INSIDE THE BRAIN

Measuring Mental Activity

A hundred years ago, people thought that emotions came from the heart. That's why we still send hearts on Valentine's Day, why we speak of broken hearts or of people who are soft- or hard-hearted.

But now we know that everything begins inside the brain. It is foolish to dismiss a sensation with "It's all in your head." Of course it is in your head; everything is.

Until quite recently, the only way scientists could estimate brain activity was to measure heads. Measuring produced some obvious discoveries—babies with shrunken brains (*microcephaly*) suffered severe intellectual disability; brains grew bigger as children matured.

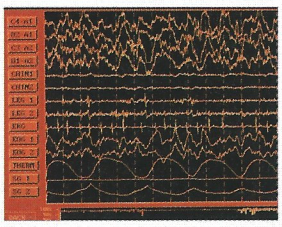
Measuring also led to some obvious errors, now discredited. In the nineteenth and early twentieth centuries, many scientists believed the theory that bumps on the head reflected intelligence and character, a theory known as *phrenology*. Psychiatrists would run their hands over a person's skull to measure 27 traits, including spirituality, loyalty, and aggression. Another example was that some scientists said that women could never be professors because their brains were too small (Swaab & Hofman, 1984).

Within the past half-century, neuroscientists developed ways to use electrodes, magnets, light, and computers to measure brain activity, not just brain size (see Table 2.4). Bumps on the head and head size (within limits) were proven irrelevant to intellectual processes. Researchers now study cognitive processes between input and output. Some results are cited later. In this feature we describe methods.

TABLE 2.4

Some Techniques Used by Neuroscientists to Understand Brain Function

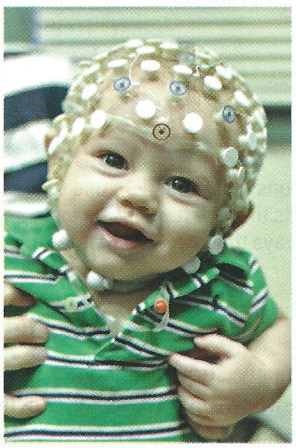
EEG (electroencephalogram)



Robert J. Herko/The Image Bank/Getty Images

The EEG measures electrical activity in the cortex. This can differentiate active brains (beta brain waves—very rapid, 12 to 30 per second) from sleeping brains (delta waves—1 to 3 per second) and brain states that are half-awake, or dreaming. Complete lack of brain waves, called flat-line, indicates brain death.

ERP (event-related potential)



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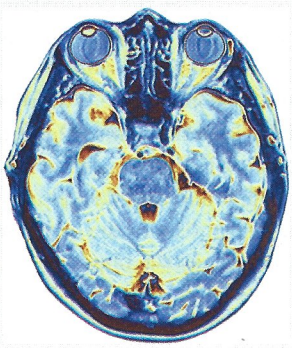
The amplitude and frequency of brain electrical activity changes when a particular stimulus (called an event) occurs. First, the ERP establishes the usual patterns, and then researchers present a stimulus (such as a sound, an image, a word) that causes a blip in electrical activity. ERP indicates how quickly and extensively people react—although this method requires many repetitions to distinguish the response from the usual brain activity.

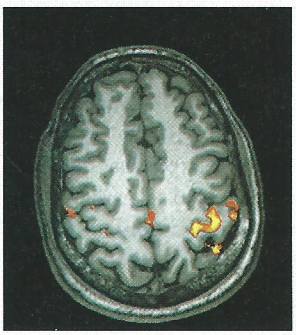
MRI (magnetic resonance imaging)



Pasieka/Science Source

The water molecules in various parts of the brain each have a magnetic current, and measuring that current allows measurement of myelin, neurons, and fluid in the brain.

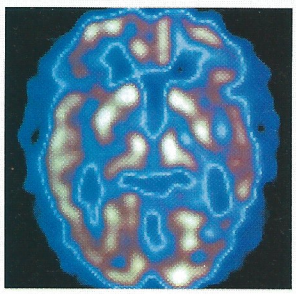
fMRI (functional magnetic resonance imaging)



Kul Bhatia/Science Source

In advanced MRI, function is measured as more oxygen is added to the blood flow when specific neurons are activated. The presumption is that increased blood flow means that the person is using that part of the brain. fMRI has revealed that several parts of the brain are active at once—seeing something activates parts of the visual cortex, but it also may activate other parts of the brain far from the visual areas.

PET (positron emission tomography)



Tim Beddow/Science Source

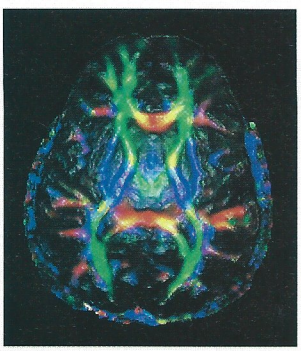
When a specific part of the brain is active, the blood flows more rapidly in that part. If radioactive dye is injected into the bloodstream and a person lies very still within a scanner while seeing pictures or other stimuli, changes in blood flow indicate thought. PET can reveal the volume of neurotransmitters; the rise or fall of brain oxygen, glucose, amino acids; and more. PET is almost impossible to use with children (who cannot stay still) and is very expensive with adults.

fNIRS (functional near-infrared spectroscopy)

Pat Greenhouse/The Boston Globe via Getty Images

This method also measures changes in blood flow. But, it depends on light rather than magnetic charge and can be done with children, who merely wear a special cap connected to electrodes and do not need to lie still in a noisy machine (as they do for PET or fMRI). By measuring how each area of the brain absorbs light, neuroscientists infer activity of the brain (Ferrari & Quaresima, 2012).

