perceptual skills are learned or inborn, research would have to move into the laboratory.

Many psychologists believe that our most important visual skill is depth perception. You can imagine how difficult, and probably impossible, survival would be if you could not perceive depth. You would run into things, be unable to judge how far away a predator was, or step right off cliffs. Therefore, it might be logical to assume that depth perception is an inborn survival mechanism that does not require experience to develop. However, as Eleanor Gibson and Richard Walk point out in their article, "Human infants at the creeping and toddling stage are notoriously prone to falls from more or less high places. They must be kept from going over the brink by side panels on their cribs, gates on stairways, and the vigilance of adults. As their muscular coordination matures, they begin to avoid such accidents on their own. Common sense might suggest that the child learns to recognize falling-off places by experience—that is, by falling and hurting himself" (p. 64).

Some studies claim that the researchers are not publishing their data as fully and completely as they should and, therefore, their findings cannot be independently evaluated. These same critics also claim that there are many articles reporting on case studies demonstrating strong environmental influences on twins that Bouchard and Lykken fail to consider. Finally, as DNA analysis becomes increasingly accurate, researchers who question Bouchard and Lykken's findings are suggesting that DNA testing needs to be used to test the validity of the twin findings.

RECENT APPLICATIONS

In a 1999 book chapter, Bouchard reviews all of the nature-nurture evidence from the Minnesota twin registries (Bouchard, 1999). He concludes that, overall, 40% of the variability in personality and 50% of variation in intelligence appears to be genetically based. In this book, he also reiterates his position discussed above that your genes drive your selection of environments and your selection or avoidance of specific personality-molding environments and behaviors.

Research at the Minnesota twin centers continues to be very active. The most current updates on their findings may be found on their Web site at http://www.psych.umn.edu/psylabs/. Some fascinating new research is examining very complex human characteristics and behaviors that few would have even guessed to be genetically driven, such as love, divorce, and even death (see http://www.psych.umn.edu/psylabs/mtfs/special.htm 2000). They have studied people's selection of a mate to see if "falling in love" with Mr. or Ms. Right is genetically predisposed. It turns out that it is not! However, believe it or not, the researchers did find a genetic link to divorce. If one member of a pair of identical twins was divorced, the chance that the other would also divorce was found to be 45%. This was significantly higher than the 20% rate of divorce in Minnesota overall.

Finally, even death appears to be genetically influenced. Researchers at the Minnesota twin labs found that identical twins are quite likely to die at the same age (even if reared apart) while fraternal twins tend to die at different ages.

Arvey, R., Bouchard, T., Segal, N., & Abraham, L. (1989). Job satisfaction: Environmental and genetic components. *Journal of Applied Psychology, 74*(2), 187–195.

Arvey, R., McCall, B., Bouchard, T., & Taubman, P. (1994). Genetic influences on job satisfaction and work value. *Personality and Individual Differences, 17*(1), 21–33.

Billings, P., Beckwith, J., & Alper, J. (1992). The genetic analysis of human behavior: A new era? *Social Science and Medicine, 35*(3), 227–238.

Bouchard, T. (1994). Genes, environment and personality. *Science, 264*(5166), 1700–1702.

Bouchard, T. (1999). Genes, environment, and personality. In S. Ceci et al. (Eds.), *The nature- nurture debate: The essential readings,* pp. 97–103. Malden, MA: Blackwell.

DiLalla, D., Gottesman, I., Carey, G., & Bouchard, T. (1996). Heritability of MMPI personality indicators of psychopathology in twins reared apart. *Journal of Abnormal Psychology, 105*(4), 491–500.

http://www.psych.umn.edu/psylabs (2000)

http://www.psych.umn.edu/psylabs/mtfs/special.htm (2000)

has been studied, it is usually found to be true. Affectionate people have, indeed, received more affection from their parents. Bouchard and Lykken are proposing, however, that variation in "affectionateness" may be, in reality, genetically determined so that some children are just born more affectionate than others. Their in-born tendency toward affectionate behavior, causes them to *respond* to affection from their parents in ways that reinforce the parents' behavior much more than non-genetically affectionate children. This, in turn *produces* the affectionate behavior in the parents, not the other way around. The researchers contend that genes function in this way for many if not most human characteristics. They state it this way:

> The proximal [immediate] cause of most psychological variance probably involves learning through experience, just as radical environmentalists have always believed. The effective experiences, however, to an important extent are self-selected, and that selection is guided by the steady pressure of the genome. (p. 228)

CRITICISMS AND RELATED RESEARCH

As you might imagine, a great deal of related studies have been carried out using the database of twins developed by Bouchard and Lykken. In general, the findings continue to indicate that many human personality characteristics and behaviors, are strongly influenced by genes. Many attributes that have been seen as stemming largely or completely from environmental sources are being reevaluated as twin studies reveal that heredity contributes either the majority of the variation or a significantly larger proportion that was previously contemplated.

For example, studies from the University of Minnesota team found that not only is the vocation you choose largely determined by your genes, but also about 30% of the variation in your overall job satisfaction and work ethic appears due to genetic factors (Arvey et al., 1989; Arvey et al., 1994) even when the physical requirements of various professions were held constant. Other studies comparing identical (monozygotic) twins with fraternal (dizygotic) twins, both reared together and reared apart, have focused more directly on specific personality traits that are thought to be influential and stable in humans (Bouchard, 1994; Loehlin, 1992). These and other studies' findings determined that the people's variation on the characteristics of extraversion-introversion (out-going versus shy), neuroticism (tendency to suffer from high anxiety and extreme emotional reactions), and conscientiousness (degree to which a person is competent, responsible and thorough) is explained more (65%) by genetic differences than by environmental factors.

Of course, not everyone in the scientific community is willing to accept these findings at face value. The criticisms of Bouchard and Lykken's work take several directions (see Beckwith et al., 1991; Billings et al., 1992).

> IQ test score has increased in recent years. The present findings, therefore, do not define or limit what might be conceivably achieved in an optimal environment. (p. 227)

Basically, what he is saying is that while 70% of the variation in IQ is due to naturally occurring genetic variation, 30% of the variation remains subject to increases or decreases due to environmental influences. These influences include many that are well-known, such as education, family setting, toxic substances, and socio-economic status.

2. The basic underlying assumption in Bouchard and Lykken's research is that human characteristics are determined by some combination of genetic and environmental influences. So, when the environment exerts less influence, differences must be attributed more to genes. The converse is also true: as environmental forces create a stronger influence on differences in a particular characteristic, genetic influences will be weaker. For example, most children in the United States have the opportunity to learn to ride a bicycle. This implies that the environment's effect on bicycle-riding is somewhat similar for all children, so differences in riding ability will be more affected by genetic forces. On the other hand, variation in, say, food preferences in the United States are more likely to be explained by environmental factors because food and taste experiences in childhood and throughout life are very diverse and will, therefore, leave less room for genetic forces to function. Here's the interesting part of the researchers' point: They maintain that personality is more like bicycle-riding than food preferences.

   The authors are saying, in essence, that family environments exert *less* influence over who the kids grow up to be than do the genes they inherit from birth. Understandably, most parents do not want to hear or believe this. They are working hard to be good parents and to raise their children to be happy individuals and good citizens. The only parents who might take some comfort from these findings are those who are nearing their wit's end with out-of-control or incorrigible sons or daughters and would appreciate being able to take less of the blame! However, Bouchard and Lykken are quick to point out that genes are not necessarily destiny and devoted parents can still influence their children in positive ways, even if they are only working on a small percentage of the total variation.

