THE CONCEPT.[1]

BY PROF. ERNST MACH.

THE first *movements* of new-born animals are responses to outward or inward excitations, which excitations are effected *mechanically* without the intervention of the intellect (the memory), and have their foundation in the inherited organism. They are *reflex* movements. Under this head belong the pecking of young chicks, the opening of the bills of young birds on the return of their parents with food, the swallowing of the food placed in their gullets, the suckling of young mammals, etc. It may be shown that the interference of the intellect not only does not enhance these movements, but frequently has a tendency to disturb them even.[2]

It will happen that a great variety of pleasurable and unpleasurable sensations will be produced during this process, and these sensations, which are peculiarly adapted to disengaging reflex movements, will become associated with others, which in themselves may be indifferent, and will be ultimately stored up in the memory, which has likewise gradually and simultaneously developed. Some small portion of the original excitation may then evoke the memory of the entire excitation, and this memory in turn may evoke the entire movement. The young sparrow described by me in another place affords a good instance of this,[3] and young mammals prompted by the sight of their mother to seek nourishment, furnish a second example. The movements which thus take place are the *final term* of a *series of associations;* they are no longer reflex move-

[1] Translated from Mach's *Wärmelehre* by T. J. McCormack.

[2] It is well known that after children have once been weaned they can be brought to take the breast again only with great difficulty. But it may be necessary in cases of illness to make them do so, and having noticed in one instance of this kind that the movements of sucking were actually performed during sleep, I took advantage of the situation and caused the child, while asleep and unconscious, to be laid to its mother's breast, with the result that the desired movements occurred and the difficulty was overcome.

[3] Compare my *Analysis of the Sensations*, Chicago, The Open Court Publishing Co., 1897.

ments, they are now called *spontaneous* movements. The question whether the innervation as such makes its appearance in consciousness not only by its results, but also immediately, we shall forego, since it is a debated one and since the answer to it is not absolutely necessary to our purpose.[1]

As soon as a movement B which has ordinarily followed as a *reflex* upon an excitation R is induced *spontaneously* by some excitation S, which is associated with R, the most varied complications may arise, as a result of which entirely new excitational combinations, and in consequence entirely new motor combinations, may be produced. A young animal which has reached maturity is observed to seize an object which *appears* fit for food, sniff at it, nibble at it, and finally to bolt it or cast it away. Young anthropoid apes, so Mr. R. Franceschini informs me, are in the habit of biting forthwith into everything offered them, whereas old apes will toss aside objects for which they have no use after cursory inspection only. Infants too are wont to thrust into their mouths every object they can lay hold of. A friend of mine once observed a child grasp repeatedly at a burnt spot on a table, and immediately convey the supposed object with comical earnestness to its mouth.

Under *different* circumstances having something *in common*, accordingly, the *same* activities, the same movements, are produced, (grasping, sniffing, licking, and biting). These are productive of new sensory attributes, (odors, tastes, etc.), which become in their turn *determinative* and shape the subsequent behaviour of the animal (as swallowing, laying aside, etc.) Now it is these *accordant* activities, together with the *sensory attributes* evoked by them, both of which are in some manner elevated into consciousness, that constitute, as I take it, the *physiological* foundations of the *concept*. Wherever *like* reactions are induced, there the same concept is evoked; as many reactions as there are, so many concepts will there be. No one will feel disposed to deny to an animal that has acted in the manner described, the possession of something like the germs of the concepts "food," "non-food," etc., even though the words designating these concepts be wanting. But even designation by speech, in the form of calls and cries, may under certain circumstances accompany the acts we are considering, notwithstanding the fact that the calls are provoked involuntarily and never clearly appear in consciousness as deliberate signals. The concepts which originate in this manner will be exceedingly comprehensive and vague in character; but they are none the less the

[1] Compare W. James's *Psychology*, New York, 1890, Vol. II.

most important for the animal. The situation of the primitive man is not essentially different. The consequences of the activities employed by him in his explorations and in the attaining of his ends may be considerably complicated. Take, for instance, his stopping and listening on hearing the slightest noise; his pursuit and capture of his prey; his picking, cracking, and opening of nuts, etc. The behaviour of civilised man is distinguished from that of the animal and primitive man merely by the fact that he possesses more varied and more powerful facilities for investigation and for the attainment of his ends; that he is able owing to his richer memory to make use of more circuitous methods and of a greater number of intermediary agencies (instruments); that his senses are capable of making more refined and more comprehensive observations; and, finally, that he is enabled by the richer store of language at his command to define with greater minuteness and with greater precision the elements of his activity and sensory perception, to represent these same elements clearly in his memory, and to bring them within range of the observation of others. The behaviour of the natural inquirer offers merely a further difference of degree as compared with the preceding case.

