MOTOR-FEELINGS AND THE MUSCULAR SENSE.

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THE fact that we have feelings accompanying the movements of our limbs and contractions of muscles, and that such feelings are specifically distinct, is admitted on all hands; the assignment of these feelings to the motor apparatus, and their subsumption under the rubric of a Muscular Sense co-ordinate with the other Senses, is one of the vexed questions.

Muscular tissue forms the larger proportion of the tissues constituting the organism. It enters into the composition of every organ, and is so abundantly supplied with nerves that Krause affirms every single muscle fibre to have its nerve fibril.¹ This, however, would have little significance on the current hypothesis which excludes the muscle-nerves from participation in sentient phenomena, confining them to motor-phenomena. To me it has great significance, as I shall here attempt to show.

Note, first, that Motility and Sensibility are the distinguishing properties of the animal organism. Sensation always passes into motion of some kind, and all movements are stimulated and regulated by sensory excitations. We separate in abstraction these two elements of an inseparable unity; and having for analytical purposes made this ideal distinction we easily come to imagine it real. We thus separate the sensory and motor nerves, though in reality they are integrated by ganglionic substance into one nervous arc. In other words, sensory-impulse and motor-impulse are the polar aspects of one vital process. The sentient mechanism is essentially a neuro-muscular mechanism, each neural portion of it having an ingoing nerve, a central mass, and an outgoing nerve, with

¹ KRAUSE, *Allgemeine und mikros. Anatomie*, 1876.

a centripetal and centrifugal "current" of Neurility. These polar aspects represent the antithesis of passive and active; which antithesis is further extended to represent Sensation, the subjective fact, a state of the sentient organism, and Movement, the objective fact, a change in the space-relations of the body.

The psychologist must admit the presence of a motor element in every feeling; but in consequence of the tendency to classify according to marked differences, he separates the motor feelings as a class apart, precisely as he separates those of the Systemic class from those of Special Sense. In each case he throws the whole stress on what is peculiar to it, leaving out of account all that it has in common with others; thus in optical and auditory feelings only the sensibilities to light and sound are specified, without regard to the muscular sensibilities which form integrals of optical and auditory feelings. The psychologist will likewise accept a class of motor feelings such as cannot be included under any one of the Five Senses—feelings of Effort, Resistance, Movement, Fatigue, which have characters not less distinct than those of Colour, Temperature, Sound, or Taste. Whether these are to be included under the general term Muscular Sense is a question of classification; whether they are in any respect assignable to the muscles and their innervation, or are simply the result of muscular contractions in exciting cutaneous and articular sensibilities, is a question of fact. On the latter point opinions are divided.¹

In meditating the arguments *pro* and *con* it has seemed to me that the phenomena have not always been recognised as very complex; at any rate one factor, or set of factors, has been urged in explanation of facts which involve many. Under the general term Muscular Sense we find included feelings derived 1° from motor impulses; 2° from motor intuitions; 3° from muscular contractions; 4° from the effect of such contractions on the skin. &c.; 5° from muscular co-ordinations;—or in

¹ The literature of this subject is enormous. In every physiological text-book there is a section on it, and in every scientific journal may be found essays on it. The reader may profitably consult BASTIAN, in the *British Medical Journal* for May, 1869; and BERNHARDT, *Archiv für Psychiatrie*, 1872.

popular language, feelings *prompting* and *accompanying* ideal movements, not executed; and those prompting and accompanying real movements.