3. The most intriguing implication that Bouchard and Lykken suggest is that it's not the environment influencing people's characteristics, but vice versa. That is, people's genetic tendencies actually mold their environments! Here's an example of the idea behind this theory: The fact that some people are more affectionate than others is usually seen as evidence that some parents were more affectionate with their children than were other parents. In other words, affectionate kids come from affectionate environments. When this kind of assumption

DISCUSSION AND IMPLICATIONS OF FINDINGS

These findings indicate that genetic factors (or "the genome") appear to account for most of the variation in a remarkable variety of human characteristics. This finding was demonstrated by the data in two important ways. One is that genetically identical humans (monozygotic twins) who were raised in separate and often very different settings, grew into adults who were extraordinarily similar, not only in appearance, but in basic psychology and personality. The second demonstration in this study of the dominance of genes is the fact that there appeared to be so *little* effect of the environment on identical twins who *were* raised in the same setting. Here's Bouchard and Lykken's take on these discoveries:

> For almost every behavioral trait so far investigated, from reaction time to religiosity, an important fraction of the variation among people turns out to be associated with genetic variation. This fact need no longer be subject to debate; rather, it is time to consider its implications.

There are, of course, those who will argue with Bouchard and Lykken's notion that the time to debate these issues is over. Some varying views will be discussed in the next section. However, a discussion of the implications of this and other similar studies by these same researchers is clearly warranted. In what ways do the genetic findings reported in this study change psychologists' and, for that matter, all of our views of human nature? As mentioned earlier, psychology and Western culture have been dominated for over 50 years by environmental thinking. Many of our basic beliefs about parenting, education, crime and punishment, psychotherapy, skills and abilities, interests, occupational goals, and social behavior, just to name a few, have been interpreted from the perspective that people's experience molds their personalities, not their genes. Very few of us look at someone's behavior and think, "That person was *born* to behave like that!" We *want* to believe that people *learned* their behavior patterns because that allows us to feel some measure of confidence that parenting makes a difference, that positive life experiences can win out over negative ones, and unhealthy, ineffective behaviors can be *unlearned*. The notion that personality is a done deal the moment we are born, leaves us with the temptation to say "whybother?" Why bother working hard to be good parents? Why bother trying to help those who are down and out? Why bother trying to offer quality education? And so on. Well, Bouchard and Lykken want to be the first to disagree with such an interpretation of their findings. In this article, they offer three of their own implications of their provocative conclusions:

1. Clearly, intelligence is primarily determined by genetic factors (70% of the variation in intelligence appears to be due to genetic influence). However, as the authors state very clearly,

   > [T]hese findings do not imply that traits like IQ cannot be enhanced . . . A survey covering 14 countries, has shown that the average

carried out individually so that there was no possibility that one twin might inadvertently influence the answers and responses of the other.

As you might imagine, the hours of testing created a huge database of information. The most important and surprising results will be discussed here.

RESULTS

Table 1 summarizes the similarities for some of the characteristics measured in the monozygotic twins reared apart (MZA) and includes the same data for monozygotic twins reared together (MZT). The degree of similarity is expressed in the table as correlations or "R" values. The larger the correlation, the greater the similarity. The logic here is that if environment is responsible for individual differences, the MZT twins who shared the same environment as they grew up, *should* be significantly more similar than the MZA twins. As you can see, this is not what the researchers found.

The last column in Table 1 expresses the difference in similarity by dividing the MZA correlation on each characteristic by the MZT correlation. If both correlations were the same the result would be 1.00; if they were entirely dissimilar, the result could be as slow as 0.00. Examining column 4 in the table carefully, you'll find that the correlations for characteristics were remarkably similar, that is, close to 1.00, and no lower than .700 for MZA and MZT twin pairs.

Table 1 Comparison of Correlations (*R*) of Selected Characteristics for Identical Twins Reared Apart (MZA) and Identical Twins Reared Together (MZT)*

CHARACTERISTIC	*R* (MZA)	*R* (MZT)	SIMILARITY *R*(MZA) ÷ *R*(MZT)**
Physiological	—	—	—
Brain wave activity	.80	.81	.987
Blood pressure	.64	.70	.914
Heart rate	.49	.54	.907
Intelligence	—	—	—
WAIS IQ	.69	.88	.784
Raven intelligence test	.78	.76	1.03
Personality	—	—	—
Multidimensional personality questionnaire (MPQ)	.50	.49	1.02
California personality inventory	.48	.49	.979
Psychological interests	—	—	—
Strong Campbell interest inventory	.39	.48	.813
Minnesota occupational interest scale	.40	.49	.816
Social attitudes	—	—	—
Religiosity	.49	.51	.961
Nonreligious social attitudes	.34	.28	1.21

* Adapted from Table 4, p. 226.
** 1.00 would imply that MZA twin pairs were found to be exactly as similar as MZT twin pairs.

and are referred to as *dizygotic twins*. Fraternal twins are only as genetically similar as any two non-twin siblings. As unfortunate as it sounds, twin infants are sometimes given up for adoption and placed in separate homes. Adoption agencies will try to keep siblings, especially twins, together, but the more important goal is to find good homes for them even if it means separation. So, over time, thousands of identical and fraternal twins have been adopted into separate homes and raised, frequently without the knowledge that they were a twin, in different and often contrasting environmental settings.

Bouchard and Lykken began in 1983 to identify, locate, and bring together pairs of these twins. This 1990 article reports on results from 56 pairs of monozygotic reared-apart (MZA) twins from the U.S. and seven other countries who agreed to participate in week-long sessions of intensive psychological and physiological tests and measurements (that this research is located in Minneapolis, one half of "the Twin Cities" is an irony that has not, by any means, gone unnoticed). These twins were compared with monozygotic twins reared together (MZT). The surprising findings continue to reverberate throughout the biological and behavioral sciences.

METHOD

Participants

The first challenge for this project was to *find* sets of monozygotic twins who were separated early in life, reared apart for all of most of their lives, and reunited as adults. Most of the participants were found through word-of-mouth as news of the study began to spread. The twins themselves or their friends or family members would contact the research institute, the Minnesota Center for Twin and Adoption Research (MICTAR), various social-services professionals in the adoption arena would serve as contacts, or, in some cases one member of a twin-pair would contact the center for assistance in locating and reuniting with his or her sibling. All twins were tested to assure that they were indeed monozygotic before beginning their participation in the study.

Procedure

The researchers wanted to be sure they obtained as much data as possible on during the twins' one-week visit. Each twin completed approximately 50 hours of testing on nearly every human dimension you might imagine. They completed four personality trait scales, three aptitude and occupational interest inventories, and two intelligence tests. In addition the participants filled in checklists of household belongings (such as power tools, telescope, original artwork, unabridged dictionary) to assess the similarity of their family resources, and a family environment scale that measured how they felt about the parenting they received from their adoptive parents. They were also administered a life history interview, a psychiatric interview, and a sexual history interview. All of these assessments were

You would find it much more difficult to recognize biological influences and say, "I became a writer because my DNA contains a gene that has been expressed in me that predisposes me to write well." You can't see, touch, or remember the influence of your genes and you don't even know where in our body they might be located!

