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HERMANN VON HELMHOLTZ AND THE NEW PSYCHOLOGY.

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Since the death of Darwin, the loss of no one in the scientific world has made such a deep impression as that of Helmholtz. And this is in keeping with that esteem and admiration which in an ever-increasing measure is accorded to his name in the Old and the New World as well, throughout all scientific circles, and in that more practical sphere of life which in the last decade especially has become so largely dependent upon the services of science. From the early beginning of his career, from the time of the anatomical and chemical studies of his youth, all his researches were directed towards high ends, and were crowned with great success. Whenever he smote the rock of nature, there gushed forth the living waters of knowledge. There have always been and are well-rounded, disciplined minds, authors, philosophers, and others, who are able to speak with easy assurance concerning everything in this world, and of much else besides. But they are not for the most part minds which are themselves productive; they are, on the contrary, mere imitators and makers of books. There have always been, and are, moreover, also men of marked scientific note who have proved productive in various widely divergent fields of knowledge; as, for instance, Thomas Young, who in Optics, no less than in the science of Hieroglyphics, rendered considerable service to his time; or, in a similar way, H. Grassmann. But a truly scientific spirit of extraordinary versa-

tility, and yet at the same time evincing complete unity of organization, with all its ideas harmoniously connected one with another, such the world has indeed produced, but only once in the century.

It would hardly be possible for any one man to-day to succeed in understanding all of Helmholtz' investigations equally well. But each will find a peculiar satisfaction in recalling the special impulse which he has experienced in his own department through the inspiration of Helmholtz. And the representatives of Physiological Psychology should feel themselves impelled to such a retrospect, since it is to that science that Helmholtz dedicated himself at the zenith of his power. The two works which have largely rendered his name illustrious, and from which there has proceeded an incalculable stimulus to other men, belong to our especial province. Without in the least depreciating the thoroughly original and fundamental contributions of E. H. Weber, Fechner, and Lotze, nevertheless it must be acknowledged that these two works, both on account of the scientific consequences which have followed them, and of the general and wide-spread knowledge of their contents throughout the scientific world, have more than all others served to bridge the gulf between Physiology and Psychology — a bridge across which thousands of other men now constantly come and go.

Like Dubois-Reymond, Brücke, Ludwig, Henle, Virchow, Helmholtz also came from the school of Johannes Müller. The latter who, as early as 1822, when still a youth of twenty-one, had defended the thesis '*Nemo psychologus nisi physiologus*,' had early broken loose from the chains of the Nature-philosophy of the school of Schelling, although without repudiating altogether the spirit of philosophy. He allied himself with Kant, Spinoza, Herbart. A certain taste for philosophy, at least a friendly disposition towards philosophy, was transmitted to his pupils. But in addition to such an affinity we must also note the mode of exact observation of physical phenomena and the experimental method, which were likewise introduced through Müller into German physiology. As a consequence of this method of re-

search, the scholars rejected the theory of 'Vital Force,' to which the master still adhered; and in this highly important reform of the fundamental conceptions of organic life, fraught with such weighty consequences, lay the principal difference between the new and the old epochs. Helmholtz' first work of the pioneer order, upon the 'Conservation of Energy,' represents this new spirit of inquiry. In the incomparably interesting and stimulating discourse delivered at the celebration of his seventieth birthday, he himself drew attention to the fact that his sole object in this early work had been the critical examination and classification of phenomena in the interests of physiology. On the other hand, the pupils of Müller maintained what was to them the fundamental law in the theory of sense-perception,—the doctrine of the specific energies of the nerves,—although their formulation of it did not include the Kantian elements which were attached to the law as expounded by J. Müller. Helmholtz not only accepted the doctrine in general, but, as is well known, applied it in detail in the spheres of Optics and Acoustics, and maintained the diversity of the specific energies corresponding to differences of quality within one and the same sense. A third generation is now empanelled upon this very hook. Whatever we may wish to substitute for the doctrine, we still find ourselves, in my opinion, involved in great uncertainties and obscurities. But that is beside the point here.

Intimately associated with the above-mentioned theory, as far as the facts go, although not necessarily connected with it, there arose with Müller, and also in his school, the clear and emphatic consciousness of the incompatibility of perception, and of psychological events in general, with the processes of the outer world. Müller had expressed himself, it is true, only in a guarded manner concerning the nature of the soul and its relation to the body; moreover, his ideas upon this subject can be made to agree with those of his followers as little as their's in turn with each other. But in two respects at least they were wholly at one: that psychical activities occur only in strict correlation with the physical, and yet that they are throughout

peculiar both in their nature, and in the minor laws of connection to which they are subject. Such formulas as the following were wholly foreign to their thinking: that consciousness is mere appearance, or really nothing (as the modern followers of so-called 'Parallelism' often express themselves in curious inconsistency. Indeed, the doctrine of the complete reality and unique peculiarity of the psychical phenomena may be regarded as a characteristic feature of that epoch.

