The Section of Psychology

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Classics in the History of Psychology
An internet resource developed by
Christopher D. Green
York University, Toronto, Ontario
ISSN 1492-3173

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First published in M. P. Hardy (Ed.), *Official Catalogue -- World's Columbian Exposition* (Part. vii, pp. 50-60). Chicago: W. B. Conkey.

Posted August 2000

The section of psychology comprises two rooms; the one fitted out as a laboratory in operation and other containing a collection of apparatus used in the experimental study of mental phenomena. The room devoted to the growth and development of children contains a series of illustrations of the growth of mental powers belonging to this section. An exhibit of the methods and results of modern psychology is naturally confined to these portions of the science that are most amenable to objective illustration. For this reason it is well to emphasize the fact that there are equally important divisions of the subject that are not represented

The general divisions of psychology may be enumerated as, **experimental psychology**, including the study of sensation and movement, of the relations between mind an body, of the natures and time relations or elementary mental processes, such as distinctions, choice, memory, attention, and the like, **comparative psychology**, including the study of the unfolding of the faculties of the human infant and the mental development of children, the study of various types of mind in animals, and the changes in thought and feeling that mark the advances from savagery to civilization; **abnormal psychology**, or the study of the divergences from normal mental action; in this division belong such topics as illusions, dreams, the actions of drugs, hypnotism, the various forms of insanity and idiocy, blindness and deaf-mutism.

Psychology also has very direct and practical relations to education, to medicine, to anthropology and other sciences. In the present exhibit those methods and results that stand in close relations to the methods and results of anthropometry have received special attention.

The diversions and others in common use necessarily overlap, some being characterized by method and some by subject matter, and together serve merely as a rough index of the chief lines of activity in the modern study of psychology.

THE PSYCHOLOGY LABORATORY

The object of this laboratory is to illustrate the methods of testing the range, accuracy and nature of the more elementary mental powers, and to collect material for the further study of the factors that influence the development of these powers, their normal and abnormal distribution, and their correlation with one another. The laboratory is this designed, not as those connected with universities, for a special research, or for demonstrations and instruction in psychology, but as a laboratory for the collection of tests. As in physical anthropometry the chief proportions of the human body are systematically measured, so in mental anthropometry the fundamental modes of action upon which mental life is conditioned are subjects to a careful examination. In both cases the first object is [p. 51] to ascertain the normal distribution of the quality measured. With this determined, each individual can find his place upon the chart or curve for each form of test and from a series of such comparisons obtain a significant estimate of his proficiencies and deficiencies. It should not be overlooked that mental tests of this kind are burdened with difficulties from which physical measurement are comparatively free. Our mental powers are subject to many variations and fluctuations. The novelty of the test often distracts from the best exercise of the faculty tested, so that a very brief period of practice might produce a more constant and significant result. Fatigue and one's physical condition are also important causes of variation. It is impossible in the environment of the present laboratory to secure the necessary time and facilities for minimizing these objections. They detract more from the value of an individual record than from, that of the combined statistical result. So much remains to be done in this line of investigation that at every step interesting problems are left unanswered. But what has been done emphasizes the importance and probably value of further research. The problems to be considered when once the normal capacity has been ascertained are such general ones as the growth and development with age of various powers; what types of faculty develop earlier and what later; how far their growth is conditioned upon age and how far upon education; again, the difference between the sexes at various ages, differences of race, environments, social status are likewise to be determined. The relation of physical development to mental, the correlations of one form of mental faculty with others, the effect of a special training, these together with their many practical applications form the more conspicuous problems to the elucidation of which such tests as are here taken will contribute. In addition to the interest in his or her own record, the individual has thus the satisfaction of contributing to a general statistical result

THE SERIES OF TESTS.

The apparatus is arranged on a series of tables, the attendant directing the tests from the place in back of them, while the subject, as a rule, is seated upon a chair placed between the tables. A railing separates the attendant and subject from those who may be observing the tests. Beginning on the left of the entrance from the aisle, the tests are arranged as follows:

TABLE No. 1.