Everyone's consciousness discriminates between the passive affection of a sense organ, or a surface, and the active state of an organ. If for convenience we call the first *sensation*, and the second *motor feeling*, we may define sensations as complexes of peripheral stimulation and central reaction. Although not rigorously exact (since what are called "subjected sensations" arise from central stimulation), this is sufficiently exact for general purposes. The motor feelings, on the contrary, appear to be complexes of central stimulation and peripheral reaction; though this also is qualified by the fact that sometimes the peripheral reaction is absent, or non-apparent. Here a change in the centre is a motor impulse discharged through motor nerves, and exciting contractile tremors or full contractions in the muscles. This is the initial stage of the motor feeling (though the final stage of the sensory impulse), and it is followed by the peripheral reaction: namely, the contractions with their accompanying *effects* on the skin and articular surfaces. This is the second stage, and is succeeded by another change in the centre, effected by the peripheral reaction playing back upon the centre. Into these three stages, therefore, we may analytically resolve the motor feeling. The second stage is obviously compounded of purely muscular and purely cutaneous sensibilities. If this be so, we must regard it as a great mistake to assign muscular sensations to either of the two factors in exclusion of the other; and also a mistake to assign them to both, in exclusion of the central process of innervation.

A movement is effected by muscular contractions; these muscles are innervated from a centre; they have envelopes and attachments, and, when they contract, these envelopes and attachments are pressed, stretched, and folded; the limbs cannot move without—by their ball and socket arrangement—pressing on the articular surfaces. However indispensable nerves, muscles, and skin may be as conditions in the production of muscular sensation, yet it is not the nerve, the muscle, the skin, each by itself, nor all combined, which is the seat

of feeling: for *that* we must invoke the Sensorium. Does this appear a truism? Then why is it so disregarded, as it is by those who imagine that they disprove the existence of a Muscular Sense when they prove the motor nerve and muscle to be insensible?

The outgoing nerves which move the muscles are appropriately named motor; the ingoing nerves which transmit surface stimulations are as appropriately named sensory. But here, again, having named things differently, our terms are made to carry conclusions: the outgoing nerve is denied all participation in the production of a sentient change because it is not called *sensory*. On similar grounds we might deny that the ingoing nerve has any participation in the motor change because it is not called *motor*. Nay more, the sensory nerve is only one condition in the production of sensation, it is not itself the seat of sensation, and, apart from the centre in a living organism, it also is insensible. The principle I have so often insisted on—that identity of structure implies identity of property—must here also be applied; the ingoing and outgoing nerves are identical in structure and property: both have the same Neurility, both transmit their excitations, both are blended with the central nerve substance, and both form integral elements of central activity. The nerves have different functions, or (to speak more accurately) different functional relations, because of their different anatomical distribution; but because of their common Neurility, and their common integration in the centre, they must both be conditions of sensibility. *Neither can be in action without thereby inducing a change in the central equilibrium.* The discharge on an outgoing nerve must be accompanied by a corresponding change in the state of the discharging centre. The feeling which is conspicuous after any unusual effort must be present in kind, though less conspicuous, after every effort. If we cannot cease a violent pull without being conscious of a feeling at the time of the effort, and of another feeling when the effort ceases, it is presumable that fainter feelings accompany the feebler efforts.

But let us come to the experimental evidence. That the motor nerves are only agents in the production of movement,

and never of feeling, is said to be proved, because while they are known to convey central discharges to the muscles, they are incapable of conveying peripheral stimulation to the centre. This may be so, yet if so would prove nothing of the kind. But is it so? The proof offered is that when a motor nerve is stimulated, muscles move, but no sensation is excited. This is very questionable; indeed, one cannot but point to a strange oversight on the part of those who adduce this statement. They admit that muscular contractions do *somehow* cause sensations. No one disputes it; yet experiments are adduced in which muscular contractions are said not to have their invariable concomitants. What is true is, that when the motor nerve is stimulated, muscles are moved, and no indication is given by the animal of any sensation accompanying the movement. And this is intelligible. If the sensations exist at all, they must be muscular sensations, and will not therefore manifest themselves in signs of *other* sensations. When the optic nerve is stimulated, the sensation is optical, not auditory; it is that of flash, not of a pain. So when a muscle nerve is stimulated the sensation must be muscular. It is perfectly true that the muscle may be pinched, lacerated, burned, and no sign of sensation be manifested by the animal. These are not the adequate and normal modes of excitation of the motor nerve. It does not respond to them any more than the skin nerve responds to light, or the optic nerve to sound.

