SCIENCE.—SUPPLEMENT.

FRIDAY, SEPTEMBER 17, 1886.

PSYCHOPHYSICS.

THIS is a comparatively new science, although its beginnings can be traced back into the last century. But until comparatively recent years it occupied a subordinate position in speculative psychology, and the phenomena constituting its province were not assumed to be distinct enough for separate investigation. At present, however, a certain class of students are endeavoring, by experiment, to give its method and results that exactness which is supposed to describe the function of science proper. The province of science has become more exactly defined in the course of its development until the proper criterion of its function is that measurement and demonstration of its results which takes its theories out of the reach of probabilities and conjecture and establishes them upon a basis of certainty. Introspective psychology has either presented unsatisfactory results, or the universal prepossession for experimental effects has desired to represent it so, and thereby contrast its uncertainty with the tangible and demonstrable products of exact science. However we may account for it, psychophysics has come in to dispute the territory of the older psychology, at least in the person of some of its admirers. It likes to speak of purely introspective psychology as out of date, and as if it were discredited merely because it is of the past. Innovation and change have predisposed inquirers to enthusiasm for the new, perhaps because all the great triumphs of modern science have been conquests over old views, or deviations from them ; the old has lost its prestige. Nothing has suffered more from this spirit than ' the old psychology,' as it is called by the admirers of psychophysics. The latter is taking rapid possession of scientific and philosophic interest, until students of the older philosophy are beginning to relax from their devotion, and to despair of retaining the homage which so many ages have paid to the idol of reflective thought.

Mr. Ribot's recent work on contemporary German psychology seeks to maintain and widen this breach between the two sciences : and we cannot but regret that it should be so ; for they are really distinct sciences, running parallel with each other, and have no more reason to come into conflict with each other than physics and chemistry. Their methods may be different, but are not on that account contradictory ; and the one should not be made all-absorbing to the prejudice of the other.

We frankly admit, however, that it is no wonder the scientist, accustomed as he is to experiment and definite results, feels a sense of dissatisfaction with the study against which psychophysics presents the charge of obscurity. Kantian and post-Kantian psychology has never been characterized by perspicuity ; and it is a natural revolt against it that even speculative Germany seems to have abandoned the popular gods of philosophy to find a new worship in experiments and facts quite in contrast with the genius of that people, disposed in so many particulars to take the high *a priori* road to truth, and to project every thing from consciousness, as it is accused of doing. Hence there is something of justice in the claim of psychophysics : it does tend to make its conclusions intelligible to experience ; and that is a very great gain. But, with these legitimate claims to our respect, it should not usurp the whole province of psychological experience, which it does not do, nor repudiate introspection as a proper source and method of knowledge, which it is too much disposed to do, forgetful of the fact that in so doing it really undermines the final test of its own results.

The field of psychophysics is much more limited than one would at first suspect. Its name might imply at least a partial combination of physiology and psychology : but its advocates exclude the main and distinctive features of both these sciences from it, and assign it a very limited territory ; as Dr. Wundt affirms, the field ' between inner and outer experience.' This means that it confines its investigations to phenomena which intermediate between purely mechanical events and purely reflective consciousness. Hence, on the one hand, such phenomena as circulation, assimilation, digestion, and on the other, such as perception, judgment, reasoning, memory, and imagination, are excluded from the field of its inquiries. Thus it is limited to the phenomena of sensation, which constitute the intermediate class spoken of. But even this class is not considered in its qualitative, but only its quantitative relations, hence it is still more limited. These quantitative characteristics consist of their intensity, psychic constancy, and reaction time. The last may be included under that of psychic constants, making two distinct problems for psychophysical investigation. That of the psychic constants is the more important of the two, as it has a bearing upon the speculative

problems of psychology: it is concerned mostly with the measurements of time and space, or with those primitive experiences which determine the genesis of our empirical conceptions of them.