Judgment of lengths by finger movements. Five bars with terminal stops are arrange horizontally, the one above the other and a little behind the other; the subject passes his forefinger to and fro along these bars and so forma a judgement of their relative length. He indicates his result by placing peg, bearing the number "5," in a hole on the bar which he regards as the longest, a "1" on the shortest, and "2," "3," and "4" correspondingly. Having thus arranged the one series of length in what he determines to be the true order, the apparatus is reversed and another series with smaller differences is presented for arrangement in order. The sensibility involved in this test is the information obtained from the sensations accompanying the contraction of the muscles. The result is recorded in each case as correct of as involving a certain degree of error. The true lengths are 150, 165, 181.5, 199.7, 219.6 (a ratio of increase of 1/10) for the coarse series; and 150, 157.5, 165.4, 173.6, 182.3 (a ratio increase of 1/20) for the fine series. The apparatus is entirely screened so that the bars are never seen.

This method of arranging in order a coarse and a fine series of five stimuli has been adopted in several of the tests, on account of its advantage of combining a large number of comparisons in one result, and of permitting the subject to make his own record at his own convenience. [p. 52]

Judgment of weights. The series of five weighted hard rubber boxes differing in weight are presented, and the subject required to arrange them in order of weight. The weights are held and raised between the thumb and forefinger, the sensibility involved being the combined pressure-sense of the skin and the sense of resistance overcome by the contraction of the muscles in raising the weights. Two series of weights are used, the coarse weights: 300, 320, 341.3, 364.1, 388.4 grammes (a ratio of increase of 1/15); and the finer, 300, 310, 320.3, 331, 342 grammes (a ratio of increase of 1/30)).

Touch. The minimal distance is determined for the tip of the forefinger between the points that can just be felt as two. This form of sensibility differs greatly in different portions of the body; points separated by 1/25 or 1/50 of an inch can be felt as two on the tip of the tongue, while on the back of the neck they may be separated by 3/4 of an inch and yet be felt as one. A series of fixed points are used, varying by half-millimeters up from 5 to 6 mm., and a result quickly reached. The points are necessarily applied at precisely the same moment and with a constant and known pressure.

TABLE No. 2.

Judgment of surfaces by feeling. A series of surfaces (about three inches square) are formed by winding wires of various diameters tightly around an iron form. Each turn of the wire rests close against the neighboring ones, so that a more or less rough or smooth surface is formed according to the grade of wire used. The subject places the forefinger of his right hand successively through five openings in a screen by which the surfaces are hidden from view, and feels the surfaces by passing the tip of the forefinger to and fro across it. Having estimated their relative roughness and smoothness he places a peg bearing a "5" over the coarsest surface, a "1" over the finest and the others accordingly. rile sensibility involved is a form of active touch similar to that used in judging the texture of cloths, metals, etc. A coarse and a fine series are used, the wires having diameters of .051, .063, .081, .102 and .128 inches (a ratio of increase of 1/4) in the one series; and .051, .057, .064, .072, .081 inches (a ratio of increase of 1/8) in the other series.

Rapidity of movement. The subject touches an electric key as rapidly as possible, each closing of the circuit being automatically recorded. In this way a record is taken of the maximum number of finger-movements a that the subject can make in 15 seconds. The wrist is held in order to ensure an isolated and uniform finger-movement.

Sensitiveness to pain. A gradually increasing pressure is brought to bear upon the tip of the forefinger of the left hand, and the subject is asked to indicate the moment at which the pressure first becomes at all painful. This lower limit of pain is recorded to the nearest 1/4 kilogramme (1 kgm. = 2.2 lbs.), by means of a coiled spring indicator. Three records are taken. (This apparatus is designed by Prof. Cattell of Columbia College.)

TABLE No. 3.

Equality of movements. The subject places the point of a lead pencil at the left end of a sheet of paper 15 inches long, and makes five movements by raising the pencil and bringing it down again, the attempt being to make the distances between the dots so recorded equal. The test is made with the eyes closed, the estimate of the distance moved depending upon the motor sensibility. The only limit of movement is that suggested by the length of the paper. The average distance between the dots and the average percentage of deviation are computed and recorded.