A chemist *is able* to recognise a piece of sodium at sight, but does so on the presupposition that a definite number of tests which he has clearly in mind will unfailingly give the results which he expects. He can apply the concept "sodium" to the body in question *with certainty* only provided he actually finds the same to be soft as wax and easily cut, to have a silver sheen on the cut surface, to tarnish readily, to have the capacity to float and to rapidly decompose water, to have the specific gravity 0.972, to burn with a yellow flame when ignited, to have the atomic weight 23, and so on. The concept "sodium," accordingly, is merely the aggregate of a certain series of *sensory attributes* which make their appearance upon the performance of certain *definite* manual, instrumental, and technical operations, considerably complicated in character. The concept *whale* stands for an animal which has outwardly the form of a fish, but which on careful anatomical examination is found to have a double circulation, to breathe by means of lungs, and to possess all the other classificatory marks of the mammals. For the physicist the concept "electro-magnetic unit" ($cm^{\frac{1}{2}}g^{\frac{1}{2}}sec^{-1}$) stands for that galvanic current which acting with a magnetic horizontal component of $H=0.2$ ($gr^{\frac{1}{2}}cm^{-\frac{1}{2}}sec^{-1}$) on a magnetic needle suspended in the center of a circular wire of radius 31.41 cm. through which the current has been made to pass, turns that needle 45

degrees out of the meridian. This presupposes an additional set of operations for determining *H*.

The behaviour of the mathematician is similar. A circle is thought of as a line in a plane, every point of which line can be shown by measurement or otherwise to be equidistant from a certain point in the plane. The sum of $7+5$ is that number, 12, which is reached by counting onward 5 numbers from 7 in the natural scale. In these cases also we are required to perform certain well-defined *operations* (the measurement of lengths, counting), as the result of which certain sensory attributes (namely, the equality of the lengths in the one case, and the number 12 in the other) make their appearance. The well-defined activities in question, whether simple or complicated, are analogous in every respect to the operations by which an animal tests his food; and the sensory attributes referred to are analogous to the odor or taste which is determinative of the further behaviour of the animal.

Many years ago, I made the observation that two objects appear *alike* only in case the sensation-complexes corresponding to the two objects contain common, congruent, and *identical* components. This observation has been abundantly illustrated elsewhere in my works, and I have given of it numerous examples (symmetric and similar figures, melodies of the same rhythm, etc.[1]) Attention was also drawn to the æsthetic value of the repetition of the same *motif*.[2] The idea was then naturally suggested that there lay at the basis of every *abstraction* certain *common real* psychical elements, representative of the components of the concept,[3] be those elements ever so recondite. And it was found that the elements in question were commonly brought to consciousness by some special and definite activity,—a fact which has been sufficiently discussed in connexion with the examples given above.

The concept is enigmatic for the reason that on the one hand it appears in a logical aspect as the most definite of psychical constructs; while on the other hand, in a psychological aspect, when we seek for its real visualisable contents, we discover a very hazy

1 See my *Contributions to the Analysis of the Sensations*, Eng. trans. Chicago, 1897.

2 See the articles on the *Forms of Liquid* and on *Symmetry* originally published at Prague in 1872, and now embodied in the English translation of my *Popular Scientific Lectures*, third edition. Chicago, 1898. Compare also Soret, *Sur la perception du beau*, Geneva, 1892, which carries the æsthetic considerations much farther than my work, but does not go so deeply into the fundamental psychological and physiological conditions as does my *Analysis of the Sensations*.

3 Compare Mach, in *Fichte's Zeitschrift für Philosophie*, 1865. Page 5.

picture only.[1] Now the latter, whatever its composition, must necessarily be an individual picture. The concept, however, is not a *finished image*,[2] but a body of directions for testing some actually existing image with respect to certain properties, or of constructing some image from given properties. The definition of the concept, or the name of the concept, disengages a definite activity, a definite reaction which has a definite result. The manner of the reaction,[3] as well as of the result, must find its expression in consciousness, and both are characteristic of the concept. A body is electric when it exhibits certain properties in response to certain reactions. Copper is a body of which the bluish-green solution in dilute sulphuric acid exhibits a certain behaviour when subjected to a certain treatment, etc.

