

REACTION TIME WITH REFERENCE TO RACE.

BY R. MEADE BACHE.

The fact of the coördinated existence to common observation of the apparently completed, final man, obscures in the minds of the multitude the rationale of his muscular movements. It is generally believed that in health, every one of those movements, whether in waking or sleeping, is derived from an act of either self-conscious or semi-self-conscious will. But physiology proves that some movements are simply reflex, as when, for instance, the hand may be said to draw itself away from a burn, and that others, although secondarily reflex, are still purely automatic, as when a child, having learned to walk, can walk thereafter without other self-consciousness than that necessary to start the machinery of walking; and of course every one knows that the vital movements, such as the beating of the heart and the processes of digestion, go on entirely irrespective of self-consciousness and will. Deep down in the physical constitution of man, graduated to his present condition through successively higher and higher types, with corresponding advance in structure and function, lies plain evidence of the derivation of certain contradistinguished movements, namely, automatic as contrasted with volitional movements. As the skull itself was, as discovered by Goethe, derived from upper vertebræ, it needs no demonstration to prove that, in the preceding period, there was no brain; and as all animals now provided with crania must then, nevertheless, have lived and moved and had their being, it also stands to reason that will, which has its organic seat in the brain, could have had no existence in that preceding period.

What, then, in one era of that primordial time, representing millions upon millions of years ago, constituted animal life? What indeed in some of the present forms of life, as

in the case of the simplest, the amœba, entitles them, as little protoplasmic masses, to be regarded as possessing animal life? Assimilation of food in a way analogous to digestion, and with a difference from vegetable life,—through a law almost universal even in the misty borderland between the lowest forms of animal and vegetable life,—the imbibition of nutriment in higher chemical combination than vegetable life can use it. So, also, in some of the past history of incipient man, he, too, was a creature destitute of capacity for the designed taking of food and direction of energy, destitute of any capacity for movement except that which was purely reflex, not purposive. It follows, as proved by biology, anatomy, and physiology, working hand in hand, that man having been evolved from successive forms which, at the beginning and long afterwards, were reflex in their movements, must continue, in harmony with his present environment, to be so endowed. Development depends upon natural selection and functional use, and these are in turn dependent upon environment, and man's environment has not so changed as to enable him to dispense with reflex, and secondary-reflex, combined in automatic movements.

The foundation of man's earthly existence is and was what Huxley terms 'the physical basis of life,' protoplasm; and now, in the highest estate which he has reached, metabolism of that basis, the chemical building up to higher forms and the breaking down to lower forms of protoplasm, represents the varying intensity with which he lives. So varied in its conditions and consequent manifestations is this physical basis of life that Dr. Michael Foster writes in the article 'Physiology,' in the *Encyclopædia Britannica*, "the protoplasm of one muscle must differ from that of another muscle in the same kind of animal, and the protoplasm of Smith's biceps must differ from that of Jones's." Biologists and physiologists do not deny to protoplasm, even in its simplest forms, the quality of consciousness. If they did, it would be impossible to draw the line where consciousness begins in one form of life and where it ends in another. In a certain broad, intelligible sense, it may be said generally, that where we see life of even the lowest form assimilating

food of a certain chemical constitution, there is animal existence and consciousness. There are exceptions in plant life, but they are few. But the consciousness referred to is not the kind that is covered by the term 'self-consciousness,' or by another term that is used to mark the distinction—'awareness.' By way of illustration of the difference, it may be said that the eye may be open and a picture of surrounding objects necessarily on the retina, but yet the mind may take no cognizance of the picture: the picture must be seen, but it may not be perceived. So also, in the lower protoplasmic life, there is consciousness for the requirements of mere being, but not 'awareness' of being and of its manifestations.