Reproduction of lines. Three lines, approximately one, two and three inches in length, are shown one at a time. The line is removed and the subject immediately there-upon draws a line as nearly as possible of the same length as the one just seen. The amount and direction of error of each reproduction is recorded. [p. 53]

Accuracy of aim. The subject attempts to touch with a hard rubber pencil a small cross printed

on a sheet of paper (three inches square) and placed upon the table about 18 inches away. The error, *i.e.*, the distance between the center of the cross and the point actually touched is recorded by means of carbon paper upon a sheet beneath. The subject is thus prevented from seeing his error, while a circular screen upon the pencil hides the cross a little before the point approaches it and thus insures a direct and uniform movement. The subject attempts to strike the cross ten times, and the direction and amount of each error is noted.

Division of lengths. The apparatus (devised by Prof. Muensterberg, of Harvard University) consists of a surface of black felt, about twenty inches long, with three adjustable white strips for dividing off the surface. The strips at each end are set to form a constant distance (in the present test 40 cm = 10.2 inches) and the subject's task consists in setting the middle strips so as to divide the distance exactly in two; or again, to mark off one-third of the distance. A scale may be quickly turned into position and the error in mm. noted.

Right and left movements. The subject places the forefinger of each hand upon the center of a wire, and simultaneously moves the fingers out to an equal distance in opposite directions. By means of the buttons left at the ends of the movements and a mm. scale, the difference in the extent of movement of the hands is determined. In this test right and left-handedness play an important part. The instrument was designed by Dr. Fitz of Harvard University.

TABLE No. 4.

Accuracy of movements. Starting at the center of a sheet of paper twelve inches square the subject draws a line as accurately as possibly, first toward a point at the edge of the sheet to the left, then to the right, then above and then below. The starting point and the four other points are marked by crosses. To prevent the natural retardation of the movement as the pencil approaches the cross, a small circular screen is placed upon the pencil. The error and general directness of the movement are recorded. This test, like the accuracy of aim and reproduction of movements,, involves the guidance of movements by the eye.

Judgments of lengths by sight. By pressing one or another of five keys, five cards appear bearing lines of different lengths; the subject judges, the relative lengths of the lines and indicates his judgment by placing a peg bearing the number "5" upon the key that brings up the longest line, a "1" in the shortest and so on. The apparatus is then reversed and a second series of five lines with smaller differences presented for judgment. The lines in the coarse series are 2.00, 2.10, 2.20, 2.31 and 2.43 incites in length (a ratio of increase of 1/20); and in the fine series 2.00, 2.05, 2.10, 2.15 and 2.21 inches (a ratio of increase of 1/40).

Estimation of lengths in four directions. The upper arm of a cross printed upon a sheet of paper eight inches square bears a small mark 50 mm. from the center; the subject attempts to place a mark upon the other three arms at an equal distance from the center. The divergences from 50 mm. are then measured to the nearest half millimetre[*]. The arms of the cross are unequal and a symmetrically[*sic*] placed in order to insure judgment of length from the center outward.

Form alphabet. This name is given to a series of twenty-five characters, each consisting of a vertical stroke and two horizontal strokes, one above and one below. The horizontal strokes are either both long or both short, to the right or left, or long on one side and short oil the other. Twenty-five typical variations have been detected and one of these singled out as the form to be identified. Over 200 of these forms are arranged in a chance order upon a sheet 8½ inches square, with the form to be identified clearly indicated at the top. The subject finds and marks off as rapidly as possible as many of the [p. 54] forms exactly like the one designated as he can recognize within the time allowed, ninety seconds. The number correctly and the number incorrectly marked are recorded. The test involves the power of rapidly distinguishing between small differences in length, position and form.

TABLE No. 5.

Quickness of perception. Behind a photographic shutter there appears for a brief moment (about 1/20 of a second) a card bearing a series of black dots, or dots of different colors, or words, etc. The subject attempts to determine the number and color of the dots, and to read the words, within brief period of exposure. From the correctness of the answers given the quickness of perception is estimated.

Memory. A series of printed words, numbers, etc., appears successively behind opening in a screen; as soon as the series is completed the subject attempts to write as many possible of the words or numbers in their proper order. The number correctly recalled with and without regard to order, are recorded as an indication of the range of memory, or "memory span."