The quality of sensation is not a subject of experiment, but the characteristic of intensity gives rise to what is known as Weber's law, which designs to express the relation between stimulus and sensation in respect of their quantity. It is found that sensation does not increase in a direct ratio with the increase of stimulus: and hence the law is formulated to express a geometric ratio in the increase of stimulus, and an arithmetic ratio in the increased intensity of sensation; or, inasmuch as the absolute increase of stimulus is not always the same to increase sensation, it has been expressed to indicate that "sensation grows with equal increments when the excitation grows with *relatively* equal increments;" that is, the *ratio* between the quantities of stimulus is always the same, whatever the absolute quantities may be. This law is quite accurate within a certain range, but requires modification as we approach the maximum and the minimum of sensation. The ratio between stimuli is not the same for different forms of sensation, but varies within a large degree, although it still sustains its geometric relation. This fact, as well as something of the scientific accuracy claimed for the science, will be evident in the following table of measurements, giving the ratio between stimuli required for the several senses. The numbers indicate that any given stimulus must be increased by the amount of itself expressed by the fraction in order to produce a perceptible change in sensation. Nothing has been determined for taste and smell.

For touch	1-3
For muscular effort	1-17
For temperature	1-3
For sound	1 3
For light	1-100

Thus any given object or resistance must be increased by one-third of its force in order to produce a perceptible increase of sensation; and so on with the remaining senses. But the question arises, How far do such results give mathematical accuracy and exactness to the science of psychophysics? It is claimed that its accessibility to experiment gives it the proper exactness of a science, and that the old psychology is a mere jumble of verbal disputes. But the admirers of psychophysics forget both their own admissions and the ultimate court of appeal for their conclusions, as well as the nature of the phenomena to be measured.

We have only to consult the above table to discover that only the stimuli are expressed in distinct quantitative relations. It is true that these can be definitely measured, because they are objective quantities like all other commensurable forces. But it is very different with the intensity of sensation, although Weber and Fechner presumed to express its increase in an arithmetic ratio, with the geometric ratio of stimulus. As a matter of fact, the sensation and its increase are not measured in terms of the exciting cause: if they were, something of scientific accuracy would be given the results. But as it is, the only distinct knowledge we have when there is a definite increase of excitation, is, that there is a perceptible change in the intensity of sensation. All mathematical formulae to express one sensation in quantitative relation to another are purely gratuitous: whether one sensation is once, twice, or three times as intense as another, no one can presume to declare with mathematical definiteness, because there is only a subjective criterion for intensity of sensation, and such a criterion affords no commensurating unit for others. This is admitted by psychophysicists themselves in complete unconsciousness of its significance against the claims of mathematical and scientific accuracy for psychology.

"Doubtless," says Mr. Ribot, an enthusiastic defender of the new science, "our states of consciousness are undetermined magnitudes. But is it impossible to determine them, that is, to submit them to measure? The essential condition of measure is, that there be a fixed relation between the measure and that which is measured;" and he elsewhere observes that "there is no unit or common measure to which we can refer two sensations to determine their intensive magnitudes." A still more forcible statement and admission is the following: —

"We assert without hesitation that it is brighter at mid-day than by moonlight; that the firing of a cannon makes more noise than the firing of a pistol. There is, then, a quantitative comparison of sensations; but we can only say there is equality or inequality, never *how many times* one sensation is greater than another. Has the sun a hundred or a thousand times more brilliancy than the moon? Does a cannon make a hundred or a thousand times more noise than a pistol? It is impossible to answer this question. The natural measure of sensation that each man possesses reveals to him the more, the less, the equal, never the *quantum*. Our determinations are always vague and approximate."