But, as I said, if the asserted facts were admitted, they would not carry the conclusion. We do not prove the motor nerve to be excluded from the *mechanism* of sensation by proving that it is not competent of *itself* to produce sensation. This premised, let us pass to the other argument—the *cheval de bataille* of those who uphold the essential distinction between sensory and motor nerves. A nerve is divided, thus separating from the centre the muscles to which the nerve is distributed. The portion of this divided nerve which is attached to the centre may be stimulated in any way, no sensation will be manifested; whereas, when the portion which is attached to the muscles is stimulated, these muscles move. Here, then, sensation and motion seem divorced: the more because in the

reversal of the experiment, by the division of a sensory nerve, stimulation of that portion which is attached to the centre does produce a sensation.

This negative evidence is far from decisive. If the stimulation of the motor nerve produces no appreciable change in Consciousness, this may be simply because the stimulus is not adequate and normal; for we know that inadequate stimuli leave the sensory nerves unappreciably affected. No one will conclude that the sensory nerves of the alimentary canal are insensible; because disease may eat away the membranes yet the patient be wholly unconscious of the injury. The normal and adequate stimulation of a motor nerve is the *motor impulse* discharged from its centre, and, probably, the *recurrent wave* excited by the contraction.

The outgoing impulse is admitted by all writers. The recurrent impulse is more hypothetical, and I believe I was the first writer who suggested it, and on these grounds: if we admit the Neurility of ingoing and outgoing nerves to be the same, we have no more reason to suppose that each nerve can only be excited at one end, and transmit its excitation in only one direction, than that a train of gunpowder can only be ignited at one end, and propagate its ignition in only one direction. Dubois Reymond long ago proved that each nerve conducts electricity in both directions; and the experiments of John Hunter and Bert on animal grafting prove that Neurility may be so conducted. Grafting the tail of a rat under the skin of the rat's back, the tip of the tail being inserted under the skin, its base rising into the air, is a complete inverting of the normal position; nevertheless, pinching this grafted tail produced the sensation of pain; and so accurately was this sensation localised that the rat turned round and bit the pincers. Other experiments show the same transmission in a contrary direction. Indeed, we have only to remember that the axis cylinder of the nerve is semi-liquid, to see at once that it will as readily conduct a wave in one direction as in another. Therefore I assume that when a nerve acts upon a muscle, the contraction *reacts* upon the nerve; and this gains fuller probability from the fact that between axis cylinder and contractile substance there is very considerable homo-

geneity. By this reaction the motor nerve affects the centre; so that not only do the sensory nerves which are stimulated by the contractions send their ingoing influences to the centre, but, accompanying these, the motor nerves also send their recurrent influence.

Waiving this hypothetical recurrent wave in the motor nerve, we have the less-disputable elements of—1°, a sentient change in the outgoing discharge; and 2°, the change arising from the ingoing stimulation of the sensory fibres distributed to the skin and articular surfaces; and 3°, perhaps also of sensory fibres distributed to the envelopes of the muscles, and to the interstices of their bundles.¹ A muscular sensation is a complex of these sentient changes. It is composed of changes in central innervation, changes in the active state of the muscles, and changes in their organic states. It ranges through the gamut from muscle-tone to muscle-tetanus; from contractile tremors to contractions. Even when in repose the muscles are faintly quivering; this is called their tone, and may be likened to the state of the retina when in perfect darkness, which even then has what Helmholtz picturesquely calls its *luminous dust*—a kaleidoscope of colours, now deepening now brightening,—till watching it we begin to think the ancients had some justification in calling the eye the source of light. The varying tone of muscles enters as a factor in the general state of Sentience, though rarely discriminated in Consciousness. It is one main element in languor and vigour. It is a measure of the resistance opposed by muscles to the motor impulse. This resistance in turn is a stimulus, so that greater effort succeeds. When the tension in the muscles is high, nutrition having supplied a store of disposable energy, a slight impulse excites it, and the energetic contraction which ensues, reacting on the centre, gives the feeling of power and freshness so eminently