Finally, many people are uncomfortable with the idea that they might be the product of their genes rather than the choices they have made in their lives. Such ideas smack of determinism and a lack of "free will." Most people have a strong dislike for any theory that might in some way limit their conscious ability to determine the outcomes in their lives. Consequently, genetic causes of behavior and personality tend to be avoided or rejected. In reality, genetic influences interact with experience to mold a complete human, and the only question is, which is more dominant? Or to phrase the question as it frequently appears in the media: "*Is it nature or nurture?*"

This article by Thomas Bouchard, David Lykken, and their associates at the University of Minnesota in Minneapolis, is a review of research began in 1979 to examine the question of how much influence your genes have in determining your personal psychological qualities. This research grew out of a need for a scientific method to separate genetic influences (nature) from environmental forces (nurture) on people's behavior and personality. This is no simple task when you consider that nearly every one of you, assuming you were not adopted, grew and developed under the direct environmental influence of your genetic donors (your parents). You might, for example, have the same sense of humor as your father (no offense!) because you learned it from him (nurture) or because you inherited his "sense-of-humor" gene (nature). It appears that there is no systematic way to tease those two influences apart, right?

Well, Bouchard and Lykken would say "wrong." They have found a way to determine with a reasonable degree of confidence which psychological characteristics appear to be determined primarily by genetic factors and which are molded more by your environment.

THEORETICAL PROPOSITIONS

It's simple really. All you have to do is take two humans who have exactly the same genes, separate them at birth, and raise them in significantly different environments. Then, you can assume that those behavioral and personality characteristics they have in common as adults must be genetic. But how on earth can researchers possibly find pairs of *identical people* (don't say "cloning;" we're not there yet!)? And even if they could, it would be unethical to force them into diverse environments, wouldn't it? Well, as you've already guessed, the researchers didn't have to do that. Society had already done it for them. Identical twins have virtually the same genetic structure. They are called *monozygotic twins* because they start as one fertilized egg, called a *zygote,* and then split into two identical embryos. Fraternal twins are the result of two separate eggs fertilized by two separate sperm cells

generally confident or insecure? Are you a hard-worker or do you have a lazy streak? Think about yourself in terms of these or any other questions you feel are relevant. Take your time . . . Finished? Now, answer this next, and, for this reading, more important question: "*Why* are you who you are?" In other words, what factors contributed to "creating" this person you are today?

If you are like most people, you will point to the child-rearing practices of your parents and the values, goals, and priorities they instilled in you. You might also credit the influences of brothers, sisters, grandparents, aunts, uncles, and peers who played key roles in molding you. Some of you will cite teachers or other mentors who taught you certain skills or instilled in you the desire and commitment to follow meaningful paths during your life. Still others of you will focus on key life-changing events such as an illness, the loss of a loved one, or the decision to attend a specific college or choose a major or even take a particular course that seemed to lead you toward becoming your current self. Of course, this is a very partial list of the many influences you might think of when you try to analyze the forces that shaped your personality. However, all of these influences share one characteristic in common: they are all *environmental* phenomena. Hardly anyone ever replies to the question "Why are you who you are?" with, "I was born to be who I am; it's all in my genes."

Everyone acknowledges that physical attributes, such as height, hair color, eye color, and body type are genetic. More and more people are realizing that tendencies toward many illnesses such as cancer, heart disease, and high blood pressure, have significant genetic components. But almost no one thinks of genes as the main force behind who they are *psychologically.* This may strike you as odd when you stop to think about it, but in reality there are very understandable reasons for our "environmental bias."

First of all, psychology during the second half of the 20th Century was dominated by a theory of human nature called *behaviorism.* Basically, the theory of behaviorism states that all human behavior is controlled by environmental factors including the stimuli that provoke behaviors and the consequences that follow response choices. Strict behaviorists believed that the internal psychological workings of the human mind were not only impossible to study scientifically, but that such study was unnecessary and irrelevant to a complete explanation for human behavior. Whether the wider culture accepted or even understood formal theories of behaviorism is not as important as the reality of their influence on today's firmly entrenched popular belief that *experience* is the primary or exclusive architect of human nature.

Another understandable reason for the pervasive acceptance of environmental explanations of behavior is that genetic and biological factors do not provide visible evidence of their influence. It's easy for someone to say, "I became a writer because I was deeply inspired and encouraged by my seventh grade composition teacher." You remember those sorts of influences; you see them; they are part of your past and present conscious experiences.

the caregiver is stressful and unsatisfying, the hormones created in the infant's nervous system cause the abnormal development of specific structures and emotional circuits in the cortex. According to Shore, this abnormal brain development, triggered by negative environmental factors during infancy, creates an enduring increased susceptibility to various psychological disorders later in life (p. 59). Post echos Schore's findings and goes a step further to suggest that stress and early episodes of psychological disorders such as depression or bipolar mental illness may actually leave "biochemical. . . residues in the central nervous system (CNS) in relation to their patterning, severity, and recurrence" (p. 273). In other words, Post and his colleagues are saying that an inherited tendency toward mental illness may create early abnormal psychological episodes, that, in turn, cause *physical* changes in the nervous system, leading to ongoing mental illness later in and throughout life. Based on these findings, Post suggests that early interventions may be more important than previously thought in preventing mental illnesses in adulthood.

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ARE YOU A "NATURAL?"

Bouchard, T., Lykken, D., McGue, M., Segal, N., & Tellegen, A. (1990). Sources of human psychological differences: The Minnesota study of twins reared apart. *Science, 250,* 223–229.

This study represents a relatively recent and on-going fundamental change in how many psychologists view human behavior in its broadest sense. You can relate to this change in a personal way by first taking a moment to answer in your mind the following question: "Who are you?" This may feel like a huge and complex question, but you don't have to delve too deeply or wander too far into philosophical or metaphysical territory. Just think for a moment about some of your individual characteristics: your "personality traits." Are you high strung or "laid back?" Are you shy or outgoing? Are you adventurous or do you seek out comfort and safety? Are you easy to get along with or do you tend toward the disagreeable? Are you usually optimistic or more pessimistic about the outcome of future events? Are you

Changes in the brain due to experience might lead to a better understanding of how memories are stored in the brain. This could, in turn, lead to new techniques for improving memory and preventing memory loss due to aging. Another area in which this research might prove helpful was in explaining the relationship between malnutrition and intelligence. The concept proposed by the authors in this regard was that malnutrition may make a person unresponsive to the stimulation available in the environment and consequently may limit brain development. And, the authors noted, some concurrent research suggested that the effects of malnutrition on brain growth may be either reduced by environmental enrichment or enhanced by deprivation.

RELATED RESEARCH AND RECENT APPLICATIONS

This work by Rosenzweig, Bennett, and Diamond served as a catalyst for continued research in this area. Over the more than 25 years since the publication of their article, these scientists and many others have continued to confirm, refine, and expand their findings.

For example, it has been found that learning itself is enhanced by enriched environmental experiences and that even the brains of adult animals raised in impoverished conditions can improve when placed in an enriched environment (see Bennett, 1976, for a complete review).

Some evidence exists to indicate that experience does indeed alter brain development in humans. Through careful autopsies of humans who have died naturally, it appears that as a person develops a greater number of skills and abilities, the brain actually becomes more complex and heavier. Other findings come from examinations during autopsies of the brains of people who were unable to have certain experiences. For example, in a blind person's brain, the portion of the cortex used for vision is significantly less developed, less convoluted, and thinner than in the brain of a person with normal sight.