As, at the remote period indicated, in which millions upon millions of years are involved, man having no skull, and therefore no capacity of 'awareness,' his functions were then only reflex. Graduated beyond that point, he yet, in correspondence with his acquired vertebrate formation, became possessed of nervous structure serving the needs of his advancing form of life. If the being from which he was derived had no skull, it had neither cerebrum, cerebellum, pons, nor medulla oblongata, all of which are contained within the skull. He must at one time have had only a spinal cord, the present structure of which makes it a nerve centre as well as a conductor of nervous impressions. Therefore, in the being which was to become man, the spinal cord, which now represents the nervous agency of voluntary movements and tactile impressions must, as it was not dominated by will through the presence of brain, have been the seat of mere vital impressions and reflex action unaccompanied by perception. An animal, the amphioxus, the lowest of the vertebrates, still extant, has no head, but merely a vertebral column. The condition of man differs essentially now from that of his past. In addition to the spinal cord's being now more highly differentiated, it may also now be dominated by the will, through the organ of the brain, and it generally is, even in a measure during the incoördination of the nervous system during sleep, for the sense of existence and of personal identity is never lost even in dreams.

Endowed as man now additionally is, he consists of two physical beings, one of which, automatic, may or may not at times be dominated by the other, the intellectual, gifted with perception, intention, and will. He is, moreover, so organized now, and must so remain as long as the requirements of his present environment endure, as to bring it about that the dominant brain can give general, instead of particular, instructions to its automatic slave, which the latter will faithfully carry out to the extent of its physical ability. The automatic man is the educated slave of the brain, as proved by the fact that the art of walking, as well as all other complex actions, had to be acquired through the expenditure of a certain amount of instruction, attention, effort, and time. Walking is a complex muscular performance in which the man wills that his body shall walk, and leaves to his automatic part the execution of the task. Having been once acquired, the ability has become and remains purely automatic, and whatever may be said of walking applies with equal force to any other complex muscular movement of man. One should not suppose that when an athlete is striking the punching bag of a gymnasium with the utmost rapidity of which he is by training capable, that each blow emanates from a special act of will. If that were so, each blow would show the 'reaction time' of the man; that is, the interval between perception and action. But this is obviously not so, for the number of blows, dividing the time in which they are struck, proves that intermediate perception between every two is eliminated. When, for instance, Corbett, the boxer, stands in profile and strikes the bag as rapidly as possible, the play of his forearms resolves itself into a blur, in which their outlines are scarcely visible. In striking the punching bag, perception for each action represented by a blow is discarded. The will determines that the blows shall be delivered, that they shall be delivered with a certain rapidity, and it continues throughout the operation to supervise their delivery, but it cannot supervise each, any more than it can determine their speed, which necessarily depends upon the automatic excellence of the instrument with which it is dealing. The will, which means simply the mind

resolved into action, has, in the case under consideration, nothing to do with the matter but to start, to preside over the action, to modify, and to stop it.

The preceding statements of fact bring us face to face with an important conclusion to be drawn which entirely differs from popular conception of the subject. Herbert Spencer somewhere calls attention to the contrast between the savage and the civilized man, in the circumstance that the former is so much more than the latter a creature of secondary reflex movements, and he illustrates this by remarking that, if a savage hurts his foot against a stone, the likeliest immediate response on his part is to kick the stone; an action indicating a development far inferior to that of a civilized, not to say an intellectual man. Now, the popular notion is, that the higher the intelligence of a man, the more immediately responsive his movements must be to stimulus. But we have already seen reason to believe that, all educated movements being automatic, it is the lower, and not the higher man, who should be more responsive to stimuli of the sort which are related to secondary reflex action, that men, in proportion to their intellectuality, should tend less and less to quickness of response in the automatic sphere, that the reflective man should be the slower being. That this is so I have for a long while believed, and I find to my mind a sufficient reason for its so being in the fact that the automatic preceded the intellectual condition of man, and that, with the decline of his primal rude life, secondary reflex movements should have become in lesser and lesser degree a necessity for his self-preservation. He should have discarded, I thought, in proportion to his intellectual advance, whatever was becoming less and less useful to him in his changed environment. In all evolution is modified or discarded whatever there is of lessening or no requirement for life under new conditions.

