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The Measurement of Basic Capacities in Motor Control

Carl E. Seashore
The State University

THE MEASUREMENT OF BASIC CAPACITIES IN MOTOR CONTROL

CARL E. SEASHORE.

The same principle that led the merchant to adopt the plan of making an inventory of his stock occasionally has led to the introduction of psychological methods in the rating of capacities for various kinds of service. Among these, perhaps the intelligence tests are the best known and most used at the present time, particularly as now employed for the entire United States Army.

Our laboratory has recently been at work on the development of a series of motor tests which are of a basic nature, so that the information should be of value in the diagnosis of fitness for various occupations requiring motor control. The selection has gradually simmered down to the following:

1. *Motor ability.* This is measured in terms of the speed and regularity of the simplest possible repeated movement. Ordinarily we use a tap with the tip of the finger. We assume, subject to further verification, that the ability shown in one part of the body is a reasonable index to corresponding ability in other parts of the body, provided we exclude special acquired skills. It is necessary that the test be equally fair to all in that no one will have had special practice. This should be equally true of all the tests.

2. *Timed action.* Here we require a person to mark time in some very simple but exact way at the rate of about one beat per second, and we measure the average deviation from the average time, which he himself sets, and use that as an index to his capacity for keeping time. This capacity is involved in many every-day reactions, *e. g.*, in music, marching, dancing, and in the work of a great many skilled operatives in the industries.

3. *A simple response to a simple signal—simple reaction.* A signal, such as a sound or a light or a touch, is given, and we measure the time that it takes to make a response to this signal. This is known as sensory-motor time or simple reaction time.

4. *A simple response to a complex stimulus—complex reaction.* It is agreed that the stimulus shall be, *e. g.*, a loud sound or a weak sound, the two sounds being alike in every other

respect. The instructions are: If the sound is strong do not respond, if it is weak, respond. This type of action requires a high form of mentality, the power of deliberation and choice. The observer has first to delay reaction and discriminate between a weak and a strong sound, and after this is done, choose either to act or not to act.

5. *A complex response to a complex stimulus—serial action.* The highest form of action may be represented in a generic way by presenting one from a group of stimuli calling for a particular one of a group of possible actions. For example, suppose four bells are located in different parts of the room and the observer is seated at a typewriter with two fingers of each hand on designated keys with the instruction that each bell shall be identified by a particular key so that, when that bell rings, the correct key is to be pressed. We then have a contrivance by which the pressing of the key rings another bell which calls for a similar action, and this keeps on indefinitely, making it possible to record the speed of action, the amount of action in a given time, and the degree of reliability in terms of errors.

6. *Precision of action.* The control of movement may be measured in terms of precision in direction, precision in distance, precision in force, and precision in time of movement. In measuring precision of direction we use a drill gauge so mounted with an electric pointer that the observer can put the pointer into the hole without touching the margin of the hole; if it touches the bell rings. The test consists in finding for a given form of movement how small a hole he can put the pointer into without touching the edge, using a steady regular movement. Similar tests may be made for distance, time, and force of action.

7. *Strength and endurance.—The ergograph.* Here we employ a new model of ergograph in which a person is required to make his maximum lift against the spring with the biceps and associated muscles in a given position, thirty consecutive times, and a graphic record is made showing the exact amount of each pull. The regularity and the rate in the falling off of the strength of the pull in thirty trials is a fair index to reliability and endurance.

In order to make these tests available on a large scale, we have encountered the very difficult problem of adapting instruments. The instruments which we employ in the Psychological Laboratory for these tests would cost over a thousand dollars

and some of them are complicated and delicate. Fortunately, we have hit upon a sort of universal apparatus which can be used for most of these tests. It consists of an ordinary phonograph with a series of small attachments. During the year we discovered the surprising fact that the current phonograph motors have an extraordinary high degree of constancy. Under favorable conditions the variation from revolution to revolution of the disc in a good phonograph is less than one thousandth of a second. This is a higher degree of precision than we really need for the measurement of time. We then devised an electromagnetic marker carrying an ordinary fountain pen and mounted this on an endless screw so that it writes on a piece of white paper placed on the disc plate. With this marker we can connect the signal and the response apparatus so that a mark is made at the time of the stimulus and another at the time of the response. The reading is made simple and quick by the fact that the stimuli can be made at one point through an automatic key, and the time scale consisting of a circle divided into thousandths of a revolution can lie under the disc. In order to get the reading in a given record, all that we need to do is to run a guide lever from the central pivot and over the mark on the record. This will then point to the reading on the scale in terms of hundredths or even thousandths of a second.

By this means we measure the motor ability, timed action, simple reaction, and complex reaction in the series of motor tests. The same outfit is, however, available for many other measurements not belonging to the series and becomes a cheap and exceedingly valuable general instrument in the laboratory.

One of my students, Mr. C. F. Hansen, designed a very clever device for the serial action. It consists essentially of a four track contact strip attached to the carrier of a typewriter in such a way that, for every time a key is struck, a new signal will appear. It may be used in connection with any kind of electric exposing apparatus for visual or auditory stimuli.

For the measurement of endurance we have devised a new ergograph which makes use of the muscles of the forearm in the most natural position of pull. It is built on the principle of the spring dynonometer and makes an automatic ergogram.

PSYCHOLOGICAL LABORATORIES,
THE STATE UNIVERSITY.