Marian Diamond, one of the authors of the original article, has applied the results of work in this area to the process of human intellectual development throughout life. She says, "For people's lives, I think we can take a more optimistic view of the aging brain. . . . The main factor is stimulation. The nerve cells are designed for stimulation. And I think curiosity is a key factor. If one maintains curiosity for a lifetime, that will surely stimulate neural tissue and the cortex may in turn respond. . . . I looked for people who were extremely active after 88 years of age. I found that the people who use their brains don't lose them. It was that simple" (Hopson, 1984, p. 70).

Finally, two separate studies (Post et al., 1996; Schore, 1996) applied Rosenzweig's notions of environmental influences on brain development to mental illness in humans. In Schore's study, evidence was presented indicating that an infant's early emotional experiences in relation to the primary caregiver may influence the production of certain brain chemicals that play a role in the physical development of the cortex, the part of our brain that is responsible for our most complex functions such as thinking, perception, and emotion. When the emotional attachment of the infant to

The criticism of differential handling was a valid one in that the enriched rats were handled twice each day when they were removed from the cage as the toys were being changed, while the impoverished rats were not handled. It was possible, therefore, that the handling might have caused the results and not the enriched environment. To respond to this potential confounding factor, the researchers handled one group of rats every day and did not handle another group of their litter mates (all were raised in the same environment). No differences in the brains of these two groups were found. Additionally, in their later studies, both the enriched and impoverished rats were handled equally and, still, the same pattern of results was found.

As for the criticisms relating to stress, the argument was that the isolation experienced by the impoverished rats was stressful and this was the reason for their less developed brains. Rosenzweig et al. cited other research that had exposed rats to a daily routine of stress (cage rotation or mild electric shock) and had found no evidence of changes in brain development due to stress alone.

One of the problems of any research carried out in a laboratory is that it is necessarily artificial. Rosenzweig and his colleagues were curious about how various levels of stimulation might affect the brain development of animals in their natural environments. They pointed out that laboratory rats and mice often have been raised in artificial environments for as many as 100 generations and bear little resemblance genetically to rats in the wild. To explore this intriguing possibility, they began studying wild deer mice. After the mice were trapped, they were randomly placed in either natural outdoor conditions or the enriched laboratory cages. After 4 weeks, the outdoor mice showed greater brain development than did those in the enriched laboratory environment. "This indicates that even the enriched laboratory environment is indeed impoverished in comparison with a natural environment" (p. 27).

Finally, the most important criticism of any research involving animal subjects is the question of its relationship, if any, to humans. There is no doubt that this line of research could never be performed on humans, but it is nevertheless the responsibility of the researchers to address this issue, and these scientists did so.

The authors explained that it is difficult to generalize from the findings of one set of rats to another set of rats, and consequently much more difficult to try to apply rat findings to monkeys or humans. And, although they report similar findings with several species of rodents, they admit that more research would be necessary before any assumptions could be made responsibly about the effects of experience on the human brain. They proposed, however, that the value of this kind of research on animals is that "it allows us to test concepts and techniques, some of which may later prove useful in research with human subjects."

Several potential benefits of this research were suggested by the authors in their article. One possible application was in the study of memory.

increases in weight quite readily in response to experience whereas the rest of the brain changes little" (p. 25). This measurement of the ratio of the cortex to the rest of the brain was the most accurate measurement of brain changes. This was because the overall weight of the brain varies with the overall weight of each individual animal. By considering this ratio, such individual differences are canceled out. Figure 2 illustrates this finding for all of the 16 studies. As you can see, in only one experiment was the difference not statistically significant.

Finally, there was a finding reported relating to the synapses of the brains of the two groups of rats. The synapse is the point at which two neurons meet. Most brain activity occurs at the synapse, where a nerve impulse is either passed from one neuron to the next so that it continues on, or it is inhibited and stopped. Under great magnification using the electron microscope, it was found that the synapses themselves of the enriched rats' brains were 50% larger than those of the impoverished rats.

DISCUSSION AND CRITICISMS

After nearly 10 years of research, Rosenzweig, Bennett, and Diamond were willing to state with confidence, "There can now be no doubt that many aspects of brain anatomy and brain chemistry are changed by experience" (p. 27). However, they were also quick to acknowledge that when they first reported their findings many other scientists were skeptical, since such effects had not been so clearly demonstrated in past research. There were criticisms contending that perhaps it was not the enriched environment that produced the brain changes, but other differences in the treatment of the rats such as mere handling or stress.

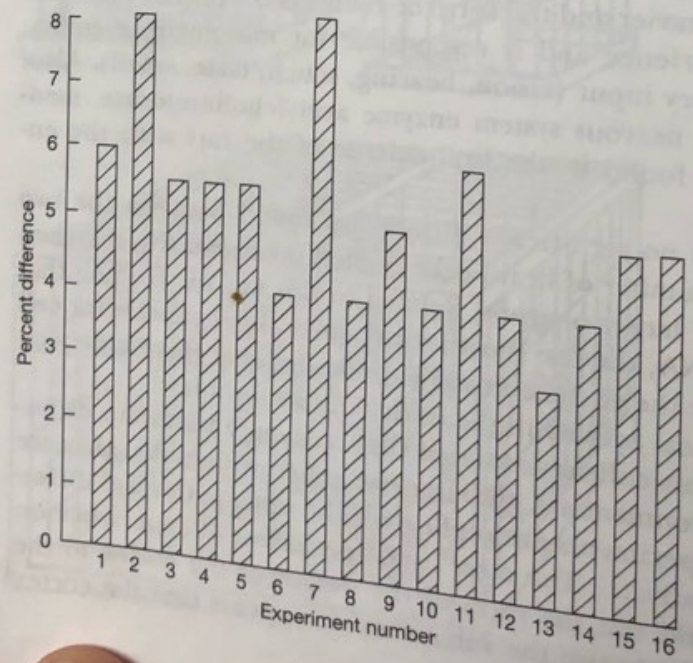

FIGURE 2 Ratio of cortex to rest of brain: Enriched compared with impoverished environment. (Results in experiments 2 through 16 were statistically significant.) (adapted from p. 26)

3. The enriched environment was virtually a rat's Disneyland (no offense intended to Mickey!). Six to eight rats lived in a "large cage furnished with a variety of objects with which they could play. A new set of playthings, drawn out of a pool of 25 objects, was placed in the cage every day" (p. 22).

The rats were allowed to live in these different environments for various periods of time, ranging from 4 to 10 weeks. Following this differential treatment period, the experimental rodents were humanely sacrificed so that autopsies could be carried out on their brains to determine if any differences had developed. In order to be sure that no experimenter bias would occur, the examinations were done in random order by code number so that the person doing the autopsy would not know in which condition the rat was raised. The researchers' primary focus was on the differences in the brains of the enriched rats versus the impoverished rats.

The rats' brains were dissected and the various sections were measured, weighed, and analyzed to determine amount of cell growth and levels of neurotransmitter activity. In this latter measurement, there was one brain enzyme of particular interest called *acetylcholinesterase.* This chemical is important because it allows for faster and more efficient transmission of impulses among brain cells.

Did Rosenzweig and his associates find differences in the brains of rats raised in enriched versus impoverished environments? Here are their results.

RESULTS

Results indicated that the brains of the enriched rats were different from the impoverished rats in many ways. The cerebral cortex of the enriched rats was significantly heavier and thicker. The cortex is the part of the brain that responds to experience and is responsible for movement, memory, learning, and all sensory input (vision, hearing, touch, taste, smell). Also, greater activity of the nervous system enzyme acetylcholinesterase, mentioned previously, was found in the brain tissue of the rats with the enriched experience.

