An essay on some of the relations of volition to the physiology and pathology of the spinal cord / by William Frederick Barlow.

AN ESSAY

ON

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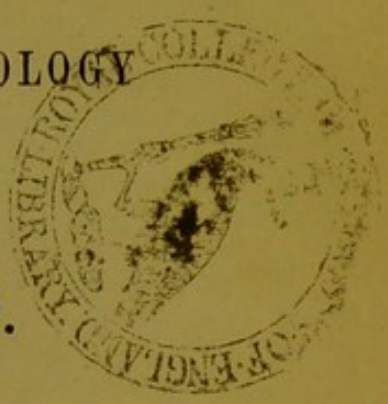
TO THE

PHYSIOLOGY AND PATHOLOGY

OF THE

SPINAL CORD.



By WILLIAM FREDERICK BARLOW, M.R.C.S.

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AN ESSAY ON

SOME OF THE RELATIONS OF VOLITION,

&c. &c.

PART I.

Now that the spinal cord has come to be considered, not as a mere appendage of the brain, or as a large nerve only, but as an organ having a function of its own, acting obediently to a special law, (the beautiful simplicity of which calls for admiration), the exact relation of it to the brain is in need of a careful and full investigation. The cord is neither a simple appendage to an organ, nor an organ exclusively, but both; it is a large cerebral nerve, reporting sensations, and conducting motions, but it possesses a structure also, which Dr. Marshall Hall has denominated by way of distinction, the *true spinal marrow*, which is the seat of a strictly independent function.

Movements which are performed through the cord as a nerve, modify those which it excites as an organ. What a number of phenomena in muscular motions are there, which can neither be explained by the brain alone, nor by the spinal marrow alone, but only by a reference to their combined functions. Those functions in health work together as with a common aim. It is, for instance, through their united influence, that we not only breathe, but conform our breathing to changing circumstances, and make the air "answer," in the terse phrase of Hunter, "the purpose of sound as well as of life." There are some observations of Flourens, in his celebrated work, on the "unity" of the "nervous system," and that unity must not be forgotten in the attention given to its isolated parts; for we can no more understand the nervous system taken as a whole, by limiting the observation to a single division of it, than we can comprehend the operation of a complex machine, by fixing the mind upon a compartment alone. And it is only when we view that system in its entire aspect, and note the perfect and necessary concord of its various parts, that we can fully appreciate the extraordinary system and contrivance which pervade it, "toutes choses étant causées et causantes, aidées et aidantes, médiatement et immédiatement, et toutes s'entretenant par un lien naturel et invisible, qui lie les plus éloignées et les plus différentes."*

I have chosen so comprehensive a title for this essay, that I might properly allude to some phenomena which must have been passed over otherwise, and which, in my judgment, are full of interest, and eminently suggestive. I have consulted the observations of certain physiologists and pathologists, with a full sense of their importance; and I may here allude to the writings of Dr. Marshall Hall, Sir Charles Bell, M. Flourens, and Professor Müller, with the excellent notes appended to his work by its classical translator Dr. Baly.

Many muscular motions which are complex now, would of course be far simpler were they without the pale of volition and emotion, but as things are, we must take whatever modifies them into complete account, and ask diligently, "what is urging forward, what impedes, what predominates, what is subservient."†

Nothing can be worthier of close physiological remark than the contrast

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* Pascal. This admirable passage has been recently cited by Mr. Vincent in the "inquiry" prefixed to his Observations on Surgical Practice.

† Bacon's Novum Organum, Pickering's edition, p. 126.

of the complete and headless animal. A perfect has to be compared with, what may be termed, a mere dynamic life, which, in a relative sense, can be called life by a figure only, for it is as real a death, as regards the creature exemplifying it, as though no motion could be excited in its muscles, as though nothing existed external to itself. No longer can it perceive or order; should it obey any volition, it must be a volition which is not its own. It may be provoked to associated actions, and forced to assume the semblance of the voluntary; but such actions are the consequence of a blind subjection to a purely physical law. The particular power on which a function *immediately* reposes must not be exclusively examined. Perfect life consists not in one force, but in the combination of forces working to an end; and the same may be remarked also of perfect function.

There are reflex actions which we can prevent occurring by an exertion of the will. By this the closure of the eyelid can be hindered when the eyelash is touched, the effects of tickling can be resisted, and the action of temperature opposed; and these are common but good instances, of what is signified by the function of the brain and spinal marrow antagonizing. It may be here observed, that every muscle which the will acts upon, has every kind of involuntary motion which can be excited in it placed under the control of the will, so long as the will can reach it, and contend with, and be exercised with a force superior to that power which causes the involuntary contraction.

In a short paper which I published in 1840,* to which Dr. Marshall Hall† and Dr. Baly,‡ have done me the honour to refer, I instanced the influence of volition over certain spinal movements, but it prevails over others not spinal in their origin.

Volition has a no less obvious than wide relation to movements of an involuntary kind, originating in the brain, though performed *through* the cord.

It is related, more or less, to most physiological reflex actions.

It modifies also many reflex movements which are pathological.

It counteracts spasmodic actions of centric and physical origin, and others of centric but not physical origin, viz., those of emotion.

Its power should be investigated with especial reference to the motor force of the spinal marrow, as the latter is affected by accident, disease, rest, activity, excess of action, exhaustion, age, sex, temperment, changes of the blood, and all the disturbing causes which can be discovered.

The state of the will itself, moreover, as regards the degree of its energy, and the perseverance it is exerted with, and as modified by age, disease, or imperfect development of the brain, demands fair consideration.

A mere glance at the relations of volition to the physiological actions of the spinal marrow, shows how variously it is adapted as circumstances demand. Its relation to the closure of the eyelid, the sphincters of egestion, the act of swallowing, the function of parturition is special in each instance.