Reproduction of lengths by memory. In a former test (Table No, 3) the subject drew lines as nearly as possible of the same lengths as three pattern lines shown. He now draws these lines again according to his recollection of them. The increase of error is due to the fading of the sense-image in the memory.

TABLE No. 6.

Location reaction. A white spot upon a metal strip may be placed at any portion of about one-sixth of the circumference of a circular track (diameter about 36 inches). The spot is concealed by a screen, the falling of which is the signal for the subject to find and touch the spot as accurately and quickly as he can. The fall of the screen starts and the touching of the spot stops the swing of a pendulum-chronoscope. The time is thus measured to the nearest 1/100 of a second and the error in position to the nearest millimeter. This apparatus was designed by Dr. Fitz of Harvard University.

TABLE No. 7. -- REACTIONS.

Simple reactions: Touch, hearing, sight. The time to be measured is that elapsing between the presentation of a stimulus and the indication by the subject that the resulting sensation has been received. The subject receives a tap on the back of the hand, hears the stroke of a bell or sees a white spot in back of a falling screen; the same movement that produces the touch, the sound, or the fall of the screen starts an electric chronoscope, registering one-hundredths of a second. The reaction consists in touching a key, which instantly stops the chronoscope.

Complex reactions: Choice of two touches. The right or the left shoulder of the subject is touched, and as quickly as possible he touches a key with his right hand if the touch has been on the right shoulder; with the left hand if upon the left shoulder. The increase of time above the simple reaction is that needed for determining the place of the stimulus and for choosing the proper movement.

Choice of five numbers and movements. The stimuli are the five numbers, 1, 2, 3, 4, 5, exposed by the falling of the screen, and the reaction the touching of the particular one of the five keys bearing the number exposed. The time measured is that needed for reading the number and choosing the proper one of five movements.

The apparatus is also arranged for the determination of the time of a variety of mental processes, such as color distinction, naming pictures, reading, adding, classifying, associating, etc.

In all tests several records are made. These time measurements are important as a test of general mental alertness, and as a means of studying mental processes not readily susceptible of measurement by the usual methods. [p. 55]

TABLE No. 8.

Copying test. The time needed for writing ten given short words from a printed copy is

measured to the nearest second.

Association test. The time needed for thinking of and writing down an association to each of ten given words is measured. The difference in time between this and the preceding test gives some indication of the readiness of association.

Picture and word test. The rapidity with which a given ten words or pictures can be found amongst forty is measured. This time serves as an index of general mental alertness, and also gauges the closeness of association between word and picture. The test is further arranged to yield some indications of memory, first as the power to recall and secondly as the power to recognize. First the subject attempts after a given interval to write as many of the forty words or pictures as he call recall; and then he attempts to mark off on a sheet containing sixty pictures or words in irregular order (the original forty and twenty others) as many as he can recognize as having seen on the former sheet. The number of pictures or words correctly recalled and correctly recognized gauges the capacity of this form of memory, while the time needed for the various stages of the test gives a further useful indication.

OPTICAL TESTS.

On the west wall to the rear of tables 6 and 7 are arranged a series of tests of the range and accuracy of form and color vision.

Range of vision. The subject views at a distance of five meters (16.4 feet) a card bearing in proper sizes a series of rings either complete, or open at one or two places to the left, right, above or below. He is given a blank spaced off like the large card and draws the forms in their proper places as well as he can. All naming or reading is thus avoided; while the smallest set of circles correctly drawn determines the range of vision. The sizes extend from 30 to 2.5 diopters. (The execution of this test is due to Dr. C. A. Oliver of Philadelphia, Pa.)

Accuracy of vision. Groups of dots of various sizes 40 to 2.5 diopters are viewed at a distance of 5 meters, the subject counting the number of dots in each group. The smallest size of dot correctly counted indicates the accuracy of vision.

Color-sense. A series of 28 circular patches of color are arranges in their spectral order around the circumference of a large black disc. These colors are indicated by a number from 1 t o28. Through a circular opening at the center of the large disc, any one of ten colors may be made to appear; each central color in indicated by a letter, A B C, etc. The test consists in matching successively each of the ten central colors with one at the circumference. This the subject does as rapidly as possible; the nature of the error is an indication of defects of color-vision which the time furnishes an index of the development of the color-sense.