While there were no significant differences found between the two groups of rats in the number of brain cells (called neurons), the enriched environment produced larger neurons. Related to this was the finding that the ratio of RNA to DNA, the two most important brain chemicals for cell growth, was greater for the enriched rats. This implied that there had been a higher level of chemical activity in the enriched rats' brains.

Rosenzweig and his colleagues stated that "although the brain differences induced by environment are not large, we are confident that they are genuine. When the experiments are replicated, the same pattern of differences is found repeatedly. . . . The most consistent effect of experience on the brain that we found was the ratio of the weight of the cortex to the weight of the rest of the brain: the sub-cortex. It appears that the cortex

Implicit in Rosenzweig's research was the belief that animals raised in highly stimulating environments will demonstrate differences in brain growth and chemistry when compared with animals reared in plain or dull circumstances. In each of the experiments reported in this article, 12 sets of three male rats, each set from the same litter, were studied.

METHOD

Three male rats were chosen from each litter. They were then randomly assigned to one of three conditions. One rat remained in the laboratory cage with the rest of the colony; another was assigned to what Rosenzweig termed the "enriched" environment cage; and the third was assigned to the "impoverished" cage. Remember that there were 12 rats in each of these conditions for each of the 16 experiments.

The three different environments (Figure 1) were described as follows:

1. The standard laboratory colony cage contained several rats in an adequate space with food and water always available.
2. The impoverished environment was a slightly smaller cage isolated in a separate room in which the rat was placed alone with adequate food and water.

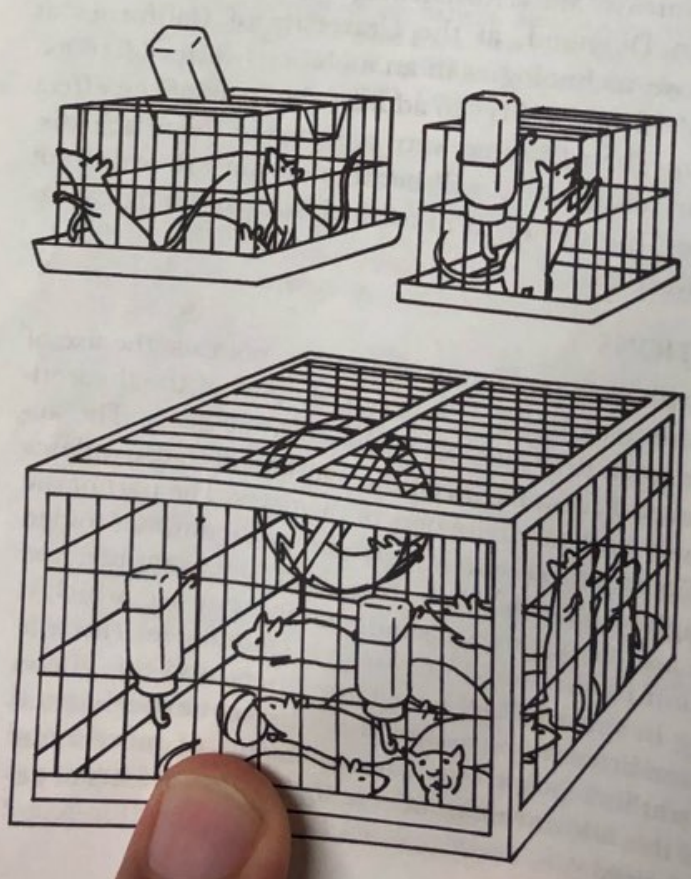

FIGURE 1 The three cage environments

you suppose is the reasoning behind supplying infants with so much to see and do? Well, aside from the fact that babies seem to enjoy and respond positively to these things, it is most parents' belief, acknowledged or not, that children need a stimulating environment for optimal intellectual development and proper development of the brain.

The question of whether certain experiences produce physical changes in the brain has been a topic of conjecture and research among philosophers and scientists for centuries. In 1785, Malacarne, an Italian anatomist, studied pairs of dogs from the same litter and pairs of birds from the same batches of eggs. For each pair, he would train one subject extensively over a long period of time while the other would be equally well cared for, but not trained. He discovered later, in autopsies of the animals, that the brains of the trained animals appeared more complex, with a greater number of folds and fissures. However, this line of research was, for unknown reasons, discontinued. In the late nineteenth century, there were attempts to relate the circumference of the human head with the amount of learning a person had experienced. While some early findings claimed such a relationship, later research determined that this was not a valid measure of brain development.

By the 1960s, new technologies had been developed that gave scientists the ability to measure brain changes with great precision using high magnification techniques and assessment of levels of various brain enzymes and neurotransmitter chemicals. Mark Rosenzweig and his colleagues Edward Bennett and Marian Diamond, at the University of California at Berkeley, incorporated those technologies in an ambitious series of 16 experiments over a period of 10 years to try to address the issue of the effect of experience on the brain. Their findings were reported in the article discussed in this chapter. For reasons that will become obvious, they did not use humans in their studies, but rather, as in many classic psychological experiments, their subjects were rats.

THEORETICAL PROPOSITIONS

Since psychologists are ultimately interested in humans, not rats, the use of nonhuman subjects must be justified. In these studies, part of the theoretical foundation concerned why rats had been chosen as subjects. The authors explained that for several reasons, it is more convenient to use rodents than to use higher mammals such as carnivores or primates. The part of the brain that is the main focus of this research is smooth in the rat, not folded and complex as it is in higher animals. Therefore, it can be examined and measured more easily. In addition, rats are small and inexpensive, which is an important consideration in the world of research laboratories (usually underfunded and lacking in space). Rats bear large litters, and this allows for members from the same litters to be assigned to different experimental conditions. Finally, the authors point out, various strains of inbred rats have been produced, and this allows researchers to include the effects of genetics in their studies if desired.

the picture was projected. Normal control subjects were correct regardless of which hemisphere "saw" the drawings. This implies that communication between your brain hemispheres is necessary for imagining or simulating in your mind the movements of others, that is, "putting yourself in their place" in order to perceive their actions correctly.

Finally, some researchers have been exploring the possibility that interdependent functioning of the two hemispheres of the human brain may help explain various psychological conditions known as dissociative disorders in which a person undergoes a major shift in identity and consciousness, such as *Multiple Personality Disorder* or *fugue states* (e.g., Schiffer, 1996). The idea behind this notion is that in some people with intact, "nonsplit" brains, the right hemisphere may be able to function at a greater-than-normal level of independence from the left, and may even take control of a person's consciousness for periods of time. This may offer a plausible explanation for dissociative psychological disorders, especially if the left hemisphere has little or no memory of these episodes, and, therefore, the person cannot talk about them and would very likely deny their existence. So, is it possible that multiple personality disorder might be the *expression* of hidden personalities contained in our right hemispheres? It's something to think about . . . with *both* of your hemispheres.

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MORE EXPERIENCE = BIGGER BRAIN?

Rosenzweig, M. R., Bennett, E. L., & Diamond, M. C. (1972). Brain changes in response to experience. *Scientific American, 226,* 22–29.

If you were to enter the baby's room in a typical American middle-class home today, you would probably see a crib full of stuffed animals and various colorful toys dangling directly over and within reach of the infant. Some of these toys may light up, move, play music, or do all three. What do

developed in order for you to improve certain skills. Jarre Levy, a psychobiologist at the University of Chicago, has been in the forefront of scientists who are trying to dispel the notion that we have two separately functioning brains. She claims that it is precisely because each hemisphere has separate functions that they must integrate their abilities instead of separating them, as is commonly believed. Through such integration, your brain is able to perform in ways that are greater than and different from the abilities of either side alone.