The reflex closure of the eyelid at at one time, and its direct voluntary closure at another; the admirable manner wherewith the levator, antagonizes with the orbicularis, palpebræ; the comparative state of these muscles in wakefulness and sleep, and the several phenomena arising from their paralysis in various kinds and modifications of disease, are all instructive matters as regards our inquiry.

The will influences the sphincters of egestion only at certain times; they contract perfectly and almost constantly in strict independence of it, but it affects them occasionally, and can always affect them when exerted for that purpose. As to the uterus and œsophagus, it is but indirectly connected with the functions of those parts. It prepares for deglutition; it aids at the completion of parturition; but by no act of volition can the œsophageal or uterine fibres be contracted. It is needless to dwell on the opposite way in which it gives assistance in these cases, or on the far more important part which it plays in the former than in the latter; it is indispensable to the one, unless its place be supplied by a volition acting from without, just as it is supplied daily in instances of coma, just as Flourens supplied it when he

* See Lancet, Jan. 1840.

† Medico-Chirurgical Transactions, Vol. xxiii. p. 124.

‡ Translation of Müller's Physiology, p. 800.

nourished creatures whose brains had been removed; but labour, as all know, can be effectually accomplished without any assistance whatever of the will.

Clear and most interestingly varied evidence of the relation of the will to the reflex function is tendered by respiration. No function is at once so independent of, and yet so obedient to volition.

Breathing, so far as it is muscular, presents a double aspect. It is peripheral in source, involuntary in action, or it would cease whenever volition ceases; but it is likewise centric and voluntary, and can be checked, hurried, and most delicately modulated, as any one may be taught by experimenting on himself, or may learn from common speech or oratory, or the performances of the singer, who uses it as an instrument of music.

Strange reflections have been made upon thts function by certain philosophers, who appear to have held it necessary to *seem* to understand it before they actually did so. And here I am reminded of a remark of Mr. Lawrence, in reference to explanations which are not explanations, which may be cited not inappositely. "A learned professor, to be sure, would lose his credit, if he had not a reason for everything that happens."

It is plain that respiration is an involuntary act, as we learn from the phenomena of sleep, hybernation, coma, to say nothing of the anencephalous fœtus, of children who have been born breathing despite the destruction of their brains by obstetrical interference, and the remarkable experiments of Legallois and Flourens.

Nor has it been in any way difficult to affirm that the medulla oblongata is indispensable to the act, since the performance of an experiment of Legallois, who instantly stopped the breathing of the brainless animal by destroying the medulla oblongata at the place of origin of the nervus vagus. But in *what manner* the medulla oblongata is essential, remained one of the chief mysteries of life. Neither Legallois, nor Flourens, nor Sir Charles Bell had explained it. It was left to Dr. Marshall Hall to discover the mode of operation of a function rivalling the circulation in importance. "As the connecting link," says this celebrated physiologist, "between the excitor nerves, in other cases, has been neglected, so the first link or the excitor nerve itself has been overlooked in reference to respiration. Legallois, Sir Charles Bell, M. Flourens, Professor Müller himself, all agree in considering the medulla oblongata the *primum mobile* of respiration. I had myself adopted this view up to the period of writing my second memoir. I have since ascertained that, not the medulla oblongata, but the pneumogastric nerve, is that primum mobile, as its excitor in ordinary respiration, and the fifth and spinal nerves as its excitors in certain extraordinary circumstances.*

It does not seem to me superfluous to allude to this part of the question here, for the true relation of volition to an involuntary act cannot be properly comprehended until the nature of that act be known. Do we not, in consequence of Dr. Marshall Hall's researches, now contemplate the will's influence over involuntary breathing, not as over a function of which we can only say that it is involuntary, but as over a function respecting which we have obtained knowledge *whence* it springs, and *how* it is effected.

Amongst the first and chief inquiries which present themselves, is the following:—how long can respiration be sustained where there is no volition? There are some observations which throw much light upon this point.

I. The long duration of insensibility, such as diseases and injuries of the brain exemplify, wherein the breathing continues to the support of life, go far to show to how great an extent this function is independent of the will, when viewed as *vital*.

II. The history of the anencephalous fœtus which is altogether without volition, strikingly pictures the maintenance of respiration as a purely physical function. But how long would the function thus endure, provided the frame were duly nourished? All of us have read the remarkable account given by that distinguished surgeon, Mr. Lawrence, of a child born without a brain, which lived *four* days.† No

* See Diseases and Derangements of the Nervous System, p. 161, and some observations of the same author in his last memoir. See also Dr. W. Budd's able retrospective address.

† See Medico-Chirurgical Transactions, Vol. 5.

imperfection of the vital functions seems to have been noted at the time of its birth. It lived as the sleeping live, though more profoundly unconscious than they are. It breathed naturally, took food, and the intestines were relieved of their contents. What caused its death, then, seeing that it could be nourished, that its blood was aërated, and egestion performed? Mr. Lawrence remarks—"Breathing went on as naturally as in a child with a perfect brain; and, so far as this function was concerned, the creature in question might undoubtedly have continued to live. Why, then, it will be asked, did it die? I really could not procure a sufficiently accurate history of its life to answer this question. Probably the same scruples which led the nurse to keep it away from the sight of the mother, may have inclined her to doubt whether any attempts ought to be made to prolong its life: hence we may perhaps infer that it died from want of food." What extreme care would have been necessary to preserve it long I need not say. Proper food, regularly, cautiously given, a due exposure to fresh air, and great attention to the state of its temperature, would have been obviously necessary.* But only a physiologist would have felt an interest in a monster so horribly defective. People in general would have naturally desired for it the speediest dissolution possible.