While J. Müller, after the appearance of his *Handbuch der Physiologie*, turned his attention more to the development of Comparative Anatomy, Helmholtz' investigations, in accordance with his natural gifts, took quite another direction. He was naturally qualified to be a mathematical physicist of the first rank. While his class was reading Cicero in the Gymnasium, he had been computing the path of light beams through the telescope, and establishing certain propositions which were later used by him in his invention of the Ophthalmoscope. He then became a physician for wholly practical reasons, although by no means contrary to his own tastes; yet after the completion of his great works on psychophysics he again turned his attention to mathematical physics. His most essential reforms in the theories of hearing and sight are due to his command of mathematical principles, in connection, to be sure, with an unusual inclination and aptitude for psychological analysis and with an extraordinary inventive talent for the construction of apparatus. In the latter respect, he himself makes the interesting observation, that his youthful predisposition for geometrical methods of treatment was developed in the course of his many experiments into a kind of mechanical intuition; he could feel, as it were, how the angles and lines distribute themselves in a mechanical contrivance, a peculiarity which is also often found in experienced mechanics and machinists.

The '*Physiological Optics*' appeared in parts during the decade, 1856-66. The studies for this undertaking naturally extended to a much earlier date. The invention of the Ophthalmoscope in 1851 was already an incidental fruit of his exhaustive studies in dioptrics. Then followed the sev-

eral publications, upon the Theory of Color, upon Accommodation, upon the Telestereoscope. The great activity in optical investigations, especially in the fifties and sixties (consider, for instance, such names as Brücke, Dove, Listing, Volkmann, Chevreul, Plateau, Fechner, Brewster, Wheatstone, Maxwell), makes the high standard which Helmholtz' work attained more easily comprehended, and increases our astonishment at the intellectual force which was able to gather under new and quickening points of view this wealth of manifoldly divergent results, both native and foreign, and work them into a consistent whole. We must not overlook the fact also that Helmholtz took scarcely any results from others without independent verification. Then the subject of Dioptrics, which had been to a certain extent already written out, received thorough revision, both theoretical and experimental, at his hands. The methods were perfected in both their applications (Ophthalmometer, Micro-optometer), all the constants in the investigation of the eye more accurately determined, and the mechanism of accommodation cleared up in its essential features.

In the subsequent portions of the work in which Helmholtz establishes the peculiar distinction between sensation (as of color) and perception (as of space), the following form the principal features: the revival and detailed elaboration of Young's Theory of Color—the first comprehensive discussion of the complex relations of color sensations—and the development of the empirical theory of space. The two theories have passed into nearly all the text-books of Physiology, and have had numberless popularizations; the very best, indeed, of these being by Helmholtz himself, whose *Popular-wissenschaftliche Vorträge* call out our ever-increasing admiration. Throughout the extensive range of the popular science literature of Germany, there are very few counterparts to these lectures. They are unpretentious and yet, while in good taste, sufficiently ornate; they preserve as admirably the golden mean between excessive diffuseness, on the one hand, and too rigid concentration on the other; they are equally free from anecdotes and rhetorical extravagances, and especially free from the common method of first

caricaturing old or opposed views in order to set them aside with superior wisdom as childish and absurd.

Since then, as is well known, the theory of color has been zealously attacked from many quarters, and other theories, especially that of Hering, have been opposed to it. The decision in this controversy is still in abeyance. It would not be becoming for me to enter the lists for either side in this connection. To psychologists, however, the question should present itself more strongly than heretofore, whether the so-called composite colors, in distinction from the primary colors, really result from a number of simultaneous sensations, after the analogy of a chord of tones, or whether, on the other hand, these combined color appearances which originate in one and the same place on the retina, constitute an absolutely simple sensation. If I understand them aright, both Helmholtz and Hering uphold the former view, while the majority of psychologists support the latter, and there has been no adequate discussion of the matter. For each investigator seems to consider his own view self-evident.

An especially attractive part of Helmholtz' theory of color, from a psychological point of view, is his explanation of simultaneous contrast. He here introduces a principle which he also turned to good account on other occasions: that, by virtue of our past experiences, we often come to judge and designate objects of sense as quite different from what they really appear to us at the moment to be.