When you read a story, for example, your right hemisphere is specializing in emotional content (humor, pathos), picturing visual descriptions, keeping track of the story structure as a whole, and appreciating artistic writing style (such as the use of metaphors). While all this is happening, your left hemisphere is understanding the written words, deriving meaning from the complex relationships among words and sentences, and translating words into their phonetic sounds so that they can be understood as language. The reason you are able to read, understand, and appreciate a story is that your brain functions as a single, integrated structure (Levy, 1985).

In fact, Levy explains that there is no human activity that uses only one side of the brain. "The popular myths are interpretations and wishes, not the observations of scientists. Normal people have not half a brain, nor two brains, but one gloriously differentiated brain, with each hemisphere contributing its specialized abilities" (Levy, 1985, p. 44).

RECENT APPLICATIONS

The continuing influence of Sperry's and Gazzaniga's split-brain research echoes the quote from Levy. A review of recent medical and psychological literature reveals numerous articles in various fields referring to the early work and methodology of Roger Sperry as well as to more recent findings by Gazzaniga and his associates. For example, a study from 1998 conducted in France (Hommet & Billard, 1998) has questioned the very foundations of which Sperry's and Gazzaniga's studies, namely that severing the corpus callosum actually divides the hemispheres of the brain. The French study found that children who were born without a corpus callosum (a rare brain malformation) demonstrated that information was being transmitted between their brain hemispheres. The researchers concluded that significant connections other than the corpus callosum must exist in these children. Whether such subcortical connections are present in split-brain individuals is as yet unclear.

Later that same year, a study was published by a team of neuropsychologists that included Gazzaniga, from several prestigious research institutions in the United States (University of Texas, Stanford, Yale, and Dartmouth) demonstrated that split brain patients may routinely perceive the world differently from the rest of us (Parsons, Gabrieli, Phelps, & Gazzaniga, 1998). The researchers found that when subjects were asked to identify whether drawings presented to only one brain hemisphere were drawn by right- or left-handed people, the split-brain patients were only able to do so correctly when the handedness of the artist was the *opposite* of the hemisphere to which

information if the two halves are divided. Indeed, there is some research evidence to suggest that split-brain patients have the ability to perform two cognitive tasks as fast as a normal person can carry out one.

SIGNIFICANCE OF FINDINGS

These findings and the subsequent research carried out by Sperry and Gazzaniga and others are extremely significant and far-reaching. There is now evidence that the two halves of your brain have many specialized skills and functions. Your left brain is better at speaking, writing, mathematical calculation, and reading and is the primary center for language. Your right hemisphere, however, possesses superior capabilities for recognizing faces, solving problems involving spatial relationships, symbolic reasoning, and artistic activities.

Our increased knowledge of the specialized functioning of the two hemispheres of the brain allows us to better treat victims of stroke or head injury. By knowing the location of the damage, we can predict what deficits are likely to exist as the patient recovers. Through this knowledge, appropriate relearning and rehabilitation strategies can be employed to help patients recover as fully and quickly as possible.

Gazzaniga and Sperry, after years of continuous work in this area, concluded that each hemisphere of your brain really is a mind of its own. In a later study, split-brain patients were tested on much more complex problems than have been discussed here. One question asked was, "What profession would you choose?" A male patient verbally (left hemisphere) responded that he would choose to be a draftsman, but his left hand (right hemisphere) spelled by touch in block letters *automobile race* (Gazzaniga & LeDoux, 1978). In fact, Gazzaniga has taken this theory a step further. He now maintains that even in people whose brains are normal and intact, there may not be complete communication between the two hemispheres (Gazzaniga, 1985). For example, if certain bits of information, such as those forming an emotion, are not stored in a language format, the left hemisphere may not have access to it. The result of this is that you may feel sad and not be able to say why. Since this is an uncomfortable cognitive situation, the left hemisphere may try to find a verbal reason to explain the sadness (after all, language is its main job). However, since your left hemisphere does not have all the necessary data, its explanation may actually be wrong!

CRITICISMS

The findings from the split-brain studies carried out over the years by Sperry, Gazzaniga, and others have rarely been disputed. The main body of criticism about this research has focused instead on the way the idea of right- and left-brain specialization has filtered down to popular culture and the media.

There is now a widely believed myth that some people are more *right-brained* or more *left-brained*, or that one side of your brain needs to be

the right hemisphere excel? Sperry and Gazzaniga found in this early work that visual tasks involving spatial relationships and shapes were performed with greater proficiency by the left hand (even though these patients were all right-handed). As can be seen in Figure 2, copying three-dimensional drawings (using the pencil behind the screen) was much more successful with the left hand.

Finally, the researchers wanted to explore emotional reactions of split-brain patients. While performing visual experiments, Sperry and Gazzaniga suddenly flashed a picture of a nude woman to either the left or right hemisphere. In one instance, when this picture was shown to the left hemisphere of a female patient:

> She laughed and verbally identified the picture of a nude. When it was later presented to the right hemisphere, she said . . . she saw nothing, but almost immediately a sly smile spread over her face and she began to chuckle. Asked what she was laughing at, she said: "I don't know . . . nothing . . . oh—that funny machine." Although the right hemisphere could not describe what it had seen, the sight nevertheless elicited an emotional response like the one evoked in the left hemisphere. (p. 29)

DISCUSSION

The overall conclusion drawn from the research reported in this article was that there are two different brains within each person's cranium, each with complex abilities. Gazzaniga notes the possibility that if our brain is really two brains, then perhaps we have the potential to process twice as much

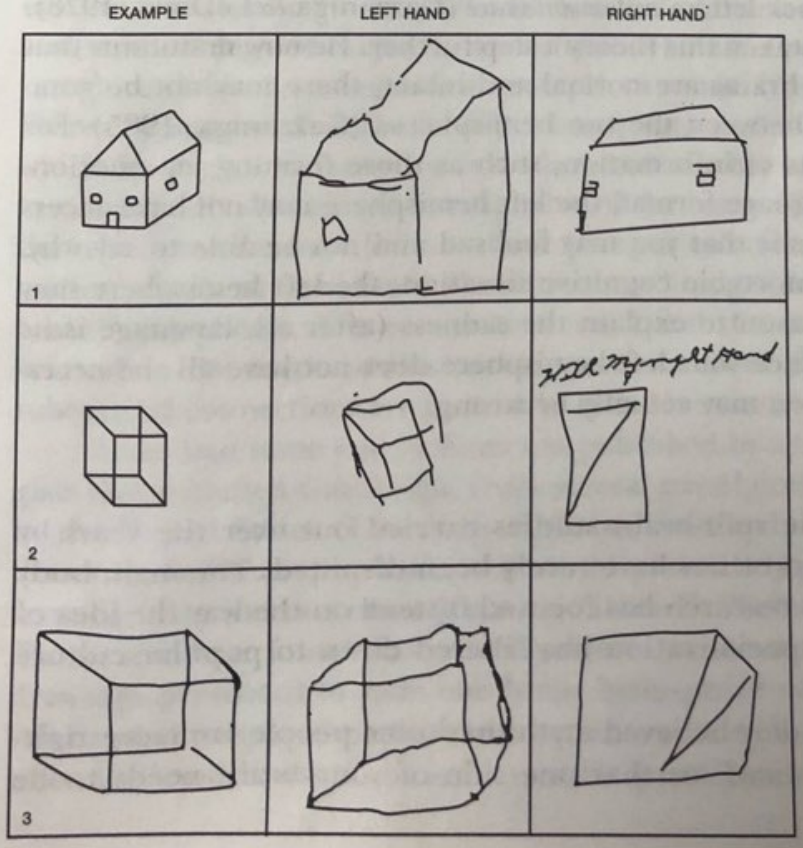

FIGURE 2 Drawings made by split-brain patients. (adapted from "The Split Brain in Man," by Michael S. Gazzaniga)

reach under the screen with their left hand and touch a selection of objects, they were always able to find the one that had been presented visually.