¹ The existence of sensory fibres distributed to the envelopes of muscles and penetrating between the bundles is asserted by SAOHS, *Archiv für Anatomie*, 1874, p. 195; and ARNDT, *Archiv für mikros. Anat.* ix. p. 481. We must remember, however, that all methods hitherto employed for determining such questions are open to many illusions; the only decisive evidence—that of actually tracing a fibre from centre to periphery—is impossible; and the experimental evidence always involves an assumption of the main point.

pleasurable. The fresh, vigorous animal delights in exercise. The vigorous mind feels a similar delight in overcoming resistance in the combination of ideas.

Are these feelings due solely to the foldings and stretchings of the skin and to pressures on articular surfaces, when muscles are contracted? Are they due to changes in the Sensorium produced by the outgoing impulse? Each of these opinions finds eminent advocates. Let us examine them. "When a blind man," says Bell, "or a man blindfolded, stands upright, neither leaning upon nor touching aught, by what means does he maintain his erect position? The symmetry of his body is not the cause. A statue of the finest proportion must be soldered to its pedestal, or the wind will cast it down. How is it, then, that a man sustains the perpendicular posture, or inclines in the due degree towards the wind that blows upon him? It is obvious that he has a sense by which he knows the inclination of his body; and that he has a ready aptitude to adjust the parts of it, so as to correct any deviation from the perpendicular. What sense is this? He touches nothing, sees nothing; it can only be by the adjustment of the muscles that the limbs are stiffened, the body firmly balanced and kept erect. In truth, we stand by so fine an exercise of this power, and the muscles from habit are directed with so much precision, and with an effort so slight, that we do not know how we stand. But if we attempt to walk on a narrow ledge, or rest in a situation where we are in danger of falling, or balance on one foot, we become subject to apprehension; and the actions of the muscles are then, as it were, magnified, and demonstrative of the degree in which they are excited."¹ If we watch an infant learning to walk, or attend to our own sensations when learning some new muscular movement, we shall become aware of the necessity of a very fine sensibility for all these adjustments. It is only by means of guiding sensations that we can perform such actions.

There still remains the question whether the sensations derived from muscular contraction can in any degree be referred to the muscle-nerves. Schiff maintains that all the phenomena attributed to the muscular sense are due to the

¹ BELL, *On the Hand*, p. 238; 5th edition.

foldings and stretchings of the skin when the muscles contract. Spiess and Schröder van der Kolk hold the same view. And there is much to be said for it, though, as I before intimated, all the evidence adduced in its support only proves that one among the several factors is the effect of contraction of the skin. In a paper of mine, read at the British Association in 1859, were recorded decisive experiments (reproduced in the *Physiology of Common Life*, vol. ii. pp. 284 *sq.*) showing that muscular adjustments could not be wholly due to cutaneous sensibility. These are confirmed by clinical observations of partial and even complete cutaneous anæsthesia with little or no loss of muscular feeling and co-ordination. The patients are conscious of motor impulses, and are able to co-ordinate their movements: under what conditions, and with what amount of completeness will presently be noted. A frog deprived of its skin exhibited the same co-ordinations of a complex order as a frog intact. Not only so, but a frog without its brain and without its skin, exhibited similar co-ordinating power. Nothing here remained except the mesencephalic and spinal centres, and the ingoing and outgoing nerves; but the ingoing nerves were no longer capable of being stimulated from the surface, the skin having been removed; and accordingly neither pinching, pricking, burning, nor any other irritation of the surface caused the faintest sign of sensation; if, therefore, the ingoing nerves played any part at all here, it must have been through the sensory fibres distributed to the muscles and the articular surfaces. But these could only be affected when the muscles had already been *moved*; consequently, the motor impulse carried through the outgoing nerves must have been antecedent to any passive sensation caused by ingoing nerves. This conclusion enables us to explain how even after destruction of the sensory channel, by division of the posterior roots, movement and co-ordination were still possible. I found the locomotive co-ordination still effected, not perfectly, it is true, after the posterior roots of one limb were divided; and Brown-Séquard, after division of the roots of all the limbs! Such evidence is not to be gainsaid by the fact that injuries to the posterior roots, or even anæsthesia of the skin, very