DTI (diffusion tensor imaging)



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DTI is another technique that builds on the MRI. It measures the flow (diffusion) of water molecules within the brain, which shows connections between one area and another. This is particularly interesting to developmentalists because life experiences affect which brain areas connect with which other ones. Thus, DTI is increasingly used by clinicians who want to individualize treatment and monitor progress (Van Hecke et al., 2016).

For both practical and ethical reasons, it is difficult to use these techniques on large, representative samples. One of the challenges of neuroscience is to develop methods that are harmless, quick, acceptable to parents and babies, and comprehensive. A more immediate challenge is to depict the data in ways that are easy to interpret and understand.

Brain imagery has revealed many surprises. For example, fNIRS finds that the brains of newborns are more active when they hear the language that their mother spoke when they were in the womb than when they hear another language (May et al., 2011). fMRI on adolescents has found that a fully grown brain does not mean a fully functioning brain: The prefrontal cortex is not completely connected to the rest of the brain until about age 25. Brain scans of new mothers reveal that babies change their mothers' brains (P. Kim et al., 2016).

All the tools indicated on these two pages have discovered brain plasticity and variations not imagined in earlier decades. However, sensitive machines and advanced computer analysis are required for accurate readings. Even then, all we know is whether parts of the brain are functioning and active—or not. Changes in light absorption, or magnetism, or oxygenated blood flow in the brain are miniscule from one moment to the next. Interpreting what that means is more complex.

For example, it would be good to replace the conventional lie detector, which is unreliable, with brain imaging. But current technology is not ready (Rose, 2016).

Variations within and between people make it difficult to know what someone is thinking via brain scans. Once again, this confirms the need for theory: Without an idea of what to look for, or what it might mean, the millions of data points from all brain images might lead naive scientists to the same trap as earlier measurements of the skull—their own bias.

SUMMARY

What Theories Do

1. A theory provides general principles to guide research and explain observations. Each of the five major developmental theories—psychoanalytic, behaviorist, cognitive, sociocultural, and evolutionary—interprets human development from a distinct perspective, providing a framework for understanding human emotions, experiences, and actions.

2. Theories are neither true nor false. They are not facts; they suggest hypotheses to be tested and interpretations of the myriad human behaviors. Good theories are practical: They aid inquiry, interpretation, and daily life.

3. A developmental theory focuses on changes that occur over time, uncovering the links between past, present, and future. Developmental theories attempt to answer the crucial questions of the life span.

Grand Theories

4. Psychoanalytic theory emphasizes that adult actions and thoughts originate from unconscious impulses and childhood conflicts. Freud theorized that sexual urges arise during three stages of childhood—oral, anal, and phallic—and continue, after latency, in the genital stage.

5. Erikson described eight successive stages of development, each involving a crisis to be resolved. The early stages are crucial, with lifelong effects, but the emphasis is not only on the body and sexual needs. Instead, Erikson stressed that societies, cultures, and family shape each person's development.

6. Behaviorists, or learning theorists, believe that scientists should study observable and measurable behavior. Behaviorism emphasizes conditioning—a lifelong learning process in which an association between one stimulus and another (classical conditioning) or the consequences of reinforcement and punishment (operant conditioning) guide behavior.

7. Social learning theory recognizes that people learn by observing others, even if they themselves have not been reinforced or punished. Children are particularly susceptible to social learning, but all humans are affected by what they notice in other people.

8. Cognitive theorists believe that thoughts and beliefs powerfully affect attitudes, actions, and perceptions, which in turn affect behavior. Piaget proposed four age-related periods of cognition, each propelled by an active search for cognitive equilibrium.

9. Information processing focuses on each aspect of cognition—input, processing, and output. This perspective has benefited from technology, first from understanding computer functioning and more recently by the many ways scientists monitor the brain.

Newer Theories

10. Sociocultural theory explains human development in terms of the guidance, support, and structure provided by each social group through culture and mentoring. Vygotsky described how learning occurs through social interactions in which mentors guide learners through their zone of proximal development.

11. Sociocultural learning is also encouraged by the examples and tools that each society provides. These are social constructions, which guide everyone but also which can change.

12. Evolutionary theory contends that contemporary humans inherit genetic tendencies that have fostered survival and reproduction of the human species for tens of thousands of years. Through selective adaptation, the fears, impulses, and reactions that were useful 100,000 years ago for *Homo sapiens* continue to this day.

13. Evolutionary theory provides explanations for many human traits, from lactose intolerance to the love of babies. Selective adaptation is the process by which genes enhance human development over thousands of years. Societies use laws and customs to protect people from some genetic impulses.

What Theories Contribute

14. Psychoanalytic, behavioral, cognitive, sociocultural, and evolutionary theories have aided our understanding of human development. However, no single theory describes the full complexity and diversity of human experience. Most developmentalists are eclectic, drawing on many theories.

KEY TERMS

developmental theory (p. 37)
psychoanalytic theory (p. 39)
behaviorism (p. 41)
classical conditioning (p. 41)
operant conditioning (p. 43)
reinforcement (p. 43)
social learning theory (p. 45)
modeling (p. 45)
cognitive theory (p. 45)
cognitive equilibrium (p. 46)
assimilation (p. 47)
accommodation (p. 47)
information-processing theory (p. 47)
sociocultural theory (p. 51)
apprenticeship in thinking (p. 52)
guided participation (p. 52)
zone of proximal development (p. 52)
selective adaptation (p. 58)
eclectic perspective (p. 62)