The right hemisphere was found to be able to think about and analyze objects as well. Gazzaniga reported that when the right hemisphere was shown a picture of an item such as a cigarette, the subjects could touch 10 objects behind the screen that did not include a cigarette, and select an object that was most closely related to the item pictured—in this case an ashtray. He went on to explain:

> Oddly enough, however, even after their correct response, and while they were holding the ashtray in their left hand, they were unable to name or describe the object or the picture of the cigarette. Evidently, the left hemisphere was completely divorced, in perception and knowledge, from the right. (p. 26)

Other tests were conducted to shed additional light on the language-processing abilities of the right hemisphere. One very famous, ingenious, and revealing use of the visual apparatus came when the word HEART was projected to the patients so that *HE* was sent to the right visual field and *ART* was sent to the left. Now, keeping in mind (your connected mind) the functions of the two hemispheres, what do you think the patients verbally reported seeing? If you said *ART,* you were correct. However, and here is the revealing part, when the subjects were presented with two cards with the words *HE* and *ART* printed on them and asked to point with the left hand to the word they had seen, they all pointed to *HE!* This demonstrated that the right hemisphere is able to comprehend language, although it does so in a different way from the left: in a nonverbal way.

The auditory tests conducted with the patients produced similar results. When patients were asked to reach with their left hand into a grab bag hidden from view and pull out certain specific objects (a watch, a marble, a comb, a coin) they had no trouble. This demonstrated that the right hemisphere was comprehending language. It was even possible to describe a related aspect of an item with the same accurate results. An example given by Gazzaniga was when the patients were asked to find in a grab bag full of plastic fruit "the fruit monkeys like best," they retrieved a banana. Or when told "Sunkist sells a lot of them," they pulled out an orange. However, if these same pieces of fruit were placed out of view in the patients' left hand, they were unable to say what they were. In other words, when a verbal response was required, the right hemisphere was unable to speak.

One last example of this amazing difference between the two hemispheres involved plastic block letters on the table behind the screen. When patients were asked to spell various words by feel with the left hand they had an easy time doing so. Even if three or four letters that spelled specific words were placed behind the screen, they were able, left-handed, to arrange them correctly into words. However, immediately after completing this task, the subjects could not name the word they had just spelled. Clearly, the left hemisphere of the brain is superior to the right for speech (in some left-handed people, this is reversed). But in what skills, if any, does

Visual Abilities

One of the first tests involved a board with a horizontal row of lights. When a patient sat in front of this board and stared at a point in the middle of the lights, the bulbs would flash across both the right and left visual fields. However, when the patients were asked to explain what they saw, they said that only the lights on the right side of the board had flashed. Next when the researchers flashed only the lights on the left side of the visual field, the patients claimed to have seen nothing. A logical conclusion from these findings was that the right side of the brain is blind. Then an amazing thing happened. The lights were flashed again, only this time the patients were asked to point to the lights that had flashed. Although they had said they only saw the lights on the right, they pointed to all the lights in both visual fields. Using this method of pointing, it was found that both halves of the brain had seen the lights and were equally skilled in visual perception. The important point here is that when the patients failed to *say* that they had seen all the lights, it was not because they didn't see them, but because the center for speech is located in the brain's left hemisphere. In other words, in order for you to say you saw something, the object has to have been seen by the left side of your brain.

Tactile Abilities

You can try this test yourself. Put your hands behind your back. Then have someone place familiar objects (a spoon, a pen, a book, a watch) in either your right or your left hand and see if you can identify the object. You would not find this task to be very difficult, would you? This is basically what Sperry and Gazzaniga did with the split-brain patients. When an object was placed in the right hand in such a way that the patient could not see or hear it, messages about the object would travel to the left hemisphere and the patient was able to name the object and describe it and its uses. Then, when the same objects were placed in the left hand (connected to the right hemisphere), the patients could not name them or describe them in any way. But did the patients know what the object was? In order for the researchers to find out, the subjects were asked to match the object in their left hand (without seeing it, remember) to a group of various objects presented to them. This they could do as easily as you or I. Again, this places verbal ability in the left hemisphere of the brain. Keep in mind that the reason you are able to name unseen objects in your left hand is that the information from the right side of your brain is transmitted via the corpus callosum to the left side, where your center for language says "that's a spoon!"

Visual Plus Tactile Tests

Combining these two types of tests provided support for the findings above and also offered additional interesting results. If subjects were shown a picture of an object to the right hemisphere only, they were unable to name it or describe it. In fact, there might be no verbal response at all or even a denial that anything had been presented. But if the patients were allowed to

brain and the same object could be searched for by either hand among various objects behind the screen (see Figure 1).

Finally, testing auditory abilities was somewhat more tricky. When sound enters either of your ears, sensations are sent to both sides of your brain. Therefore, it is not possible to limit auditory input to only one side of the brain even in split-brain patients. However, it is possible to limit the *response* to such input to one brain hemisphere. Here is how this was done. Imagine that several common objects (a spoon, a pen, a marble) are placed into a cloth bag, and you are then asked to find certain items by touch. You would probably have no trouble doing so. If you place your left hand in the bag, it is being controlled by the right side of your brain, and vice versa. Do you think either side of your brain could do this task alone? As you will see in a moment, both halves of the brain are not equally capable of performing this task. What if you are not asked for specific objects, but are simply requested to reach into the bag and identify objects by touch? Again, this would not be difficult for you, but it would be quite difficult for a split-brain patient.

Gazzaniga combined all of these testing techniques to reveal some fascinating findings about how the brain functions.

RESULTS

First of all, it should be noted that following this radical brain surgery, the patients' intelligence level, personality, typical emotional reactions, and so on were relatively unchanged. They were very happy and relieved that they were now free of seizures. It was reported that one patient, while still groggy from surgery, joked that he had "a splitting headache." When testing began, however, these subjects demonstrated many unusual mental abilities.