III. I will read an extract from the experimental researches of Flourens, which, making all allowance for difference of structure, bears intimately on the point:—

"I removed at once the two cerebral lobes of a fine and vigorous fowl. This fowl, deprived of its two lobes, lived *ten* whole months in the most perfect health, and would have surely still survived, if, at the moment of my return to Paris, I had not been obliged to abandon it."*

If we bound our views by the phenomena of disease, we shall be apt to conclude that the brain is a more immediately vital organ than it really is, so very commonly does the breathing, on the will being abolished, become deranged and impeded in some sort, and put life in peril. But we must always most accurately distinguish between such cases as simply abstract the influence of the brain, and those which interfere also with the functions of the spinal marrow, particularly with the office of that most important part of it—the medulla oblongata; for here is found *le point vital*, as Flourens justly styles it. A broad difference may be observed often between concussion and compression, lying in the fact that in the former the brain is exclusively affected, whilst in the latter the spinal marrow is affected also *through* the brain, and hence there is stertorous breathing, accompanied, perhaps, with difficult deglutition and affections of the sphincter muscles. I think it may be concluded of such cases of concussion as kill on the instant, that the medulla oblongata is irrecoverably involved in the shock. It is known well enough that cerebral affections are dangerous in proportion as they damage the functions of the cord. Flourens has spoken of the successive affection of the nervous centres in asphyxia, wherein the loss of cerebral function is peril; that of spinal is death. And during recovery from the dangers of asphyxia, how inviting as well as cheering to observation, is the gradual progress from the first inspiration artificially excited to the first indication of restored voluntary power over the respiratory muscles! The brain, the heart, and the lungs have been called the tripod of life, and also *atria mortis*; but these terse and beautiful phrases would be more correct were the medulla oblongata substituted for the brain.

"The brain sleeps," says Dr. Marshall Hall,—"the spinal marrow never sleeps." Cerebral respiration yields to repose; whilst spinal, mere physical respiration, remains. But has the latter

* It is clear that modifications of structure and function have much to do with the duration of life in the absence of food. "A bird, deprived of food," says Liebig, "dies on the third day; while a serpent, with its sluggish respiration, can live without food three months and longer." As to temperature, Dr. W. F. Edwards, that most original investigator, observes—"It is well known to be difficult to rear children that are born long before the full time, such as those of the sixth month of pregnancy. In general, the care which is employed for preserving the heat by means of clothing would be insufficient, as I have ascertained in the case of young animals which are born in a similarly imperfect state. There ought to be a continued external application of heat until the body has acquired sufficient development." But infants born at the full time die, it may be presumed, *occasionally* from the action of cold.

* Du Système Nerveux. Seconde édition, p. 87.

ever been known to be stayed also when slumber clouds the faculties? It would appear to have been thus arrested in a case related in the work of Sir Charles Bell,—one of the few works which will be read hereafter. Speaking of the patient, Sir Charles observes—"This is his present condition:—On falling asleep, just at the moment when volition and sensibility cease, the involuntary motions also stop, with a sensation of death, under which he awakes generally convulsed. His medical friends have sat by him and watched him, and they have found that, when sleep is overpowering him, the breathing becomes slower and weaker; the heart and pulse also fall low and cease to beat as sleep comes on, and after a short time he awakes in terror. . . . The case presents to us a lively idea of what would result, were the involuntary nerves subjected to the same law as the nerves of sense and volition; for then sleep, by overpowering both, would be death."*

But our admiration of respiration in the light of a physical involuntary function, must not divert us from a contemplation of its subjection to the will, or the assistance which the will most clearly renders it in cases of difficulty.

In exciting respiration in a reflex manner by impressions on the general surface, it is obvious that the effect of them is palpably modified by the will. Tickling, temperature, and other physical agents, are not followed by movements when the mind interposes, as in the absence of its interference. The respiratory muscles, too, are affected by emotion with a facility inverse to the power of the will. When the will is either languid or overcome, and passion predominates, the rhythm of respiration is broken, and it becomes often completely convulsive. The power of volition, on the other hand, is not rarely exemplified, provided an extraordinary effort be made, where the respiratory movements are disordered by disease. Thus it may be noticed to check the deep inspirations and violent sobbings which occur in some of the severer forms of chorea. Stammering familiarly illustrates a marked antagonism between volition and emotion. Emotion is at times its essence, and well-directed, energetic, confident volition, constitutes its cure.

To refer, again, to the production of respiration by appropriately stimulating the fifth and spinal nerves, which might be truly called the *provisional* excitor nerves of this function, I may remark that the states of body in which it is *thus* often so readily occasioned, are those wherein such excitement of it is needed most. In syncope, infantile asphyxia, the coma of convulsion, and narcotic poisioning, the application of cold is singularly effective in producing inspiration. I once assisted in saving the life of a child who had taken opium, by applying cold to the face and chest, due regard being had to the warmth of the surface. Inspiration was unfailingly produced by its use; and, on its employment being omitted, the breathing ceased, the lips became purple, and asphyxia threatened.

But when the will is active, the effect of cold is different, its impression can be resisted, but the success of resistance has its limits: a plunge into the cold bath when the surface is warm is a cause of deep, often sobbing respiration, whether the will endeavour to prevent it or not, though volition could have prevailed easily over the operation of cold if it had been applied to a smaller surface. This fact furnishes a hint as to the use of cold when employed as a remedy in certain cases of suspended animation and convulsive affections. It is occasionally used, and rejected as useless, because of the insufficient mode of its application.

The respiratory muscles are excited to motion in states of insensibility just as paralytic limbs may be, and precisely through the same principle; and let not the obviousness of the remark keep us from a contemplation of the unity of action to which movements, at first sight so unlike, conform. It is surely of interest to observe, that, by the very means which enable us to move the paralytic limb,—and amongst them I may point especially to temperature,—we can re-excite also the stopped respiration, and again make active the machinery of life.