Shade. Nine shades of grey are arranged upon a board, not in the order of their intensity, and are indicated by numbers. Then one of the shades is shown singly and the subject attempts to identify it by its number. The number and nature of the errors gauges his ability to see slight distinctions of shade.

In addition to these tests of which systematic records are made, there are tests of the confusion of colors; preference of colors, singly and in pairs, preference of proportions, and other tests which cannot be further described.

Demonstration table. Upon a long table near the east wall are shown some pieces of apparatus and materials, illustrating a few typical principles in the study of sensation. [p. 56]

Among the points demonstrated may be mentioned, color contrast, color mixture, subjective colors, duration of the after image, stereoscopic combination, double-images, retinal rivalry; peripheral vision, blind spot, estimation of size, visual interpretation, contrast of extent and intensity of pressure, upper and lower limit of audibility, etc., etc.

Charts, curves, etc. Along the west wall and portions of the east wall are arranged a series of curves representing in graphic form the results of investigations of various sensory, motor and mental faculties. The largest group is devoted to sets of curves showing the results of tests, many of them the same as those taken in the laboratory, and all of similar purpose. These results are based upon tests taken at nine different colleges, upon 850 persons, with college students predominating. They represent the normal accuracy and distribution of certain forms of sense and motor capacity and mental powers, and the nature of the error when a constant error is involved. Other groups of curves illustrate the results of research upon the relation between mind and body, on memory, illusions, involuntary movements, reaction times, association, etc., etc.

Photographs of psychological laboratories. Upon the south wall and adjoining portions of the east and west walls, the chief psychological laboratories of this and other countries are represented by photographs. This collection gives a general view of the extensive material provisions that have been made for the further development and teaching of experimental psychology. The photographs are accompanied by outlines of courses of study in psychology. The foreign universities represented are Bonn, Geneva, Paris, Prague, Rome, Tokio[*sic*]; the American are Brown, Clark, Columbia, Cornell, Harvard, Illinois, Pennsylvania, Princeton, Toronto, Wellesley, Wisconsin and Yale.

The material contained in this laboratory has been collected by the Section of Psychology of the Department of Ethnology, with the aid of the psychological department of the University of Wisconsin. With the exceptions already noted; the apparatus has been prepared and in most cases designed for the purposes of this laboratory.

The electrical supplies are exhibited by the Ansonia Electrical Company; the shutter used upon table No. 5 is exhibited by the Bausch and Lamb Optical Company, Rochester, N.Y.

APPARATUS ROOM.

The collection of apparatus aims to exemplify the chief forms of apparatus and material used in special research and general study of mental phenomena. Some of this apparatus is used as well by physiologists, physicists, and physicians, but the greater portion has been designed especially for psychological purposes.

The apparatus has been collected by the Section of Psychology of the Department of Ethnology, the chief contributors being the psychological departments of the following universities: Brown, Harvard, Pennsylvania, Toronto, Wisconsin; the following instrument makers: Cambridge Scientific Instrument Co., Cambridge, England; H. Elbs, Freiburg, Germany; R. Jung, Heidelberg, Germany; J. D. Kagenaar, Utrecht, Holland; M. Kohl, Chemnitz, Germany; C. Krille, Leipsig, Germany; F. Mayer, Strassburg, Germany; W. Petzold, Leipsig, Germany; R. Rothe, Prague, Austria; E. S. Stohrer, Leipsig, Germany; Ch. Verdin, Paris, France; Milton-Bradley CO., Springfield, Mass.; Ganun & Parsons, New York; Meyroitz Bros., New York; Que n[*sic*] & Co., Philadelphia; E. S. Ritchie & Sons, Boston; Yarnall, Philadelphia, together with a number of individual exhibitors.