The popular notion that the more highly organized a human being is, the quicker ought to be the response to stimuli, is true only of the sphere of higher thought, not at all of that of auditory, visual, or tactile impressions, which invite secondary reflex action. As here stated, response to

such stimuli, not depending upon the more highly organized, but upon the less highly organized portion of the nervous system, the most ordinary intelligence should suffice for its exercise; and in proportion to intellectual advancement, there should be, through the law of compensation, a waning in the efficiency of the automatism of the individual. It has been contended, as an unanswerable argument, by a crucial test, that other things being apparently equal, high intelligence in one man as compared with another would result in the favorable issue to him of a pugilistic contest in which he might be engaged with that other. But here is introduced an element which is not necessarily involved in consideration of the 'reaction time' of two of the kind of men usually engaged in such contests. The answer, therefore, is that, other things being equal, relatively greater intelligence should give its possessor the victory, but only on the condition that the intelligence is superior, but not high, for it does not require high intelligence to conduct a pugilistic contest; while, on the other hand, inasmuch as the intelligence requisite for the conduct of a pugilistic contest is at best low, if one of the combatants, otherwise apparently equal, be an intellectual man, that is, has intelligence far beyond the purpose, and the other has nothing but intelligence sufficient, the former would be handicapped by his lesser relative automatic excellence, lost perforce of his intellectuality. His intellectuality having been gained at the expense of his automatic capacity, he would be defeated by the man whose lower, but sufficient, intelligence had subtracted less from his primitive constitution. The law of compensation is binding, and declares that growth in one direction of correlated structure and function involves diminution in another, and here we have a case of distinctly correlated structure and function. In a word, the automatic superiority of the less intellectual man being greater as such than that of the other, and his intelligence quite equal to the purpose of pugilism, he would win in a pugilistic contest. If it were otherwise, then the theory here brought forward, as supported by observation, and by experiment remaining to be finally presented, would fall to the ground.

Pride of race obscures the view of the white with reference to the relative automatic quickness of the negro. That the negro is, in the truest sense, a race inferior to that of the white can be proved by many facts, and among these by the quickness of his automatic movements as compared with those of the white. Many men, however, resent any claim for him of superiority, even in the low sphere of automatic movements, notwithstanding that there are several negroes and mulattoes at the present day in the ring whose excellence is scarcely approached, some of whom have often cheerfully encountered opponents of much greater size and weight for the privilege of being able to prove their skill. When additionally it is considered that the negro has in pugilism the advantage over the white in length of arm and thickness of skull, it ought easily to be seen that, with equal opportunity, were prejudice not so strongly against him, he would be regarded as the boxer *par excellence* of the world. It would be vain to say that Corbett is as quick as, or quicker than, any negro boxer. He may be quicker than any present negro boxer, but even that is doubtful. It is, however, contrary to all scientific practice to generalize from the case of a single or even of a few individuals by way of establishing a law. It is relative race characteristics of which there is now question, as previously there has been question of the relation between different individuals of the same race. Any one who will dispassionately observe any group of skylarking whites, and compare them with a group of negroes under the same circumstances, would be forced to admit that the latter are quicker in their movements; that the negro is, in brief, more of an automaton than the white man is. When bluff John L. Sullivan declared of the colored boxer, Jackson, that he would not fight him because of his race, he probably builded better than he knew when using the word superiority in the sense not related at all to a pugilistic contest.

Having, from observation, for a long while believed the fact to be as here stated, with reference to the relative automatic excellence of individuals of lower races as compared with those of higher ones, and having additionally ascribed

the fact, if it be a fact, to the cause mentioned, I finally determined to submit the matter to the test of experiment. With magneto-electric apparatus, now so common and easily adapted to various investigations of the sort, Professor Lightner Witmer, of the University of Pennsylvania, has at my suggestion made a number of experiments for determining the reaction time of Whites, Indians, and Africans, with the results as given below. The reaction time of women, as settled by the same indisputable method, was long since determined as less than that of men, and this result, it will be observed, is in strict accordance with the fact that the brain development of men, as compared with that of women, is greater, even when taking into account the relatively greater weight of normal individuals of the male sex as compared with that of normal individuals of the opposite one.