The influence of the will over respiration is very strikingly exemplified by the phenomena of disease. I need

* The Nervous System of the Human Body. By Sir Charles Bell, F.R.S. See Appendix, p. 148.

only allude to asthma, wherein the patient so forcibly contracts the auxiliary muscles of the function, as Sir Charles Bell has so graphically depicted. In the peculiar breathing of abdominal and thoracic inflammations, to which patients resort with all the uniformity of instinct, volition, though emotion may blend therewith, bears a conspicuous part. Sir Benjamin Brodie has described the animal whose nervi vagi have been divided as breathing with "intense" volition; and this term appears to me equally applicable to many cases in which respiration distressfully labours. Such breathing is seen in some diseases of the chest, and, not seldom, as death draws near. As it approaches, speech becomes difficult, often impossible. The power of volition which remains to the dying is often all required to maintain the breathing. But instances in which all the aids of respiration are brought into play must have struck every observer —instances in which it would be dangerous to give an opiate—dangerous to withdraw volition by any means.

Let us put the question, whether volition might not be used oftener as a remedy in disease? What deep inspirations can we take by volition, and what is "depth of inspiration," but an expression synonymous with that of "full oxygenation of the blood?" Dr. Holland has directed attention to this point in his philosophical "Medical Notes and Reflections,"*—a work full of the most admirable observations. "Might not more be done in practice towards the prevention of pulmonary disease, as well as the improvement of general health, by expressly exercising the organs of respiration?" Dr. Marshall Hall has suggested that full voluntary inspirations would be of service in certain cases of convulsive affections. Mr. Bishop, who has devoted so much attention to the physiology and pathology of the voice, has recently spoken, before this Society, of the power of volition over disordered respiration in cases of defective articulation.

Taking the function of respiration from first to last, what chapter is there in the history of life which more calls for and rewards diligent research and philosophical inquiry? Regarding it merely as respects volition, we perceive in it, amongst other things, a type of what we are at our birth, and what we gradually arrive at. From the time of its establishment we perceive it becoming, step by step, more and more amenable to, more and more used by, the will; and the marvellous manner with which volition adapts it to many complex movements—a manner forgotten in the amazing facility of their performance—may serve to remind us of that higher exercise of the voluntary power whereby we control the intellectual faculties, and point them where, and guide them how, we choose. It is in great part by the rule of volition over the respiratory muscles, that we are enabled to change the silent air into the audible, eloquent interpreter of thought; and articulate voice is a true reflex of the mind of man, of its kind, its range, its endowments, and its power.

* See Exercise of Respiration. Medical Notes and Reflections. 2d edition, p. 265.

PART II.

Let us now turn to pathology for illustrations of the power of the will over convulsive actions. Whytt, John Hunter, Heberden, Dr. Marshall Hall, Dr. Holland, and others, have given instructive illustrations of it.

Sometimes the will opposes spasmodic action by influencing the very part wherein it occurs; at other times, by exerting itself on an opposite part, as where one sterno-cleido-mastoideus muscle prevents the spasm of its fellow, or flexor resist extensor muscles.

A common example of the power of volition over spasm is furnished by cramp; the extension of the leg is a cure for it often, as many have experienced, when it attacks the muscles of the calf.

I had the opportunity of examining a gentleman, some time ago, who was under the care of Dr. Marshall Hall for an inveterate affection of the spinal cord: he could control, for a little while, by dint of energetic volition, the most distressful spasmodic movements of his arms and legs; and he well described his attempts to overcome them as a "struggle between himself and his complaint."

In the paralysis of the hand which lead produces, there is, occasionally, a tremulous and strictly involuntary movement at the beginning of the affection, which can be arrested by a strong effort of the will.

The movements of chorea are often observed to be checked by volition.

The palsied shaking hand of age can also be steadied momentarily.

The same may be observed of the tremors attendant on nervous exhaustion, and of the agitation which emotion causes.

Even where the spinal marrow is extremely excited, the brain is not altogether powerless, as tetanus and hydrophobia strikingly demonstrate. It has been observed by Dr. Baly: "that even an excessive tendency to action may exist in the cord, and yet be controlled by cerebral or mental influence, is very clearly shewn in cases of poisoning by strychnine. In a case of this kind observed by the translator at the St. Pancras Infirmary, the excitability of the centres of reflex action was such, that a slight touch applied unexpectedly to any part of the surface caused a convulsive start or spasm of the whole body; while, if the patient was forewarned of it, the same stimulus produced not the least effect. The voluntary contact of the patient's own hand with other parts of his body also caused no muscular spasm."*

The illustrious Hunter was no stranger to the fact that the will holds in check spasmodic movements, and that the latter are more prone to happen when it is either feeble or powerless. This may be proved readily by the following remarks:—"Voluntary muscles, the stronger they are the more they are at the command of the will; and the weaker they are the more they seem independent of the power of the will, and seem to be either at their own command or that of the nerve. Strong people are less subject to spasms than weak, which may arise from custom; the strong muscles being more healthy and oftener in use, and therefore become more at the command of the will.

"Women, children, and sick men, are subject to fits for the reason just mentioned; perhaps also diseases of the uterus for the same reason are the causes of spasmodic complaints, it being very little at the command of the will but of other circumstances; and from this disposition it draws in other

* See his Translation of Müller's Physiology, p. 801.

parts by consent, and so brings on general spasm."*

The observation of Mr. Hunter on the great liability of the uterus to spasm, and the reason he assigns for it, is of great interest, and shews very clearly how fully his mind was convinced of the power of the will in subduing spasmodic action. I must point, moreover, to what he says of the predisposition of women, children, and sick men, to fits. With regard to children, it will not be denied, I think, that the *relative* state of the brain and spinal cord at the beginning of life deserves much more consideration than it has yet received. Dr. West, in one of his excellent lectures now being published in the MEDICAL GAZETTE, has referred to the predominance of the latter organ to explain the comparative frequency of the convulsions of children. Proneness to convulsion may certainly be stated, *cæteris paribus*, to be inversely to the energy of the will.