The apparatus is classified throughout according to the purposes for which it is used, and each bears a label explaining its mode of use and acknowledging its source. There are ten cases of apparatus, the contents of which are indicated as (beginning upon the left of the entrance from the aisle) *Touch; the eye-light and form sense; color-sense; color-sense; binocular vision* (in lower case, color contrast); *hearing* (in lower case visual inferences); [p. 57] *movement* (in lower case optical illusions); *recording apparatus; time-measuring apparatus; reaction-time accessories*.

In addition there are arranged upon platforms in the center of the room and near the north wall, as well as on the tops of the cases, a miscellaneous series of apparatus too large to be exhibited in the cases.

Touch. What is popularly termed touch includes a group of sensibilities connected with the skin. The chief of these are the form and space sense of the skin, sense of pressure, sense of temperature, and the sensations accompanying muscular contraction. The form-sense is most usually tested by æsthesiometers, which determine the smallest between [*sic*] two points that may be felt as two, this distance differing widely in different portions of the body. A variety of designs of such apparatus is exhibited. Another group of instruments have for their object the determination of the smallest outline and solid shapes that may be distinguished when placed upon the skin; of the slightest differences in texture and in thickness that can be felt; of the perception of movement upon the skin; of the relation between lengths as judged by the skin and by the eye; of the combination of touch-impressions, and the like.

As types of apparatus for the study of the pressure sense, test-weights and special forms of pressure balances are exhibited. These are used to determine the smallest differences in weight that can be perceived under various circumstances. The temperature sense is represented by simple devices for locating and mapping the hot and cold spots, or the special points of the skin specifically sensitive to heat or cold. A number of devices for studying the extent and accuracy of the sense of movement completes the inventory of this case.

The eye -- light and form sense. As the processes of seeing are most directly related to the structure of the eye, and the formation of the image and the movements of the eyes, the first group of optical apparatus is devoted to these points. The case contains several forms of artificial eyes by which the relations and functions of the several parts of the eye may be conveniently reproduced; special devices for illustrating the changes accompanying accommodation, the path of the rays, the formation of the image upon the retina, the movements of the eyeballs; also apparatus for determining the chief forms of optical defects.

The methods of testing the form sense of the eye, *i.e*, the accuracy and range of vision under different conditions, are represented by perimeters, optometers, test-dots, test-letters, test-forms, test-diagrams, etc. Devices for demonstrating the blind spot, and a variety of accessory apparatus (shutters, diaphragms, dark-tubes) are also included in this section.

Color-sense. The first of the two cases devoted to the color-sense contains a variety of color-wheels, illustrations of color mixture, and methods of detecting color-blindness. The color-wheel is at once the simplest and most universal method of obtaining variations in color and shade. The various types differ mainly in respect to the manner of rotation, whether by hand, foot, clock-work or electric motor, while special wheels have been devised to permit the proportions of colors to he changed while the wheel is in motion. All these types are represented. In a frame upon the wall are displayed the methods of preparing discs for experiments in color vision; these include slit discs sliding upon one another and thus producing ally desired proportion of the component colors; graded mixture, mixture by half-discs, and thus showing the resulting color and the components at the same time; distinction between pigment and color mixture; methods of measuring color proportions, etc.

The various methods of detecting color blindness are displayed in this and the following case. For convenience these methods may be classified as the matching, the naming, the confusion and the quantitative methods, The matching method consists in placing before [p. 58] the subject a series of pattern or typical colors and requiring him to select out all colors like them. The matching methods are represented by Homgren's worsteds in various forms, by Galton's test wools, a series of wools arranged by Dr. Oliver, the Magnus Jeffries color card, etc. For practical purposes the distinction of colors as signals, and of naming them correctly is important and has led to a variety of devices for detecting the readiness with which given colors can be recognized and named. Several such devices are exhibited. The confusion method is represented by arrangement of colored bands, with narrow strips of a different color inserted upon them, by colored letters printed on colored backgrounds; by Stilling's test plates

consisting of figures formed by irregular blotches of color upon a background of another color, and by other variations of these. In all these a person with a certain form of color defect is unable to read or distinguish what is clear to the normal eye. In the quantitative tests the object is to determine the precise amount of white and colored light that give rise to the two colors that are wrongly pronounced the same. The chief forms of such apparatus exhibited are those designed by Prof. Holmgren, Prof. Donders and Prof. Hering.

