THE PSYCHOLOGICAL BULLETIN

GENERAL REVIEWS AND SUMMARIES

PSYCHOPHYSICAL MEASUREMENT METHODS

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Blondel and Rey (1) raise the question as to the dependence of the threshold for light stimuli on the intensity and duration of the stimulus. They come to the conclusion that Bloch's law which makes the threshold depend on the quantity of illumination (the product of optical energy times duration) holds for stimuli of comparatively high intensity only. The following argument is of considerable theoretical interest to psychophysics. Ribière made experiments on the distance inside of which a light of given intensity but variable duration could be seen. It was found that this distance increased constantly with duration of the light stimulus between the limits 0.25 to 1.78 seconds without attaining the distance at which a constant light could be seen. From this it follows that the so-called minimum stimulation is well defined only with reference to a certain duration. The absolute minimum stimulation would be the one produced by a liminal stimulus after an infinite duration.

Wm. Brown (2) undertook to write a short text-book for the use of the student of quantitative psychology, which is a wider field than psychophysical investigation. The first chapter contains a presentation of the methods, which is perhaps a little short but presents the methods of constant stimuli and of just perceptible differences in some detail. The reader will be pleased to find a new idea. Brown proposes to apply Pearson's theory of the curves of distribution to the study of psychometric functions. The difficulties of this promising enterprise are by no means small, but they may be overcome.

P. Desroche (3) made observations on the influence of the distance of a constant source of light on the phototropic reactions of *Chlamydomonas Steinii*. The animals were first attracted to one side of a drop by a light placed at a certain distance, and then the drop was turned by 180° so as to attract the animals to the other side. The speed of this movement was determined. In the study of the influence of the distance of the light on the speed, one has to distinguish two cases. If several hundred of these animals are placed in the drop the distance of the light influences their speed in a way closely resembling the law of Fechner. If a single animal is experimented on, one finds that its speed is uniform and does not depend on the distance of the light. If, however, the distance of the light increases, the animal does not move straight towards the light and it indulges in frequent stops. Desroche believes that the similarity of his results with the law of Fechner is the result of the compound influence of the individual movements of the animals which become more irregular the greater the distance of the light.

R. Dodge (4) raises the question whether introspective facts are the only mental reality, or whether there are other real indicators of mental life. Rejecting the first view he welcomes every fact, no matter whether its source is pathology, neurology, introspection, or the observation of animal behavior, as long as it is capable of throwing some light on human psychology. There are certain facts like fatigue, or mental work, which are not accessible to introspection, but which are nevertheless as valid indications of mental facts as any result of introspection. Experimental evidence that certain mental capacities undergo measurable objective changes is as true a psychological fact as anything discovered by introspection. Introspection is a real and important factor in certain fields of work, but is only one among many.

Chas. Henry (5) attempts to apply mathematical methods to the general problems of biology, an enterprise for which he is doubly qualified as the author of a text-book on mathematics, and the director of a physiological laboratory. His problem is to study sensitivity and muscular irritability as dependent on the intensity and duration of the stimulus. He studies particularly the sensations of light produced by a variable optical energy of constant duration and those produced by constant energy of variable duration. He tries to determine the character of this dependence and finds that it is identical with the so-called photographic function, which gives the amount of silver reduced by a variable intensity of light of constant duration. It is likely that the curve of photographic action also gives

the process of nervous excitation produced by a variable optical energy of constant duration. Only a certain part of this curve, however, corresponds to conscious processes; the rest of it, from a certain point of inflection on, represents the course of nervous excitation not accompanied by mental processes. The entire curve is called the psychophysical curve, and the author believes that its nature very likely remains the same for different kinds of sense perception. From this one would have to conclude that the processes produced by different stimulations resemble each other to a high degree.

Studying the excitation of the muscle the author assumes that it is directly proportional to the duration of the effort. The dependence of these two quantities can be expressed in a myophysical law and can be studied by the self-registering ergograph for the total work. The curves obtained in this way closely resemble the curve of sensations. The author then proceeds to show that the form of the functions for the irritability of the senses and the muscles do not differ much from those for the change in the weight of cells placed in a medium where the products of dissimulation accumulate, provided that assimilation diminishes in the course of time. These considerations show the possibility of connecting the psychophysical and myophysical laws with those of physical chemistry and of finding the principles of a general mathematical theory of irritability.

The second part of the book is very curious. The author assumes a certain general principle from which he deduces the laws for the variations in the apparent size of straight lines and the wave-lengths of complementary colors. Short mention is made of my demonstration that the arithmetic mean of a group of observations is the most probable value if these observations are made systematically.

E. Jacobson (6) studied the interference of qualitatively different stimuli. The technique of this kind of experiments is not very well developed and its methodology is still untouched by modern refinements. The author did not feel called upon to comply with the requirements of psychophysical experimentation, and the outcome is that there is hardly one result in his paper that would stand a thorough test.

P. Lasareff (7) studies the influence of the size of the visual field on the threshold of sensations. He represents his results by the formula of Helmholtz who modified the psychophysical formula of Fechner by taking into consideration the illumination of the retina.

W. Reimer (8) studied the history of the notion of intensity with special reference to the applications which this notion has found in

psychology. This historical sketch, however, does not include the most recent researches in this field.

F. H. Safford (9) took up the rather technical question as to the number of decimal places to be retained in the numbers of relative frequency and in the coefficients of the equation of the psychometric functions set up by Lagrange's formula. He concludes that the relative frequencies in my monograph on statistical methods should be cut to three instead of four decimal places, and that the number of figures retained by me in Lagrange's formula is entirely too large. He also criticizes my expression of treating the data without a definite hypothesis about the psychometric functions.