It would not be uninstructive to collect the instances which variously exemplify the simultaneous occurrence of feeble or abolished volition and spasmodic or involuntary movements. In all these cases it must be inquired, not only what is the state of the will, but what is the condition of the motor force?

Some of these cases I have already cited. Others might be stated; many more than I shall have space for. The quivering lip and trembling hand so commonly seen in typhus fever, have these not some relation to the state of volition, which is used with a slowness and feebleness typical of the sluggishness of the entire mind?

Amongst the symptoms of cerebral atrophy in aged persons, Dr. Sims mentions muscular tremors. How far are these to be explained by the altered functions of this organ, or a disturbance of the due relation which should exist between it and the spinal cord? May we not feel sure that, as abolition of the voluntary power is one manifest predisposing cause of convulsive affections, so must a defective or feeble state of it also make way for them in different degrees?

As to the loss of such power, it may be stated here that convulsive movements can be, in some cases, as readily excited in all the voluntary muscles of the comatose, as they can be provoked, in other instances, in certain of them in the paralytic. I have had opportunities of observing this fact in the coma of children.

All know how common are convulsions in very early life. The spinal cord is perfect in function, the brain most imperfect. And not only is the motor force of the former, to speak comparatively, very slightly governed by the will, but there is every thing to favour its augmentation. It is scarcely at all exhausted by voluntary motions. The passions, which are but dawning, waste it not as afterwards. It is apt to be morbidly increased by the long time spent in repose. The mucous and cutaneous membranes may, moreover, be held to be more impressible by irritants than at a later period. When volition becomes somewhat educated, the time of dentition comes to be anticipated, which is full of dangers peculiarly its own. The affections which it causes are a study of themselves.

In reference to the relation of volition to the motor force, as its controller and exhauster, it must be kept in mind always that there are not two motor forces, one for the brain and one for the spinal marrow; but one force alone, used sometimes by the brain, but constantly by the spinal marrow. The spinal marrow is its reservoir, as well as its distributer in part. The brain has no share in furnishing it whatever. Flourens has shewn that the cerebral fibres cannot *directly* produce motion. The *rationale* of many convulsive seizures turns upon this fact. When I speak of the antagonism of the brain and spinal marrow, I allude not to a contention between opposite forces, but to the same force made active by different causes. It is because the brain expends the power of the spinal marrow that it exhausts that organ, as Dr. Marshall Hall maintains. And let us note, that the motor force of the cord has much to do with acts of volition, for what could the will avail without a material through which to manifest itself? "The cord," says Professor Müller, "is always charged with motive power. The force of our voluntary movements is also dependent on the motor tension of the spinal cord."*

* Works of John Hunter, Palmer's edition, vol. iv. p. 442.

* Elements of Physiology, p. 805.

In considering the will as an antagonistic power, it is most instructive to measure, as far as can be done, the degree of force which it is able to resist, and that by which it is completely overcome. Volition may be simply demonstrated as the antagonist of spasmodic action, by immersing the hand in water through which a galvanic current is made to pass, the circle being broken and completed at intervals in the usual way; all contraction of the muscles can be effectually opposed by the exercise of the will so long as the current has a certain force: but let the force be augmented, and they can be governed no more. And if a frog, after the same manner, be exposed to a force reduced to a degree adapted to the subject of experiment, we may remark the animal struggling therewith, and not without success; but the muscles of the limbs will be spasmodically affected the moment an intenser power is employed. So also when strychnia begins to act, as I have seen in experiment, voluntary efforts may for a little while contend with the commencing tetanus; but the poison rapidly takes full possession, and there is no longer, to speak physiologically, a voluntary muscle. And the death of the swimmer by cramp is an illustration of the reflex action of the muscles of the limbs, produced by the impression of cold on the surface, which completely sets at nought all efforts of the will. The success of voluntary resistance to spasmodic actions is nicely limited by the energy which marks them; and herein is found the plain explanation of the will availing in some cases where it fails in others.

Much information may be gained from the pathology of sleep respecting the effects of the withdrawal of the will in abnormal conditions of the nervous system. Sleep, in relation to convulsive affections, may be viewed both as to the absence of volition and the increase of muscular irritability which attends it. Some convulsive affections are wont to surprise, or become aggravated, just as the waking is passing into the sleeping state; and, of course, *augmented* irritability can have no concern with the supervention or aggravation of these; they are rather referable to mere suspension of volition. Increase of irritability has fixed relations, doubtless, to degree of duration and soundness of sleep, and may be reasonably held to explain, altogether or in part, some kinds of convulsive seizure, for the measure and intensity of the motor force may surely be such as to predispose to attacks which have a direct dependence on its disturbance. The special irritability of the hybernating animal has been beautifully investigated and described by Dr. Marshall Hall. It is developed and persists, although no food be taken, to meet all exigencies during its protracted rest. An excessive irritability may be noticed in some cases of paralysis wherein reflex actions may be provoked; the muscles of the affected parts are no longer exhausted by volition, and *virtually* may be said to sleep; but their repose has a duration more comparable often to that of hybernation than ordinary slumber. The amount of the motor force has doubtless a most intimate connection with spasmodic diseases; *relatively* it is greater in the child than the adult. Not a few cases of spasmodic affections during sleep are probably referable neither to withdrawal of the will alone, nor to augmentation of the motor force alone, but to the combined effects of both. Here, as in so many instances in medicine, a complex problem is presented, and effects have to be studied which may not be imputable to one cause only, but to the united action of two or more causes.