Although I do not, in contradiction of my own statement, mean to imply from the few experiments here presented, that they should be regarded as conclusive of the views here expressed, yet I present them for what they are numerically worth, with the intention to increase their number, and in the hope that, from the fact of their presentation, other persons will be led to follow the same line of investigation.

CAUCASIAN RACE.

Different Persons.	Age.	Auditory.		Visual.		Electric Shock.	
		Mean of 10 Observations.	Mean Variation.	Mean of 10 Observations.	Mean Variation.	Mean of 10 Observations.	Mean Variation.
1	22	135	7.0	152	10.0	141	4.0
2	24	130	7.0	140	8.0	128	11.0
3	16	141	13.0	174	10.0	187	9.0
4	14	132	8.0	159	10.0	138	3.0
5	15	182	20.0	214	6.0	142	14.0
6	19	147	19.0	164	11.0	119	13.0
7	18	139	12.0	155	22.0	95	11.0
8	19	170	15.0	191	12.0	150	27.0
9	20	123	6.0	164	9.0	121	7.0
10	15	234	17.0	201	12.0	229	15.0*
11	24	119	7.8	118	3.0	103	6.7
12	15	111	12.1	145	3.9	133	6.8
Final Means,	19	146.92	12.0	164.75	9.7	136.33	10.6

* In all the tables the figures represent thousandths sec. Compare times in this line by all three tests. They are abnormally slow.

INDIAN RACE.

Different Persons.	Age.	Auditory.		Visual.		Electric Shock.	
		Mean of 10 Observations.	Mean Variation.	Mean of 10 Observations.	Mean Variation.	Mean of 10 Observations.	Mean Variation.
1	18	165	5.7	168	8.5	152	3.5
2	21	115	5.5	121	3.9	100	3.4
3	14	128	5.4	148	6.2	118	2.5
4	23	144	6.1	127	3.1	122	3.6
5	14	70	6.2	119	4.8	94	5.3*
6	16	104	11.0	139	9.9	121	5.4
7	16	109	10.1	151	6.3	123	2.4
8	17	107	10.6	120	6.2	90	3.9
9	17	120	13.0	141	6.9	120	8.2
10	18	117	12.4	141	7.7	110	5.8
11	19	100	5.3	118	3.7	114	4.6
Final Means,	17½	116.27	7.7	135.73	6.1	114.55	4.4

* Pure blood Indian. Abnormally quick.

AFRICAN RACE.

Different Persons.	Age.	Auditory.		Visual.		Electric Shock.	
		Mean of 10 Observations.	Mean Variation.	Mean of 10 Observations.	Mean Variation.	Mean of 10 Observations.	Mean Variation.
1	16	114	7.2	157	8.4	107	10.3
2	19	113	10.4	148	14.2	108	5.4
3	19	127	7.7	131	4.6	100	3.6
4	20	125	5.7	138	6.9	120	6.0
5	19	164	24.7	173	7.0	137	13.9
6	22	104	13.4	187	10.7	178	8.7
7	26	121	13.8	118	11.8	103	5.0
8	34	148	4.0	159	5.9	141	7.7
9	38	109	4.8	165	11.2	118	6.5
10	16	120	6.0	162	8.0	112	5.0
11	25	126	5.0	144	7.0	128	8.0
Final Means,	23	130.00	9.3	152.91	8.7	122.91	7.3