Color sense. Several of the pieces of apparatus already described are contained in in [*sic*] the second optical case. In addition this case contains apparatus for illustrating changes of light and shade, contrast of light and shade, collections of discs for various purposes, chromotropes; and also apparatus used in testing the accuracy with which lines and angles and their positions in space may be estimated.

Binocular vision. The combination of the images in the two eyes to form one picture is a most important fact in vision; the apparatus whose special purpose is to illustrate the process of seeing or inferring the solidity of objects from the two retinal images is the stereoscope. As illustrations of the phenomena of binocular vision are shown rods and other apparatus for demonstrating double-images, devices for illustrating the horopter; diagram for combining points of vision and a variety of general and special stereoscopes; methods of obtaining binocular color mixture are also shown.

The lower portion of this case is devoted to the phenomena of color contrast and subjective color. The chief point illustrated is that a background of one color will change a neutral grey into its complementary; green inducing pink, yellow, blue, etc. A grey ring placed upon green paper and covered with white tissue paper seems pink; a gray[**] ring formed by the rotation of black and white upon a green sector becomes pink; a black dot seen in reflection upon a white background in proximity to a black dot viewed through red glass becomes greenish; of the two shadows of a rod, one formed by colored the other by white light, the one shadow will show the color of the light, the other the complementary color, etc. All these forms of color contrast are shown. The change of color when presented upon different backgrounds and other related points are also illustrated.

Visual inferences: Optical illusions. The lower portions of the two cases at the north end of the east wall contain illustrations of inferences from visual sensations, in distinction to the primitive sensations themselves, and of a few types of optical illusions. Stereoscopic cards illustrate the inferences of solidity or the third dimension of space; several forms of the zoetrope illustrate the inference of movement from an interrupted series of changes of position; diagrams illustrating the interpretation of lines as the pictures of objects and other similar principles re also shown. The chief types of illusions illustrated are illusions relative length and area due to contrast of particular outlines and angles; illusions of change of direction of straight lines, and deviation from parallelism of parallel lines as the result of intersecting angles, illusions depending upon irradiation, etc.

The selection of apparatus bearing upon the form and color sense has been made with the assistance of Dr. C. A. Oliver of Philadelphia. Cr. B. Joy Jeffries of Boston has contributed largely to the collection of apparatus for the detection of color blindness. [p. 59]

Hearing. The apparatus for the study of the sensations of sound, and particularly of musical perception, are so elaborate as to preclude their exhibitions hence here only the simplest types of apparatus are presented. These include bars for determining the upper limit of audibility, whistles for the same purpose; tuning forks for studying the relations of musical pitch and the sensitiveness to musical intervals; monochord for studying simple phenomena of pitch; resonators for the analysis of overtone; whistles for the study of unison; Galton's apparatus for determining slights differences of pitch, and also a few devices for studying the sensitiveness to slight differences of sound intensity; the power of sound-location and the nature and accuracy of the sense of times intervals.

Movement. This group of apparatus illustrates the function of movement as an index of mental and nervous conditions. There is an ergograph, or apparatus for recording muscular contractions and thus studying the control over muscles, fatigue, co-ordination, etc.; an apparatus for demonstrating the changes in the volume of the arm accompanying volition and mental effort; a sphygmograph for recording the pulse; several devices for recording the involuntary movements of the arm and body; dynamometers for testing the strength of muscular contractions; apparatus for determining the rapidity and regularity of movements; a device for demonstrating tremor; arm holders, and other allied pieces of apparatus.

Recording apparatus. The value of the experimental study of mental phenomena depends so frequently upon the means of recording the results that one case is devoted to types of recording apparatus. The most universal of these is the kymograph or revolving drum; the drum is driven by clockwork at a very uniform rate and is covered with glazed paper upon which a coat of soot has been collected by holding it above a burning lamp. Upon this rotating drum a series of writing points controlled by electricity or air, write their record by tracing delicate white lines as the expose the paper by rubbing off the light coating of black soot. These records are then bathed in shellac and made permanent. In the study of movement, in the recording of time intervals, in the analysis of the relations between physiological and psychological processes, in the study of the proficiency of voluntary control, in the study of interference of sensory and motor processes, and a means of making electric contact, and in a variety of other ways such an apparatus is indispensable. Several such kymographs, both simply and complex, with a variety of attachments for insuring change of rate, convenience in manipulation, adaptation to different forms of experiment, etc., are represented either by the apparatus itself of by photographs. Electrical attachments are represented by time markers, tuning forks, phonautographs, Deprez signals, electric keys, switches, magnets, etc., pneumatic attachments by simple and complex tambours of various types; apparatus for recording the movements of the lips, of the voice, of the throat, of the pulse, of the respiration, of the contraction of muscle, of the fingers and the like.