seriously disturb co-ordinations in the higher animals. We are here concerned only with showing that movements *may* be effected, co-ordinated (and felt?) in the absence of the passive sensibilities which arise in the cutaneous and deep-seated nerves. Duchenne cites cases of absolute insensibility to pricking, burning, and even electrical stimulation, in patients who felt any movements their limbs might be forced to execute—felt the movements they executed themselves—felt the resistance that opposed them; in fact “chez eux la contractilité volontaire n’éprouve aucun trouble dans son action physiologique.” (*De l’électrisation localisée*, 1861, p. 425.)

Let us now, having disproved the hypothesis which assigns the phenomena to the so-called passive sensibilities due to incoming stimulation from the surface, pass to the hypothesis which assigns them to the active sensibility of the outgoing discharge. This hypothesis takes two forms, a physiological and a metaphysical. Dr. Clifford Allbutt briefly expresses the first in these terms: by muscular sense he means “the consciousness of the varying states of Neurility in the motor nerves, and of tension in the central cells connected with them.” (*British Med. Journal*, Feb. 20th, 1869.) Professor Bain expresses it thus: “The sensibility accompanying muscular movement coincides with the *outgoing* stream of nervous energy, and does not, as in the case of pure sensation, result from any influence passing inwards by incarrying or sensitive nerves.” The sensitive nerves are, he thinks, “the means by which the *organic* states of the muscle affect the mind. It does not follow that the *characteristic feeling of exerted force* should arise by an inward transmission through sensitive filaments; on the contrary, we are bound to presume that this is the concomitant of the outgoing current by which the muscles are stimulated to act.” (*Senses and the Intellect*, p. 77.) To the same effect Ludwig and Wundt, the latter establishing a distinction between innervation-feelings and muscle-feelings. (*Physiologische Psychologie*, p. 316.)

The metaphysical form of the hypothesis is that we are endowed with a “native power” of estimating the force necessary for each movement; just as we are by some philosophers believed to be born with an intuition of Space, and a “sense of

distance." In this view, Force is the direct revelation of Consciousness, which, when projected into the external world, appears as Cause. Independent of and antecedent to all experience, we know the degree of Force, or Effort, which a movement demands: this is a birthright of the Soul.

A combination of the metaphysical and physiological view may be found in Johannes Müller, who was too good a physiologist to adopt the purely metaphysical view, and too much of a metaphysician to adopt the physiological view thoroughly. "It is not certain," he says, "that the idea of the force employed in a muscular contraction depends solely on a sensation. We have a very exact notion of the quantity of nerve-force starting from the brain which is necessary to produce a certain movement." This is true, or false, according to the point of view: it is true if the notion is a *motor intuition framed out of registered experiences*—just as we have an exact idea of a circle before we draw it; an exact idea of the pain which will follow a prick, before the pin touches the skin; an exact idea of the distance of an object before we stretch our hands to seize it. But these illustrations show the error of the view which, placing the cart before the horse, supposes the notion to have been in existence *before* movements which it ideally reproduces had originally produced it. And the error becomes conspicuous in the light of clinical evidence that when there is *anæsthesia* the patient is utterly incapable of regulating the force. Not only does he cease to hold an object on ceasing to look at his hand, but he is so unable to regulate his muscular energy that he crushes a brittle object when he grasps it, as an infant crushes a butterfly; and if he grasps your hand, it is spasmodically—he cannot lessen the pressure at your request. The estimate of force is independent of the muscular sensation only as the idea of a circle is independent of the power of drawing it. I may have a mental vision of a human face, but my attempt to draw on paper what I thus see will be successful only in proportion to the education of my muscles. The registered experiences of former efforts have furnished me with motor intuitions; but the carrying of these into effect depends upon the motor feelings being normal—the numbness of cold, or the pain of rheumatism, will disturb the mechanism.