The relation of volition to the reflex function of the spinal cord is very strikingly exemplified by such cases of paralysis as allow of the production of reflex movements. As a general rule it may be stated, that the facility wherewith such actions can be excited corresponds to the degree of diminution of the voluntary power. Cases, wherein they have been most readily caused, shew that it becomes less and less easy to occasion them, as the will more and more regains its proper authority. Dr. William Budd's observation of one instance will be found true of many:—"As voluntary power increased, the susceptibility to involuntary motions, and the extent and power of these, diminished." It follows that a great susceptibility to those spasmodic actions which irritation of the surface causes, is amongst the evidences of perfect, or nearly perfect, cerebral paralysis. Of course those paralytic

affections are exclusively spoken of, wherein the muscles remain connected with the cord.

I would beg attention to two or three cases of paralysis of different features, but all agreeing in the common point of demonstrating the power of the will in counteracting motions of a spasmodic character.

I have observed reflex movements easily excited in a state of coma, and an impossibility of occasioning them on the return of consciousness and volition. In 1846 I visited a little child, who had been comatose (from tuberculous meningitis, I believe,) for more than twenty-four hours: so perfect was the coma, that no sign of sensation could be elicited, even by painstaking: a pinch, the prick of a pin, were clearly unfelt; but on very lightly drawing my finger to and fro across the palm of the hand, it was grasped very tightly, and yet altogether in an involuntary manner. On tickling the sole of the foot, the leg was retracted, and the toes moved briskly; and the like result followed the fall of a few drops of water upon the integuments of the extremity. A deep inspiration was also occasioned by the application of cold to the cheek. On my next visit I found the vital powers feebler, and the reflex actions somewhat less powerful. Involuntary movements of the limbs, when once excited, continue for a short while after the removal of the stimulus which caused them; in consequence, perhaps, of fresh points of the surface coming into contact with the bed-clothing. The mother of the child mentioned, that a touch would sometimes throw the leg into spasms, and that the arm was bent forcibly during the action of the leg. She observed, moreover, when she perceived how I excited the fingers to contraction, that she did not think that any feeling was shewn thereby, but that it was a sort of convulsion; so fully had she convinced herself that the child was insensible, having never been able to rouse him in any manner. How often have I heard a self-styled philosopher make a remark less worthy of attention! The child died, but previously to dying became conscious, and moved voluntarily; and during this temporary return of sensation and volition, I could not excite any reflex actions of the limbs.

In another case of complete coma, I produced such movements by tickling the soles of the feet.

I would proceed to draw notice to a remarkably interesting case of paralysis, very minutely observed by Mr. Busk in the Seamen's Hospital, Dreadnought, and related by Dr. W. Budd in his admirable paper on the pathology of the spinal cord. The whole case merits most attentive study, but I must content myself with a passage or two to illustrate the antagonism between the will and the reflex movements. In allusion to the patient's improvement, it is remarked: "On the first return of voluntary power, the patient was enabled to restrain, in some measure, the excited movements; but this required a distinct effort of the will; and the first attempts to walk were curiously affected by persistence of the susceptibility to excited involuntary movements. When he first attempted to stand, the knees immediately became forcibly bent under him: this action of the legs being excited by contact of the soles with the ground. On the 95th day, this effect did not take place until the patient had made a few steps; the legs then tended to bend up, a movement which he counteracted by rubbing the surface of the belly; this rubbing excited the extensors to action, and the legs became extended with a jerk. A few more steps were then made; the manœuvre was repeated, and so on. This susceptibility to involuntary movements from impressions on the soles diminished; and, on the 141st day, as before stated, Colborne was able to walk about, supporting himself on the back of a chair, which he pushed before him; but his gait was unsteady, and much resembled that of chorea."*

I recently witnessed a very interesting case, in which involuntary movements of centric causation, were, whilst the paralysis was imperfect, resisted by the will; but, on the power of volition being quite destroyed, reflex movements could be occasioned, and most readily.

It was an example of paralysis from disease of the cord affecting it where it lies encased by the cervical vertebræ, which ultimately prevented the will from operating on both the upper and lower limbs.

* Medico-Chirurgical Transactions, vol. xxii. p. 173.

The complaint progressed for a while, without producing loss of sensation, or even spasm. One day, however, I observed the fingers in a state of involuntary flexion, and the patient complained of his feeling as though he were losing power over them. And with reason, for though by a strenuous exertion of his will, he succeeded in straightening the fingers, he found it hard to *prevent them bending again.* On his relaxing his effort, they recovered their former position. It seemed plain that the muscles were affected by direct irritation of the cord, and that the will could be transmitted also, and thus the hand was, so to speak, the scene of action of two opposing excitors of the motor force. Meanwhile the lower extremities could be moved, and sensation was perfect all over the body. A week passed, and there was a change of symptoms. There was complete loss of voluntary motion, both in legs and arms, but no anæsthesia. The lower extremities could be variously excited to reflex movements, but especially by tickling the soles of the feet, and the application of heat. Like movements could be excited in the arm, also, by tickling the palm of the hand.

