For the treatment of disorders involving the various senses, especially those related to communication, a number of specialized fields have evolved. The *audiologist* determines deficiencies in the acuity of hearing, which often can be improved by the prescription of hearing aids. The *speech pathologist* treats disorders of speech, which may be due to damage to the structures involved in the formation of sounds or may have a neurological cause. The *ophthalmologist* is a physician who specializes in disorders of the eye, whereas the *optometrist* has no medical training and treats only those visual disorders that can be corrected by the prescription of eyeglasses. For the measurement of the acuity of the senses, as well as for the study of behavior, large numbers of instruments have been developed, which can be highly specialized.

The results of behavioral studies seldom show a simple cause-and-effect relationship but are usually in the form of statistical evidence. This peculiarity requires large numbers of experiments in order to obtain results that are statistically significant. As a result, especially in animal experiments, automated systems are frequently used to control the experiment automatically and record the results. The diversity of the field, on the other hand, has resulted in commercially available instruments that are often in the form of modules and building blocks which can be assembled by the experimenter into specialized systems to suit the requirments of a particular experiment.

One obvious way to study behavior is to measure the electrical signals in the brain and the nervous system that control the behavior, as discussed in Chapter 10. However, because the voltages recorded on an electroencephalograph are the result of many processes that occur simultaneously in the brain, only events that involve larger areas of the brain, such as epileptic seizures, can be readily identified on the EEG recording. For this reason, mental disorders generally cannot be diagnosed from the electroencephalogram, although the EEG is usually used to rule out certain organic disorders of the brain (e.g., tumors), which can show symptoms similar to those of nonorganic types of mental illness. The instrumentation used to measure the EEG is described in Chapter 10.

11.1. PSYCHOPHYSIOLOGICAL MEASUREMENTS

As stated in Chapter 10, many body functions, including blood pressure, heart rate, perspiration, and salivation, are controlled by the autonomic nervous system. This part of the nervous system normally cannot be controlled voluntarily but is influenced by external stimuli and emotional states of the individual. By observing and recording these body functions, insight into emotional changes that cannot be measured directly can be obtained. A practical application of this principle is the *polygraph* (colloquially called the "lie detector"), a device for simultaneously recording several body functions that are likely to show changes when questions asked by the interrogator cause anxiety in the tested person.

For the measurement of blood pressure, heart rate, and respiration rate in psychophysiological studies, the same instruments are used as are utilized for medical applications (see Sections 6.1 and 6.2, and Chapter 8, respectively). For measuring variations in perspiration, a special technique has been developed. In response to an external stimulus, such as touching a sharp point, the resistance of the skin shows a characteristic decrease, called the *galvanic skin response* (GSR). The baseline value of the skin resistance, in this context, is called the *basal skin resistance* (BSR). The GSR is believed to be caused by the activity of the sweat glands. It does not depend on the overt appearance of perspiration, however, and the actual mechanism of the response is not completely understood. The GSR is measured most readily at the palms of the hands, where the body has the highest concentration of sweat glands. An active electrode, positioned at the center of the palm, can be used together with a neutral electrode, either at the wrist or at the back of the hand. In some devices clips are simply attached to two fingers. Frequently, in order to increase the stability of the measurement, nonpolarizing electrodes, such as silver-silver chloride surface electrodes (see Chapter 4), are used with an electrode jelly that has about the same salinity as the perspiration. In order to minimize the polarization at the electrodes, the current density is kept below 10 $\mu A/cm^2$.

Figure 11.1 shows a block diagram of a device that allows the simultaneous measurement, or recording, of both the BSR and the GSR. Here a current generator sends a constant dc current through the electrodes. The voltage drop across the basal skin resistance, typically on the order of several kilohms to several hundred kilohms, is measured with an amplifier and a meter that can be calibrated directly in BSR values. A second meter, coupled through an *RC* network with a time constant of about 3 to 5 seconds, measures the GSR as a change of the skin resistance of from several hundred ohms to several kilohms. The output of this amplifier can be recorded on a suitable graphic recorder. A measurement of the absolute magnitude of the GSR is not very meaningful. The change of the magnitude of the GSR, depending on the experimental conditions and its *latency* (the time delay between stimulus and response), can be used to study emotional changes. A polygraph for recording physiological functions, including GSR is shown in Figure 11.2.

Instead of the change of the skin resistance, the change of the *skin potential* has been used occasionally. This is actually a potential difference of between 50 and 70 mV that can be measured between nonpolarizing electrodes on the palm and the forearm and that also shows a response to emotional changes.