Notwithstanding the masterly elucidation of this principle, the conviction has now become quite general, principally through the exhaustive researches of Hering, that Helmholtz, through a combination of circumstances, was led to resort to an artificial explanation instead of postulating a simple reciprocal action of contiguous nerve-elements upon one another. This leads us to see that it is the sensation itself which is altered, not the judgment alone. Nevertheless, this principle of explanation is so far forth of value, and it remains an important fact that deceptions respecting the nature of sensation which can be very well distinguished from real illusions, are often brought about through experience.

It was also in this book that Helmholtz first made use of 'unconscious inference' in his explanations, although the idea and the theory itself were first definitely stated in connection with his theory of space. The process through which such false judgments, as that of color-contrast, are produced, seemed to him to be analogous to the process of true inference. The misuse which many naturalists and philosophers, who had felt the influence of Schopenhauer, made of this theory, to bolster up various shallow views, gave Helmholtz an occasion later to revise his view and to substitute for unconscious inference a process of association, which certainly is truer to the psychological facts. Moreover, we must take into consideration the fact that Helmholtz, in the *Physiologische Optik*, expressed himself guardedly and with some reservation concerning unconscious inference. He says: "Although, indeed, the similarity of these psychical phenomena with those of conscious inference has been disputed, and perhaps will continue to be disputed, still the similarity of the results is not at all in doubt."

In the theory of space perception Helmholtz departs wholly, as is well known, from Joh. Müller, and erects an imposing structure on quite a different plan. Müller had made the perception of the third dimension a matter of empirical judgment, but he had not determined the necessary moments of the process precisely. It was probably the investigations of Wheatstone in single vision with non-identical points and the observations of single vision in certain squint-eyed persons, together with Lotze's ingenious disquisition upon the space-problem, which gave rise to the first tendency in this direction. Helmholtz opposes the empirical to the nativist theory. Even those who are of the opinion that no one can be wholly just to the established psychological facts without certain concessions to the theory of nativism will, nevertheless, still most readily acknowledge the credit which Helmholtz has won for himself in his treatment of this cardinal question. The antithesis between nativism and empiricism has still more extended bearings; it appears in nearly every psychological question; it characterizes entire schools which have been opposed to one

another, especially in English psychology, for a long time. The exhaustive investigation of the materials for the theory of space from an empirical standpoint has greatly lightened the critical examination of the same for all subsequent thinkers. Always in the habit of searching for certain and clear criteria, Helmholtz sought some characteristic mark to distinguish between that which is a real sensation and that which arises from some supplementary experience. That is, he recognizes as sensation only that part of our intuition which can not be accounted for through assignable experience processes, which might have produced a contrary result.

Another principle of great value, also, to acoustics, concerns the discrimination of simultaneous sensations. We have been accustomed to regard a total of sensations constantly presented together as a common sign for a single object, and the discrimination of these sensations is thereby rendered more difficult. This principle he applied especially to the explanation of experiences of single-vision. The *Physiologische Optik*, as is well known, contains also his philosophical theory of the relation of our consciousness to the outer world, to which Helmholtz in his *Thatsachen der Wahrnehmung* latterly returned, the theory that the *a priori* self-evident law of causation necessitates the acceptance by us of an outer world; that, however, our knowledge of this outer world must remain essentially a symbolical one, and that our sensations are merely signs of what is real. On the occasion of his 'Jubilee,' Helmholtz spoke in quite an elegiac strain of the reception which these views had received at the hands of philosophers. Without inquiring to what extent the blame may be due to certain weaknesses of his representation, or to what extent, also, to the high plane of discussion and the subtilty of his general concepts, or on the other hand to the dearth of clear thinking on the part of some at least of the philosophers who have not passed through the exacting discipline of physics, we are, however, certain that all his philosophical colleagues felt extremely thankful to him for his gifts in this direction also. In my own personal opinion, at least, the theory of the

symbolical knowledge of the outer world really hits upon the right conception. But be that as it may, at any rate the introduction of such considerations into his work, and the accompanying evidence of the deepest interest in philosophical problems, has been largely instrumental in keeping alive and stimulating such interest among students of nature in all lands.

The number of new investigations which were published after the appearance of the *Physiologische Optik*, and called forth by that work, made a new edition of the book desirable long ago. The author had, however, in the meantime turned to other spheres of investigation, as that of electro-dynamics, and it was not astonishing that he decided only lately upon it, when it was no longer possible for him to give due attention to the large amount of material at hand. The successive parts of this work followed each other at ever lengthening intervals of time. The serious misfortune which befel the aged investigator last autumn upon his homeward journey from America urged him moreover to a careful husbanding of his strength, and so made it possible that he should allow the last portion of the work, which includes the discussion of contrast-phenomena, to appear with no reference to Hering's labors in this sphere. This will always be most deeply regretted. The half of the work which still remains unpublished will have to be simply reprinted, only perhaps with a revision of the bibliographical references.