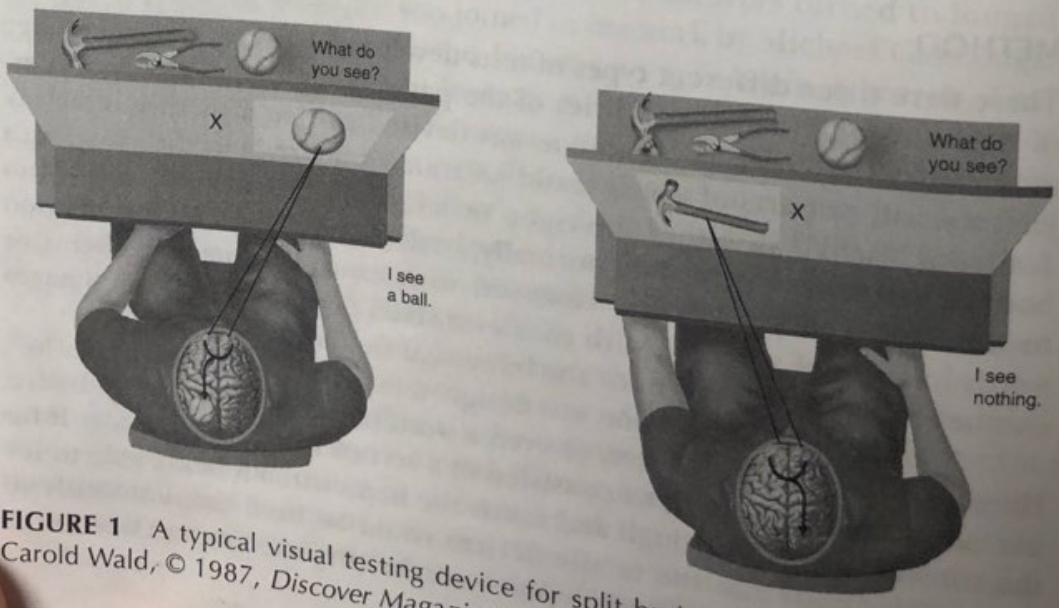

FIGURE 1 A typical visual testing device for split-brain subjects. (adapted from Carold Wald, © 1987, *Discover Magazine*)

But can scientists divide the brains of humans? This sounds like psychology à la Dr. Frankenstein! Obviously, research ethics would never allow such drastic methods simply for the purpose of studying the specialized abilities of the brain's two hemispheres. However, in the late 1950s, the field of medicine provided psychologists with a golden opportunity. In some people with very rare and very extreme cases of uncontrollable epilepsy, seizures could be virtually eliminated by surgically severing the corpus callosum. This operation was (and is) extremely successful, as a last resort, for those patients who cannot be helped by any other means. When this article was written in 1966, there had been 10 such operations, and four of the patients had consented to participate in examination and testing by Sperry and Gazzaniga to determine how their perceptual and intellectual skills were affected as a result of this surgical treatment.

THEORETICAL PROPOSITIONS

The researchers wanted to explore the extent to which the two halves of the human brain are able to function independently, and whether they have separate and unique abilities. If the information traveling between the two halves of your brain is interrupted, would the right side of your body suddenly be unable to coordinate with the left? If language is controlled by the left side of the brain, how would your ability to speak and understand words be affected by this surgery? Would thinking and reasoning processes exist in both halves separately? If the brain is really two separate brains, would a person be capable of functioning normally when these two brains are no longer able to communicate? Since we receive sensory input from both the right and the left, how would the senses of vision, hearing, and touch be affected? Sperry and Gazzaniga would attempt to answer these and many other questions in their studies of split-brain individuals.

METHOD

There were three different types of tests developed to explore a wide range of mental (cognitive) capabilities of the patients. One was designed to examine visual abilities. A technique was devised so that a picture of an object, a word, or parts of words could be transmitted only to the visual area (called a "field") in either the right- or left-brain hemisphere, and not to both. It should be noted that, normally, both of your eyes send information to both sides of your brain. However, with exact placement of items or words in front of you, and with your eyes fixed on a specific point, images can be fed to only the right or the left visual field of your brain.

Another testing situation was designed for tactile (touch) stimulation. Here an object, a block letter, or even a word in block letters, could be felt but not seen. The apparatus consisted of a screen with a space under it for the subject to reach through and touch the items without being able to see them. The visual and the tactile devices could be used simultaneously so that, for example, a picture of a pen could be projected to one side of the

vice versa. Even beyond this, though, the two brain hemispheres appear to have even greater specialized abilities.

It has come to be rather common knowledge that, for most of us, the left brain controls the ability to use language while the right is involved more in spatial relationships, such as those needed for artistic activities. It is well known that stroke or accident victims who suffer damage to the left side of the brain will usually lose their ability to speak (often this skill returns with practice and training). Many people believe that each half, or "hemisphere," of your brain may actually be a completely separate mental system with its own individual abilities for learning, remembering, perceiving the world, and even feeling emotions. The concepts underlying this popular awareness are the result of many years of rigorous scientific research on the effects of splitting the brain into two separate hemispheres.

Research in this area was pioneered by Roger W. Sperry (1913–1994), beginning about 15 years prior to the article examined in this chapter. In his early work with animal subjects, Sperry made many remarkable discoveries. For example, consider a cat that has had surgery to cut the connection between the two halves of its brain and to alter its optic nerves so that its left eye only transmitted information to the left hemisphere and the right eye only to the right hemisphere. Following surgery, the cat appeared to behave normally and exhibited virtually no ill effects. Then the cat's right eye was covered and the cat learned a new behavior, such as walking through a short maze to find food. After the cat became skilled at maneuvering through the maze, the eye cover was shifted to its left eye. Now when the cat was placed in the maze, its left brain had no idea where to turn and the animal had to relearn the entire maze from the beginning.

Sperry conducted many related studies over the next 30 years and in 1981 received the Nobel Prize for his work on the specialized abilities of the two halves of the brain. When his research endeavors turned to human subjects in the early 1960s, he was joined in his work by Michael Gazzaniga. Although Sperry is considered the founder of split-brain research, Gazzaniga's article has been chosen because it is a clear, concise summary of their early collaborative work with human subjects and is cited consistently in nearly all general psychology texts. Its selection is in no way intended to overlook or overshadow either Sperry's leadership in this field or his great contributions. Gazzaniga, in large part, owes his early research, and his ongoing leadership in the area of hemispheric specialization, to Roger W. Sperry (see Sperry, 1968; Puente, 1995).

In order to understand split-brain research, some knowledge of human physiology is required. The two hemispheres of your brain are in constant communication with one another via the corpus callosum, a structure made up of about 200 million nerve fibers. If your corpus callosum is cut, this major line of communication is disrupted and the two halves of your brain must then function independently. So, if we want to study each half of your brain separately, all we need to do is surgically sever your corpus callosum.

1 BIOLOGY AND HUMAN BEHAVIOR

Nearly all general psychology texts begin with chapters relating to the biology of human behavior. This is not simply due to convention, but rather it is because biological processes form the basis of all behavior. Each of the other subfields of psychology rests on this biological foundation. The branch of psychological research that studies these processes is called *physiological* or *biological psychology,* and focuses on the interaction of your brain and nervous system, the processes of receiving stimulation and information from the environment through your senses, and the ways in which your brain organizes all this information to create your perceptions of the world.

The studies chosen to represent this basic component of psychological research include a wide range of research and are among the most influential and most often cited. The first study discusses a famous research program on right-brain/left-brain specialization that shaped much of our present knowledge of how the brain functions. Next is a study that surprised the scientific community by demonstrating how a stimulating "childhood" might produce a more highly developed brain. The third study is new to the fourth edition and represents a fundamental change in the thinking of many psychologists about the basic causes of human behavior, personality, and social interaction: namely, a new appreciation for the significance of your genes. Fourth is the invention of the famous "visual cliff" method of studying infants' abilities to perceive depth. All these studies, the latter two in particular, also address an issue that underlies and connects nearly all areas of psychology and provides for an ongoing and fascinating debate: the nature-nurture controversy.

ONE BRAIN OR TWO?

Gazzaniga, M. S. (1967). The split brain in man. *Scientific American, 217,* 24–29.

You are probably aware that the two halves of your brain are not the same and that they perform different functions. For one thing, the left side of your brain is responsible for movement in the right side of your body, and