On watching the steps by which affections of the motor columns of the cord make progress, it is remarked, occasionally, that certain muscles of a limb are spasmodically affected to the exclusion of the rest. In the preceding case, the flexors of the fingers were first affected, whilst the extensors were left free, and so it happened that the involuntary movements of the former were opposed by the voluntary exertions of the latter. It is so when a nerve is irritated in a given manner; merely certain fibres of it may be involved, and the parts supplied by *them* are only affected; and it is quite apparent that the will can resist spasms, by acting through the very nerve which causes them. Pathology, in cases of this sort, very interestingly exemplifies a law of the action of motor nerves, which has been laid down as follows by Professor Müller :—"The application of mechanical or galvanic irritation to a part of the fibres of a nerve, does not affect the motor power of the whole trunk, but only that of the insulated portion to which the stimulus is applied." Some experiments are brought forward in illustration. "The ischiatic nerve of a rabbit being laid bare where it issues from the pelvis, different portions of it which afterwards separate from the trunk as branches, may be easily irritated individually with a needle; and it will be satisfactorily seen that those muscles only are thrown into contractions, to which the irritated portion is ultimately distributed." Again, "having separated the ischiatic nerve, before its division into the tibeal and peroneal nerves, into several bundles, I irritated each of these singly, and saw different muscles thrown into contraction by irritation of different nervous fasciculi; thus, according to the fasciculus of the nerve that was irritated, the effect produced was contraction of the muscles of the calf, or extension or flexion of the toes."*

It will be seen that these ingenious experiments are modifications of those by which Haller proved so long ago that muscles were thrown into contraction by the direct irritation of a motor nerve: what is true of such nerve as a whole is true of every branch of it; nay, is true in due degree of every fibre of which it is composed. If the spinal cord or a motor nerve be physically irritated by disease of any kind, the phenomena will vary with the extent of the affection. In pathology we discover a repetition of the phenomena, which physiology has explained. There is great force, surely, in the striking observation, "La pathologie du système nerveux n'est donc autre chose que la physiologie experimentale appliquée à l'homme." The remark, however, must not be too indiscriminately applied; for doubtless there are *many* pathological phenomena to be met with in diseases of the nervous system, which physiological investigation fails to make clear. But, because it does not explain everything, some persons have acted as though it explained nothing, and rejected this most valuable interpreter of the language of disease.

With regard to the predisposing causes of reflex actions in the limbs in cases of paralysis, I think it cannot be doubted that a suspension or loss of voluntary power holds a chief place amongst them. Irritation of the cord

* See Dr. Baly's translation of Müller's Physiology, p. 728.

has been spoken of; but if mechanical irritation acting directly on the cord itself be signified by this term, it can only apply to a limited number of instances. The precise influence of such irritation requires to be investigated. Before any phenomena be imputed to and explained by it, let good evidence be given of its existence. If spasmodic actions should occur from time to time, quite independently of any impressions upon the surface, they may be attributed reasonably in some cases to centric irritation of this kind. They may more especially be referred to it if they should quickly supervene upon an injury of the spine, or some acute affection of the cord. Where they occur in the course of some chronic disease, by which paralysis is slowly occasioned, it is more difficult to refer spasms to such a source. It must be borne in mind that the mucous membrane presents a large periphery, which is exceedingly susceptible of irritants, which may produce *reflex* movements; and such movements are very apt to be considered of direct origin. Dr. W. Budd, in the contribution which I have already cited, says of his first case, that its interest consists partly in the fact of muscular contractions being excited by stimulus acting on the mucous membrane. And abundant ground for this instructive remark is to be found in the phenomena which suggested it. In connection with this conclusion, I may mention the physiological remark of Volkmann, who produced contractions of the bodies of headless frogs by irritating their intestines. It is manifest, even from these few reflections, that it must not hastily be concluded that movements are produced by centric irritation, simply because they are not caused reflexly by impressions on the skin. But granting that this irritation exists, what is its effect in relation to the causation of reflex actions? I do not doubt, and I found the remark upon observation, that in some cases centric irritation, by convulsing the muscles, so greatly exhausts the motor force that they are rendered less susceptible of the appropriate stimuli of reflex actions than they would be otherwise. At the same time, I am well aware that spasms from centric irritation and extreme proneness to reflex movements, occasionally co-exist.* The cord, as I need not say, may have its function deranged by alterations of the blood circulating through it, and the whole reflex system becomes consequently extraordinarily excitable; but I am limiting my remarks to cases of paralysis, in which abolition of voluntary power and accumulation of the motor force, are, I think, most commonly and principally concerned as the predisposing causes of reflex actions.

The consideration of volition, as touching paralysis, is a more complex question than would seem at first sight. It must be regarded in reference to its withdrawal being partial or complete; the time during which its power has been defective or has altogether ceased; the degree of energy with which it is employed; the state of sensation which may be found accompanying its own condition; the situation and kind of the accident or disease which has caused the diminution and loss of its power; the extent of its influence, assuming some influence yet remains, over the various sorts of involuntary movements, whether they be referable to centric irritation or to excitants acting on the mucous membrane or the cutaneous surface; and a careful observation of the way in which its action both modifies and becomes modified in the progress of the case.

Volition controls movements which are strictly emotional even as it does those which arise from physical causes. This is strikingly seen in some paralytic affections, which, whilst they remove the muscles from the sphere of the will, leave them very responsive to the impulses of the passions. I have observed in two cases of hemiplegia, which seemed to me perfect as to loss of voluntary power, the comparative state of the sound and affected limbs under various and more or less intense agitations of the mind. The paralysed arm was, singly, peculiarly affected.

* It is necessary to compare the results of attempts at producing reflex actions on various occasions. A great uniformity prevails at times; but in some cases they can be far more readily occasioned at some periods than others. This fact is to be observed in an instance of paraplegia now under the care of my brother, Mr. J. N. Barlow. I do not, of course, here refer to examples of variation which can be explained by the state of volition, or the effects of exciting the limbs to motion.

In one example it was most remarkably convulsed by passion, whilst that over which volition yet presided shared not in the spasmodic movements.