Such admissions should certainly modify the pretensions of psychophysics to an accuracy not claimed or possessed by the old psychology, and they do prove fatal to the claim of any such ex-

actness as is enjoyed by the physical sciences. The truth and importance of the law within the range of stimuli will not be denied; but as long as it is a mere assumption for purposes of definite expression that intensities of sensation are mathematical multiples of each other, there will be no reason for supposing one ratio rather than another, and hence the law proves absolutely useless for determining any exactness in psychology. In any case it could reach it only by the introspective method, which psychophysicists are so disposed to disparage, and yet only a little reflection is required to observe that introspection in one of its phases is the only valid testimony to the results already obtained and formulated. The truth is, there is no intelligible reason for setting up an opposition between introspection and experiment in order to place psychophysics in the rank of exact sciences. The question should not be as to its exactness or mathematical expression, but it should be the truth of its facts and conclusions. Conformity with mathematical laws and expression is not the sole criterion of truth or science, and hence by insinuating it the investigator but declares the transient and ephemeral nature of his speculations.

The problems and phenomena of psychic constants are much more interesting and important. They are welcome also as giving much more definiteness and intelligibility to some of the questions of transcendentalism, and, far from contradicting it, they seem to confirm it. The illusions producible in our conceptions of time and space under various circumstances stimulated inquirers to experiment for some constant in our various space determinations, and to measure the duration of psychic phenomena, or the intervals between stimulus and sensation, in order to find some constant for time. The time was when these two data of intelligence were supposed to be fixed and invariable, but further observations show them exposed to all the illusions belonging to perception in general, and hence the question arose both as to their origin and their nature. Transcendental philosophy anticipated experiment in making them ideal, but it was more successful in talking about them than it was in making its views clear and intelligible. Experimental psychology has come in to furnish us with definite data for reconsidering our empirical conceptions of them.

The nervous organization exhibits very different susceptibilities in different parts of the body: in some portions of the sensorium distinct and coexistent sensations are more nearly related in space than at others. In some cases it is also difficult to distinguish direction in the moving cause of sensation. Thus in different stages of maturity and development, space relations vary in definiteness. The sensibility of different parts of the body has been accurately measured and tabulated, so as to show the different ranges of experience in sensation. For the palm of the hand, the finger-tips, the back of the hand, the arms, the shoulder-blade, the back, different parts of the face, the soles of the feet, etc., sensibility varies, both in respect to the threshold of sensation and the determination of separate excitations. In some cases there is only consciousness of affection, and no distinct knowledge of location. And in the case of vision the illusions respecting geometrical dimensions are indefinitely numerous; so that serious doubt may be raised as to the correctness of our ordinary spacial judgments, and some other constant must be demanded for theoretical purposes than is found in practical experience.

Hence the problem has been to find whether vision or muscular effort was the more accurate in the determination of space. But experiment has succeeded only in showing the corrective influence of one sense upon another without discovering any fixed conception to serve as an invariable measure for space. And so with the experience of time. Innumerable experiments show that our conception of duration can be varied with all sorts of circumstances: sometimes it appears indefinitely long, and at others incredibly short, while other facts go to prove that there was no difference in the two instances. Now moments may seem an age, and again there seems no interval of time between the beginning and the end of hours. And again our conception of time is influenced by the period required to realize an event or experience: it may be lengthened or shortened by the state of vitality, or the state of attention and application. The time between stimulus and sensation is different in different individuals, and yet it cannot be determined by subjective measurement; so that some other constant must be assumed to prove variability in any case. Hence there is a resort to heart-beats, or to certain forms of rhythm, as the better representatives of our definite conceptions for time, and perhaps to certain forms of co-existence as criteria for definable space. Thus space and time do not appear as absolute and simple as supposed in the older philosophy, but relative and complex, at least in experience. Other mental phenomena must be considered in our notion of them.

The attainment of such conclusions is due entirely to the experimental method, which has insisted upon actual demonstration of all speculations regarding ultimate conceptions. This scien-

tific spirit has added new interest to a study which was threatened with neglect, because it was too content with mere assertion, and presumed upon the self-evidence of words to communicate its wisdom. Although it may determine nothing as to the quality of sensation and consciousness, it will do much to drive away the mist that has ever hovered over many psychological speculations.