Inasmuch, therefore, as the group of operations which is involved in the employment of a concept is frequently complicated in character, it is not at all remarkable that the result of the same should be set forth before us as a visual picture only in the simplest cases. It is furthermore clear that the group of operations in question, like the movements of our body, must be thoroughly practised if we are really to possess the concept. A concept cannot be passively assimilated; it can be acquired only by doing, only by concrete experience in the domain to which it belongs. One does not become a piano player, a mathematician, or a chemist, by looking on; one becomes such, only after constant practise of the

[1] So long as this hazy picture is regarded as the main thing, no understanding of the concept can ever be reached. Mr. E. C. Hegeler has ingeniously compared the picture in question to Galton's composite photographs, which are obtained by superposing upon one another the pictures of the members of a family, whereby the differences are obliterated and the common features of the family brought into more prominent relief (See Dr. Paul Carus's *Fundamental Problems*, Chicago, 1889, page 38). I have compared this phenomenon of the concept to the ancient Egyptian paintings which combine in a single picture things which can be seen only by different views of it (*Economical Nature of Physical Research*, Vienna, 1882, English translation in *Popular Scientific Lectures*, Chicago, 1898, page 186). In my *Analysis of the Sensations*, I have given what I believe to be a more satisfactory explanation of the question.

[2] Compare *Analysis of the Sensations*.

[3] Despite all that has been said to the contrary, I find it difficult to comprehend that the inner vation of a movement does not come directly to consciousness in some manner. The conse quences only of the motion are said to be brought to consciousness by its sensations in the skin and the mere memory of these sensations is said to be sufficient to produce the movement again. It is quite true that we do not know how we perform a movement, but only what the movement is and that we wish to perform it. When I *will* to go *forward*, this psychical act is to my feeling in no wise opposed to the memories of the sensations which take place in my legs, but appears to me far simpler. It was once attempted to identify all sensations of movement with sensations of the skin, etc., but it is to-day more probable that these sensations proceed in a far simpler and consequently more reliable manner from definite, specific organs. If my conception is correct, then that sharp, delicate, and trustworthy feeling for the reactions belonging to certain concepts is much more easily intelligible. It appears to me as if one could speak in more than a merely figurative way of the innervation of imagination.

operations involved. When practice has been acquired, however, the word which characterises the concept has an entirely different sound for us from formerly. The impulses to activity which are latent in it, even when they do not come to expression, or do not appear in consciousness, still play the part of secret advisers which induce the right associations and assure the correct use of the word.[1]

Just as a technical operation may serve for testing a given object (testing by weights, dynamometric tests, the record of an indicator diagram), or for constructing a new object (the building of a machine), so also a concept may be used in a testing or constructive sense. The concepts in mathematics are mostly of this character, whereas the concepts of physics which cannot create its objects, but finds them already present in nature, are ordinarily of the first-mentioned kind. But even in mathematics, figures arise independently of the inquirer, furnishing material for subsequent investigation; and in physics also concepts are constructed for economical reasons. But the fact that mathematics operates in the main with constructions of its own creation, containing only that which it itself has put into them, whilst physics must wait before it finds out how far the objects of nature answer to its concepts, —this fact is the foundation of the logical superiority of mathematics.

Many of the concepts of mathematics show still another peculiarity. Let us consider the simple concept of the sum of $a + b$, where a and b may first be supposed to be whole numbers. This concept contains the impulse to count onward b numbers from a in the natural series, when the last number, $a+b$, is arrived at. This act of counting on may be regarded as a muscular activity which is always the same in all cases, however different, and the beginning of which is determined by a and the end by b. Through variation of the values of a and b, an infinite number of cognate concepts is created. If a and b be conceived as members of a number-continuum, there results a continuum of related concepts for which the reaction-activity is throughout the same, but where the beginning and the end are determined by properties representing members of the same continuum. Analogous considerations hold with respect to the concept of product, etc. The existence of such con-

[1] I have had frequent occasion to observe the power which latent psychical elements possess. Approaching, while deeply absorbed in thought, the house of a friend, upon whom I intended to call, I have more than once surprised myself in the act of drawing forth my own latch key. The word in other cases may call forth the same result as did the sight of the door in the present instance, without arousing to consciousness everything which corresponds to this symbol.

ceptual continua offers great advantages in those sciences to which mathematics is applicable.

A reference here to the old controversy of the nominalists and realists will be in place. There seems to be a germ of truth in both views. The "Universals" possess no physical reality, but they do possess a physiological reality. The physiological reactions are of less complexity than the physical stimuli.