The second psycho-physical work, *Lehre von den Tonempfindungen*, was published in 1863, during one of the intervals in the publication of the several parts of his first work. Studies extending through many years had preceded also in this field, some of which were already published, *Ueber Klangfarbe der Vocale*, *Ueber Combinationstone*, etc., also the popular lecture upon '*Physiological Causes of Musical Harmony*,' 1857, in which the outlines of the whole work were sketched. One can hardly picture the immense intellectual labor which the carrying out of two such literary projects simultaneously must have involved. However, the problems in the theory of sensation were reciprocally illumi-

nated, and it was precisely the similarity of the phenomena in the two spheres which led Helmholtz to the common view-point already mentioned above. It was during the attractive period of the days of Bonn and Heidelberg that, as he himself afterwards related, while leisurely tramping over the wooded hills, these ideas flowed in upon his mind.

Indeed this second work seems, externally in the form of its presentation, to betray the influence of such a happy mood and friendly environment. It not only treats of the fundamental principles of art, but is itself truly a work of art, and that, too, without any flowers of rhetoric. It is confined to the simple unfolding of the absolutely essential features of the subject. His mightiest weapon, the mathematical calculations and the deductions from previously published computations, was relegated to the Appendix. In the text itself only the manifest principles of the theory are presented to the reader; he is led step by step from the simplest truths of physical acoustics to their physiological conditions, until finally, deep in the center of the system, he is brought to the consideration of the musical scales and harmony, and over the threshold into the æsthetics of music. Here the author deliberately stops.

In Acoustics, too, the achievements of Helmholtz were not creations out of nothing. The illustrious labors of others preceded them—especially Fourier's demonstration of the possibility of resolving any periodic vibration into a number of simple harmonic vibrations; Ohm's definition of simple tones by means of harmonic vibrations, and his correspondence with Seebeck (in which Ohm approached very near to the correct explanation of timbre); Seebeck's theory of sympathetic vibrations; Wilhelm Weber's investigations concerning reed-pipes; Joh. Müller's experimental studies upon vibrating membranes and the human voice; Chladni's caretaking observations, and finally on the side of the theory of music, Rameau's application of the overtone to the theory of harmony. That the application of the theory of beats in the preceding century for a similar purpose had already been attempted, was probably not known

to Helmholtz. But he was familiar with the the hypothesis of an isolation of tones in the cochlea held by many physiologists of the preceding decade, and Harless in Wagner's Dictionary had in fact treated the organ of Corti accordingly. There is, however, a vast difference between the expression of a thought in general terms and the presenting of it in its concrete setting or in its connection with a mass of facts, and it is a long way from eminent labors along single lines and from a one-sided standpoint, to the comprehensive, all around investigation of this entire field, which inspected all sides of the problem impartially, and went even into the depths of the history of music. The work has passed through four editions. Owing to the comparatively small number of subsequent works, as well as to the almost universal acquiescence in his opinions, it was possible to satisfy the demand for new editions without too great difficulty. The most essential changes concerned the significance of the organ of Corti (from the first to the second edition) and the theory of the psychological conditions of tone-analysis (from the third to the fourth edition). It seems almost a pity to have to acknowledge that even this magnificently constructed work will not in all its main features defy the ravages of time. This is, however, my firm conviction. The explanation of timbre, that old riddle, will, however, remain a permanent acquisition. But whether it was correct to deduce timbre and consonance from one and the same principle, that of the overtones, and to define dissonance by means of beats, that is the chief question.

What human achievement, however, can defy time and know no change? Considerations of a critical nature will not disturb the satisfaction with which we feel that our century has beheld an immense advance of science, and that we ourselves were contemporaries of the man who accomplished it. Only in the last few months has it been the privilege of the writer of these lines to know him. Whoever has been thus fortunate will always hold in lively remembrance the massive head, the large, thoughtful eyes, the repose of manner, the modest and unpretentious bearing.

But we shall always retain as his most valuable legacy the inseparable union of scientific and philosophical research, and the profound conception of the mental life, grounded throughout upon actual facts, and for that very reason the loftier and more truly ideal.*

* Translated from the author's manuscript by Professor John Grier Hibben, Princeton College.