Time-measuring apparatus. The study of the time consumed by simple mental processes forms one of the main divisions of experimental psychology. The applications of such study and the generalizations to which it leads are of importance and value in many directions. Time-measuring apparatus is also needed in other types of psychological research.

For measuring long intervals a stop-watch and a metronome are shown; the stop-watch measuring to the nearest fifth of a second, the metronome to the nearest one-quarter of a second. More convenient is an automatic metronome which can be started and stopped by the closing of an electric circuit and which registers the number of oscillations. The metronome may be made to register its oscillations upon a rotating drum; two forms of interrupting clocks for this purpose are also exhibited. By means of these clocks a great range of intervals may be accurately recorded. [p. 60]

Tuning forks registering 1/100 or 1/250 second are exhibited. The chronoscope D'Arsonval enables the observer to read off on a dial 1/100 of a second, and has the advantage of being noiseless. A mechanical clock designed by Prof. Muensterberg also registers to 1/100 second; a water chronoscope, the time being measured by the amount of fall of a column of water, registers to 1/200 second or less: while the Hipp chronoscope (two mountings of which are shown) registers to the nearest 1/1000 second. There are also exhibited certain special reaction-time instruments, that record by the vibration of a fork the interval elapsing between the presentation of a stimulus and a response to it; those represented are designed by Beetz, Donders, Exner, Bowditch and Fitz.

Accessories for reactions. To complete the outfit for the study of reaction times there are needed, means for controling[*sic*] the time-measuring apparatus; various forms of stimuli for impressing the various senses and presenting mental problems, and various simple and complex forms of reaction keys. In addition a shutter or other means of determining how much can be recognized within a brief interval of exposure is needed. Types of all these forms of apparatus are represented. For control the falling of a ball, or of a shutter, or the swing of a

pendulum may be used, the theoretical being compared with the actual time. As types of stimuli for sound, a sound-magnet which also yields a premonitory signal, and electric bell are displayed; for touch a mechanical key and an induction-coil (furnishing an electrical stimulus), and also a special key by which a shock may be given to the finger by which the reaction is made; and for sight several forms of exposure apparatus by means of which any one of two or more objects may be shown simultaneously with the starting of the chronoscope. Apparatus for a "chain-reaction," in which the reaction of one subject gives the stimulus for the next, is also shown. In addition a variety of material used as a stimuli and in the study of memory, attention and association, such as sets of words, letters, numbers, pictures, colors, lines, etc., are displayed and described. Of reaction keys there are forms for simple reaction with the finger; for reaction with any one of the five fingers, a reaction-keyboard with fifty keys, a a [*sic*] foot-key, a lip-key, speech-keys of several types, etc.

The platforms. The instruments exhibited upon the platforms are all apparatus for showing the relation between the attention and the moment of receiving a stimulus; a large apparatus for the study of movements of the arm with and without resistance; a color-wheel for foot-power; a general optical testing-board; a large stand for the study of æsthetic proportions; a time-sense apparatus; an apparatus for demonstrating the perception of distance; a square for visual estimates of length and area; a universal chronograph for recording intervals of various durations, and several others.

Photographs, etc. Both within the cases and about the walls are exhibited photographs of apparatus, which serve to supplement the collection.

Footnotes

[*] *Classics Editor's Note: Jastrow spells this word in the French manner ("-re") here, but in the English ("-er") a few paragraphs below.*

[**] *Classics Editor's Note: Although Jastrow spell it "grey" earlier in this sentence and in the sentence before, here he spells it "gray."*

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