The first thing that strikes one, upon examination of the tables, is the relative slowness of the Whites, as compared with the Indians and Africans. This is in accordance with the theory. But what is not in accordance with it, is that the reaction time of the Indians is shown by the tables to be less than that of the Africans, and the African is not so high in race as is the American Indian. It is possible, however, that the eventual explanation of this, when enough observations shall have been secured to demonstrate a law, will be that the Indian belongs to a race which for centuries cultivated quickness of movement as a necessity of his existence. Besides, the so-called Africans on the list have a larger intermixture of white blood in their veins than have the Indians on the corresponding list. It would seem, however, that the largest factor, as a disturbing element, is derived from the circumstance that the African, of the class here referred to, of whatever infusion of white blood in his veins, inherits physiological effects from generations of slavery. It must be, if we can ascribe to the Indian, through the influence of heredity, an extraordinary low reaction time, that we should admit, through heredity, the effect of converse conditions to which the African has been subjected. Whoever has seen slaves hoeing, in their listless fashion, in a cotton-field, or engaged in other forms of labor, must feel well assured that the mental attitude thereby betrayed could not fail in the course of generations to modify physical function. In sum, the conclusion must be, so far as the tables may elucidate the subject, that the African is quicker than the White, despite his hereditary history, and the Indian is quicker than both, perforce of his hereditary history.

I wish to call attention to a strange detail, to the case of No. 5, on the list of Indians. That case happened to be one of a full-blooded Indian, and as is seen, his reaction time is marvellously low. If 70 had appeared alone as the result of the auditory test, it would be justifiable to discard the observation, but the auditory, visual, and tactile tests all correspond, in due relation to each other, and therefore it is impossible to regard this as any other than an exceptional case of quickness even amongst Indians. It is interesting to

contrast with this the case of No. 10, amongst the Whites, with reaction time about three times slower than the reaction time of the Indian No. 5. Here again we perceive, as in the case of Indian No. 5, that the times, as determined by the auditory, visual, and tactile tests correspond perfectly, and that we must regard this as a case of abnormal slowness of reaction time even among Whites.

In the list of Whites there are twelve individuals, and in the list of Indians, eleven, but only ten in the list of Africans. But, then, it must be considered, that in each of the first two lists mentioned is included an abnormal case,—one of slowness and one of quickness. It would take more than one or two additional cases to produce an entirely satisfactory mean. To obtain perfectly satisfactory final means it will be necessary, of course, to make many more observations, and these I hope eventually to secure.

The views which I have here expressed I had entertained, from observation, for very many years, long before I suspected the scientific bearing which they have. I never found any one, however, to whom I communicated them who seemed to recognize their probable truth, and it was at the beginning, and for a long period afterwards, impossible to prove the correctness of my position until the creation of electrical physiological apparatus enabled any one to put to a crucial test any such theory as is here presented. When at last the apparatus was invented, and the convenience came to me in the facility afforded by Dr. Witmer, I availed myself of the opportunity. The article which I here present was written several months ago, while the experiments at the University were proceeding. I had intended to publish it at once, and let the experiments follow, but upon reflection, I concluded to postpone its publication until it was in my power to give something that would at least point in the direction of the truth of my hypothesis, for otherwise, it might be received with entire incredulity. Now that I am able to present matter, which certainly does point, if it does no more than point, in the direction indicated, I do not hesitate any longer to publish what I have held back.

It only remains to add, for the benefit of the general reader, that the record, as represented in the tables, is made in thousandths of a second, as registered by the electromagnetic physiological apparatus. In the auditory test, the subject, upon hearing the prescribed short sound, releases a telegraphic key upon which his finger is resting. The difference of time between the sound as it takes place and the release of the key is recorded by the apparatus. In the visual test, a long pendulum is suspended away from the perpendicular in a room adjoining that in which the subject sits. The subject releases the telegraphic key at the moment when he sees a flash of light given by the pendulum-bob passing a small opening in the room where he is placed. The difference of time between the actual passage of the bob and the time when the telegraphic key is released is recorded by the apparatus. In the tactile test, a slight electric shock is given to the wrist of the subject. The difference of time between the shock and the removal of the hand from the telegraphic key is recorded by the apparatus.