It seems clear that the two hypotheses of passive and active stimulations, derived through the ingoing and outgoing nerves, having both an array of evidence showing that a feeling of movement involves sensibilities of the two kinds, leave us no alternative but to include both, and not assign the feeling to either separately. The evidence proves that muscular adjustments and motor-feelings may exist when there is anæsthesia of the passive sensibilities: therefore these latter cannot be the sole sources of the co-ordination and muscular feeling. But the evidence also shows that the passive sensibilities normally enter into the complex feeling, and any diminution of them is a disturbance of the co-ordination, and a variation in the quality of the feeling; the disturbance of co-ordination may be nullified to some extent by the co-operation of some other passive sensibility, notably that of sight, but nothing will nullify the variation in quality. Let us glance at the evidence.

A patient whose cutaneous sensibility is lost can supply its place. He walks steadily so long as he can "lean upon his eyes as upon crutches;" he can reach an object if he looks towards it; he can hold one so long as his attention is directed towards it. Close his eyes, and he staggers, moves his arms wildly; call off his attention, and the object falls from his hand. Some patients cannot even stand when their eyes are closed. Have they then lost their muscular sensibility? This has been rashly concluded. It is disproved by the co-ordination: this certainly is not *effected*, it is only *aided*, by sight. The loss of the accustomed sensations derived from the skin has disturbed the accustomed *quality* of the complex feeling, and, although the sense of Effort remains, the sense of Effect is absent. The patient does not feel the usual consequences of a movement, and therefore does not know whether it has taken place or not, unless his sight informs him; and, since the Sensorium requires that it should be informed at each step whether the movement has been effected before it innervates the successor, a bewilderment ensues; which may be faintly appreciated by any one studying his feelings when moving in unfamiliar places in the dark, or even when closing his eyes and trying to reach an object on the table. The movements

so accurately and unhesitatingly co-ordinated with the aid of sight, now become tentative and inappropriate. A similar case is that of the deaf man becoming dumb: no longer hearing perfectly the sounds he utters, no longer rightly informed of the effect, he first loses his power of rightly adjusting the efforts—speaking now in tones scarcely audible, and now in shouts—and, as the deafness increases, he finally loses the power of speech. It should be added that only such movements as we are accustomed to direct by sight are capable of being thus directed when there is cutaneous anæsthesia. We, who were not born blind, learn to direct our feet in dancing, and our hands in manipulations of complex kinds, by looking at them. Movements of the eyes, tongue, glottis, &c., are not thus aided. They are learned through the muscular feelings—as the pianoforte-playing of the blind is learned. But any considerable disturbance of the usual elements of a process must cause a disturbance of co-ordination. Heydt has shown, by experiment, how great a disturbance accompanies anæsthesia of the soles of the feet (*Der Tastsinn der Fuss-sohle*, 1862), but even this may be compensated by attentively watching the steps.