Still experiments have not yet demonstrated the derivative nature of time and space, although they have gone far to make them a matter of intelligible consideration and discussion. They have shown the variability of our empirical conceptions of them, but have not destroyed their validity as postulates of experience, because no special sense-perception may be constant enough to supply a criterion of their fixity. Indefinite conceptions of them at least are always assumed. However we may seek for some regular and uniform experiences within the ken of consciousness to serve as constants for them, or as the phenomena which determine and represent our conceptions of them, we shall find by closer scrutiny that some notion of time and space is already postulated in the very phenomena supposed to give the psychic constants for them ; that is, we shall in vain endeavor to go outside of time and space to discover events which will account for them, or present their genesis from non-spacial and non-temporal relations. But at the same time experiment is providing data to render them clearer and more tangible to ordinary reflection than older speculations. For space the theory of 'local signs,' both tactual and visual, is taking the place of transcendental conceptions; and for time, the theory of discontinuous states of consciousness that may be objectively regular and uniform in their causes.

Among the most important contributions, however, which psychophysics has given to science, are the results showing the differential functions of the nervous system. The sense of temperature has been shown to be as distinct from touch as that is from vision, and even a different nerve is required to perceive cold from that which perceives heat. How far this differentiation of the sensorium may be carried, no one can predict. But even the established conclusions of the present will exert a far-reaching influence upon psychological speculations, and none more than the fact that distinct nervous organisms are required to receive representations once supposed to be connected with the same sense. It is too soon to predict what influence it will have in modifying older views : it will certainly modify them, but there is always a truth, even in the past, that avails to survive the mortality of language ; and, although psychophysics may compel us to reconstruct some theories, it will not wholly do away with the intellectual conquests of history, or oblige us to cast dust in the face of introspective methods, merely to gratify and strengthen an unnecessary prejudice against older opinions.

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ANATOMICAL AND MEDICAL KNOWLEDGE OF ANCIENT EGYPT.

IN a paper read at a recent meeting of the Royal institution of Great Britain, Prof. A. Macalister gave an account of the ancient anatomical and medical knowledge of Egypt, of which the following is a summary from the *Lancet*.

The surviving fragments of the early literature of Egypt are mainly of a religious character ; but this is not to be wondered at, for the genius of the people was essentially religious, and their doctrine of the future state leavened their national life in almost every particular. To them the body was an integral part of the immortal humanity : therefore it could not be permitted to turn to decay, but had to be preserved from corruption that it might be a fit receptacle for the soul to dwell in through eternity. Their treatment of the body was thus dependent on their belief of its relation to the soul, and this, we learn from their religious writings, was a relationship of eternal independence. To secure perpetual preservation, the body had to be properly embalmed, the cavities opened and subjected to the action of antiseptics. Although the body was sacred, under the special protection of the god Thoth, though each part was under the guardianship of a special divinity, yet this sacredness did not preclude careful inspection and the processes necessary for preservation, for all parts had to be perpetuated.

Embalming was a religious rite, to be performed by the priests of the Cultus ; and the historian Herodotus has preserved for us what is doubtless a substantially accurate account of the different methods whereby it was done in the later times in which he lived. The organs removed from the bodies of persons of the better classes were not returned into the body, but were preserved in vases of alabaster or stone, surmounted by the heads of the four divinities of Hades, the sons of Horus and Isis.

During the ascendency of Greek influence in Egypt, Alexandria earned the reputation of being the chief school of anatomy and medicine in the world. Erasistratus, who lived in the days of Ptolemy Soter, B.C. 285, was an anatomist of such enthusiasm, that he and his disciples received from the king criminals condemned to death.

But this Alexandrian school, although upon Egyptian soil, was essentially Greek in spirit : even Herophilus had learned some of his anatomy