Sanford's variation of the method of just perceptible differences is dealt with in (10). There exists some diversity of opinion as to the real value and significance of this variation. It is shown that it does not change the final outcome of this method and that it has the character of a precaution in so far as it enables us to discover gross mistakes.

My paper (11) is a reply to (9). It is pointed out that Lagrange's formula is merely an artificial construction for the representation of the data of observations, and the coefficients in the equation set up by this formula have no immediate physical significance. If a smaller number of figures is retained in the calculation of the coefficients, the equation does not represent the empirical data at all and becomes useless. The phrase "treating the data without a definite hypothesis on the psychometric functions" merely implies that the hypothesis used for the purpose of computation is so indifferent that one could not possibly mistake it for a final solution of the problem.

A further paper (12) is of indirect importance for the problems of psychophysics. A new definition of the notions of chance and probability is given which is based on the modern theory of classes. It is shown that the notion of logical chance, that is, the relation between the general and the particular, is the only one used for defining the notion of mathematical probability. The calculus of probabilities does not make use of events which are not causally necessitated. This is shown by several examples of events which are the objects of the calculus of probabilities in spite of the fact that there does not exist any doubt as to the causes which necessitate them. The demonstration is carried as far as the deduction of the two fundamental propositions of the calculus of probabilities (the theorem of addition and the theorem of multiplication), because all the

remaining propositions can be deduced from these two by purely logical processes. Psychophysics makes very wide use of the notion of probability in so far as the method of just perceptible differences as well as the method of constant stimuli are built up on this notion. The passing of a judgment under well-defined conditions is regarded as a chance event, and the question naturally arises whether we should favor the idea of these events not being fully determined by their antecedent causes, or whether we should form an idea about them which is more in agreement with the principles of physical science. The paper shows that the use of the calculus of probabilities does not deny the causal connections between events and it is, therefore, advisable to favor the view that the passing of a judgment is an event causally fully determined in spite of the fact that we are at present unable to follow up these connections.

C. A. Willis and the present writer (13) worked out some experimental data on lifted weights. The results show the influence of variations of the standard stimulus on the constants of the psychometric functions. The standard stimuli of 100, 125, 150, 175, 200, 225 grammes were compared with appropriate comparison weights, and the results worked out by the method of constant stimuli. It was found that the constant h decreased constantly with increasing intensity of the comparison stimulus, while c remains more or less constant. These results are in agreement with those obtained in working out the data of acoumetric experiments. No well-pronounced regularity corresponding to the so-called law of Weber was found.

W. Wirth's *Psychophysik* (14) is doubtlessly the most significant publication of the year. The book is divided into two parts, the first of which contains the mathematical methods, and the second the experimental arrangements used in psychophysical investigations. It is not possible to give a full statement of the contents of this book, and we shall call attention to two significant facts only. The first is that Wirth defines psychophysics so as to let it comprise all the methods of experimental psychology. In this sense one may say that the book contains a new program for psychophysical investigation, and it cannot be doubted that the majority of workers in this field will welcome this new definition of psychophysics. The next observation refers to Wirth's treatment of the so-called psychophysical methods. He recognizes one genuine psychophysical method only, namely, the one based on the notion of the psychometric functions, the theory of which he himself has cultivated with great success. The old methods of psychophysical measurement are mentioned on

account of their historical interest and because they frequently enable one to find a rough and ready result, the exact determination of which would require a considerable amount of work. We lastly mention as significant the fact that the book appeared as part of a text-book on the methods of physiology, thereby procuring to psychophysics the standing of a recognized auxiliary science of physiology.¹

Wirth's paper (15) contains a criticism of the present writer's treatment of the method of just perceptible differences and of G. F. Lipp's use of the equality judgments. He emphasizes the hypothetical nature of the threshold, and insists that it cannot be defined in terms of the result of the method of just perceptible differences. He furthermore tries to show that the result of the method of just perceptible differences does not coincide with that of the method of constant stimuli unless one introduces some special hypothesis in regard to the nature of the psychometric functions. The appendix of the paper contains an interesting discussion of one of the series of my experiments on lifted weights. He calculates the arithmetical means of the limits and of their standard deviations in groups of 50 experiments, and tries to show that a definite effect of practice can be found in these results. It would not seem very surprising that such an influence of practice should have taken place, but it is doubtful whether Wirth's numbers definitely establish the existence of this factor.

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¹ See special review on p. 245, below.

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TESTS

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The field of tests has broadened out so that it now includes several types of investigation which do not in all cases closely resemble one another. The first group of investigations which may be regarded as being included in this topic deal with the development of methods of testing single mental processes. The purpose of these investigations is to determine the best method of procedure to be followed. There have thus far been published under the direction of the Committee on Tests of the American Psychological Association reports by Angell (2) upon Mental Imagery; by Pillsbury (29) on Tests of the Intensity of Sound; by Seashore (31) on Pitch Discrimination; by Woodworth and Wells (42) on Association; and by Yerkes and Watson (43) on Vision in Animals.

Angell describes the methods which have been used to test imagery, classifying them into objective and subjective methods. The objective methods in general, which exclude introspection, are held to be unreliable as methods of determining the type of mental imagery. The author chooses the tests which he has found to be most reliable and forms two series, adding suggestions regarding the grading of the results. Pillsbury criticises in detail the methods for testing intensity of sound, and selects the telephone as the one to be most highly recommended from the point of view of accuracy, but recommends the tuning fork from the point of view of convenience. Seashore not only recommends the most reliable apparatus for testing pitch discrimination, but also goes into some detail in giving directions for the conduct of the tests and interpretation of the results, and discusses their practical application. Woodworth and