After giving due weight to the evidence which shows the dependence of feelings of movement on the normal influence of cutaneous sensibility—evidence we have already intimated as merely disclosing one factor,—let us now consider the other side. There are cases on record of marked defect of co-ordination where *no* appreciable defect in cutaneous sensibility existed. The cases, indeed, are rare;¹ I had the good fortune to study one under Prof. Friedreich at Heidelberg. The patient was a girl, about twenty, healthy in all her organic functions, and with well-nourished, powerful muscles. The sensibilities of her skin were perfectly normal, responding to every stimulus in the normal way. Her localisation of impressions was normal. She could bend or stretch arms, fingers, legs and toes at will; and the power over her muscles was such that I could not with my utmost force bend or

¹ VULPIAN says: "On a cité quelques cas très-rares dans lesquels la sensibilité était restée intacte bien que les phénomènes d'ataxie locomotive fussent très-prononcées. Je n'ai jamais vu de cas de ce genre."—*Archives de Physiologie*, 1868, p. 148. In TROUSSEAU'S *Lectures on Clinical Medicine*, translated by BAZIRE, p. 209, two good examples are given.

straighten a limb, if she resisted me. But her co-ordination was so imperfect that she could not walk unless leaning on some one, and even then threw out her legs in a spasmodic and disorderly manner. Nor were her upper limbs more under control. If she attempted to reach an object, or to clutch one presented to her, the movements were singularly incoherent, and never succeeded until after many corrections of the effort. It took her several minutes to button her dress, though finally she always succeeded. In short, there was a great disturbance in the ordinary regulation of movements of the limbs—(those of respiration, facial expression, speech, &c., were normal),—although her skin was unaffected. I remarked to Prof. Friedreich that I had seen a frog with the sensory nerves of one limb wholly destroyed, and another with no skin at all, yet the movements in both cases were far more co-ordinated than those of this girl.

This curious example raises many questions which I cannot touch on here. It is an example of abnormal irradiation, and consequent failure of co-ordination, rather than of any absence of purely muscular feeling. The girl had muscular movements and muscular sensations, but failed to combine the movements with normal precision; the volition was normal, but there was a defect somewhere in its execution.

The experiments of Wundt (*Sinneswahrnehmungen*, p. 410) seem to prove that the muscular feelings cannot be wholly due to foldings and stretchings of the skin, or pressure of surrounding parts, in the case of the movements of the eye. The convergence and divergence of the axes, and the accommodations of the lenses, are accompanied by feelings which enable us to estimate the relative positions and distances of objects. This cannot be due to pressures: because, in the first place, the muscular sensibility is by Weber shown to be more delicate than the tactile, being indeed in the proportion of 39:40—a delicacy which rivals that of the higher senses, whereas the tactile is only 29:40; and because, in the second place, the power of estimating distance through accommodation lies within the limits of contraction; whereas, if the object, instead of approaching the eye, recedes from it, we lose all power of estimating distance when the muscles relax

instead of contracting: our estimate is then a judgment formed from the varying size of the image.

Finally, consider the marked differences in the quality of the feeling under the following circumstances: I move my fingers by a voluntary effort; you then move my fingers in the same directions, I neither opposing nor resisting the movement. In both cases the *effect* is the same—the muscular contractions, the stretchings and foldings of the skin, are the same; but in the first case there is present what is absent from the second, namely, the element of *effort*. Now suppose that I am suffering from cutaneous anæsthesia, I shall then feel the effort, but not the effect; so that unless I am looking at my fingers, I shall be unable to say whether I have moved them or not, and whether another has moved them or not. Herein we see disease analysing the two elements of a muscular feeling, active and passive, central impulse and peripheral reaction.

The Muscular Sense, to be exhaustively treated, would demand a careful survey of the facts of co-ordination and of motor intuition, which would require another essay; so that for my present purpose I must be content with the foregoing remarks. What this paper professes to show is, that although the motor sensibility is a constituent of all Feeling—since Feeling is a complex of passive reception and active discharge—there is a justification for the establishment of a special and distinct class of sensations produced by muscular movements, and for these the term Muscular Sense is appropriate. Such sensations are complexes of neuromuscular active and passive sensibilities; and although their seat is neither in muscles nor in nerves, but in the Sensorium acting on and affected by nerves and muscles, we have the same ground for including the motor nerves among the *essential conditions* of production of muscular sensations, as for including the optic and auditory nerves among the essential conditions of production of sight and sound sensations.