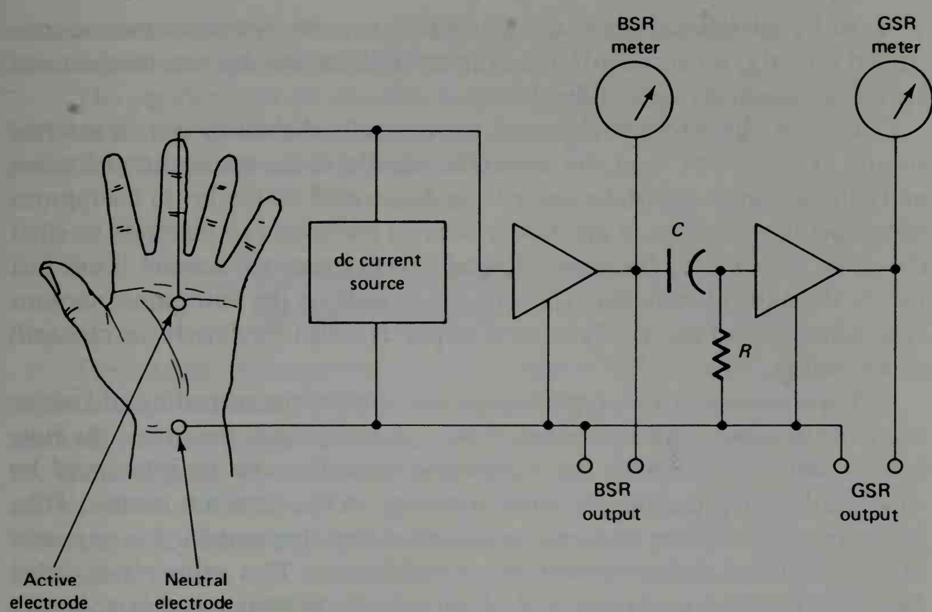
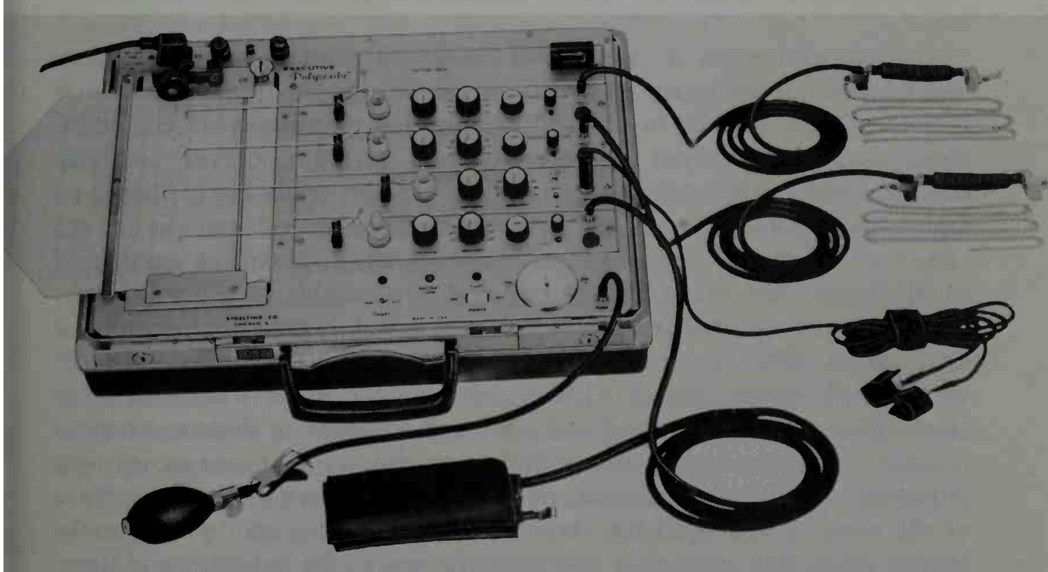


Figure 11.1. Block diagram of a device to measure and record basal skin resistance (BSR) and the galvanic skin response (GSR.)

Figure 11.2. Polygraph for the recording of four body functions. The sensors (right and bottom, clockwise) are for respiration (2 channels) galvanic skin response (GSR) and blood pressure changes. (Courtesy of Stoelting Co., Chicago, IL.)



Although the activity of the autonomic nervous system cannot be controlled directly, it can be influenced in an indirect way by two mechanisms known as *conditioning* and *feedback*.

Certain physiological responses are normally elicited by certain external stimuli. The view of food, for instance, stimulates the production of saliva and causes "one's mouth to water." As discovered by Pavlov in his famous experiments with dogs, a previously neutral stimulus can be made to elicit the same response as the view of food if it is presented several times just before the natural stimulus. This process of making the autonomic nervous system respond to previously neutral stimuli is called *Pavlovian* (or *classical*) *conditioning*.

Experiments of this type require the continuous recording of one or more of the autonomic responses. Pavlov, for example, measured the flow rate of saliva. Sometimes the autonomic responses can be influenced by simply informing the subject when a change in the response occurs. This, again, requires that the response be measured and that certain characteristics of it be signaled to the subject in a suitable way. This principle is called *biological feedback* or *biofeedback*. Although this technique had been known for some time, it received renewed interest during the early 1970s for possible therapeutic uses in controlling variables like heart rate, blood pressure, and the occurrence of certain patterns in the electroencephalogram. Biofeedback is described in more detail in Section 11.5.

11.2. INSTRUMENTS FOR TESTING MOTOR RESPONSES

Motor responses, or responses of the skeletal muscles, are under voluntary control but often require a learning process for the proper interaction between several muscles in order to perform the response correctly. Numerous devices have been described in the literature, or are available commercially, to measure motor responses and to study the influence of factors like fatigue, stress or the effects of drugs. Some of these devices are very simple. Manual dexterity tests, for instance, consist of a number of small objects that the subject is required to assemble in a certain way, while the time required for completion of the task is measured. In related instruments called *steadiness testers* a metal stylus must be moved through channels of various shapes without touching the metal walls. An error closes the contact between wall and stylus and advances an electromechanical counter. The *pursuit rotor* uses a similar principle. A light spot moves with adjustable speed along a circular, or star-shaped, pattern on the top surface of the tester. The subject has the task of pursuing the spot with a hook-shaped probe that contains a photoelectric sensor. An indicator and timer