This instance, which happened some years ago, has altered features now: the arm has permanently assumed that shape which the once transient affection of its muscles caused it to put on: the forearm is bent upon the arm: the fingers look as though in spasm, and the whole limb is drawn towards the side. Occasionally, when the patient is excited, emotion is remarked to agitate the muscles, though now it can but very slightly change the outline of the limb.

I have repeated the observation of Sir Charles Bell, that features quite lost to volition may still be expressive of emotion; and here they may serve to shew what pure unblended expression is, as likened to that which the will modifies.

In idiocy there are emotions which are kept in check but faintly, or not at all, by the will; consequently there are extreme depictions of them in the face, and irregular, and occasionally spasmodic, movements of the limbs. The voluntary muscles in some of the worst forms of the affection are little more than indicators of intense excitement and the gusts of passion. Lately I examined a case wherein the power of the will seemed all but, if not quite, limited to one of the upper limbs, and here its action was so imperfect as to put ordinary prehension out of question; but the muscles of all the extremities would violently contract and quiver during emotion. Dr. Marshall Hall, who once visited this case with me, will well remember how extraordinary was the contrast between the effects of volition and emotion, and how excessively the latter predominated. Other cases, too, shew a like spectacle; but they must be seen to be known. Words fail to paint humanity in this miserable shape. Passion rules unrestrainedly where the will should calmly govern. The sight of food, a common sound, and objects which would but just serve to impress the mere special senses of an ordinary mind, arouse unusual ecstasy, and the frame is agitated, in consequence, as though it were electrified. Its muscles are as those of the paralytic when the mind agitates them, and no power of control remains.

The disturbance of the relations of the nervous system—a subject demanding the most anxious attention of the physician — is extraordinarily exemplified by hydrophobia. What should produce one reflex action only, causes more: thus the attempt at swallowing is followed either by spasmodic breathing or general convulsions. The hand tries to raise a cup to the lips: what act of volition can be simpler, easier? But emotion arises, and, acting on the morbidly irritable cord, renders the limb rigid and immoveable. Impressions of almost every kind are violent and unlimited in their action. Vision, touch, hearing—all become avenues to exquisite torture. Reflex actions are excited as readily and generally as they are known to be in the animal poisoned by strychnine or opium: a breath of air convulses universally. Emotion is excessive, both in degree and consequence: the sound of dropping water cannot be borne. A patient, says Dr. Marcet, was asked if he could gargle, and he fell into "a violent fit of suffocation." In a patient of Dr. Lettsom, the near approach of water, the mention of drink, the motion of a handkerchief, produced agitation. But even in this terrible affection a controlling power has been remarked in volition. Sir Astley Cooper observed, that the application of cold, when sudden, convulsed, but its impression could be sustained by aid of resolution. Attempts to overcome the difficulty of swallowing are known to succeed, though they fail often in spite of effort, and a fearful paroxysm overcomes the sufferer.

How extremely opposite is the state of health, wherein we see the reflex movements properly determined, the emotions regulated, the will obeyed, and all the nervous functions in due force and balance! But we are apt to overlook this concord of action, until disease reminds us how indispensable it is, by a demonstration of the consequences of its being broken.

P.S.—I have referred in the course of my paper to the following note of Dr. Baly's, in his translation of Müller's Physiology, p. 800. "According to a third opinion, that of Volkmann,

(Müller's Archiv, 1838, p. 32,) and Mr.F. Barlow, (Lancet, Jan. 11, 1840); the excited or reflex movements of paralysed limbs are the result of the unrestrained action of a property constantly possessed by the cord in the same degree, though ordinarily controlled by cerebral influence." I quite think this statement accurate, the words "in the same degree" being omitted. Experiment seems conclusively to demonstrate its correctness. I knew nothing of the view entertained by Volkmann until I saw the remark by Dr. Baly. In reference to the production of reflex actions by experiment on animals, I suppose many observers must have come, quite independently of each other, to the conclusion that the withdrawal of the will is an indispensable step to success in producing them. But the fact, I believe, has not even now been sufficiently insisted on or *applied*. I dwelt upon it particularly in a lecture that I delivered in 1839, to which Dr. Marshall Hall has made reference in a memoir read before the Royal Medico-Chirurgical Society in 1840. I stated, "that the function of the *true spinal cord* and that of the brain would appear to antagonise, and for a wise and salutary purpose." Mr. Grainger, however, as I have very recently observed, had before the publication of the remarks of Volkmann and myself, plainly stated that the power of volition can "stop the effect of the impressions transmitted by the incident nerves;" and, speaking of experiment, instanced the opposite effects of stimuli on limbs connected with the brain, and those deprived of its influence. (See his work on the Spinal Cord, p. 115, 1837). I would refer the reader to some other observations by this physiologist. The influence of volition over involuntary actions must be a most ancient remark; but I am quite ignorant when it was first stated. The most interesting illustrations of it are to be found in the first of our authorities. The great Hunter, for example, says characteristically of respiration: "Fresh air was necessary for our existence, and it was therefore necessary that it should be regulated by some other principle than that of the will; for it is necessary when we sleep, and also when we *will*. Therefore the will has its limits of power over the involuntary actions, and the involuntary have also their limits over the actions of the will; *each, therefore, can only go a certain length in opposition to the other.*" (Croonian Lectures on Muscular Motion, Palmer's edit. of his works, vol. iv.) It only remains to add, that I was led to write upon the influence of the will over involuntary actions, because I thought the subject of high importance, and most insufficiently considered. The nature of the actions regulated, (for amongst them are both direct and reflex movements), as well as the extent and degree to which the will prevails, as a restraining, moving, or superseding power, seemed to me to need fully pointing out. It is my desire to contribute a little towards this end, for I am persuaded that the strong and widely pervading energy of volition is very far from being taken into full and accurate account, either by physiologists or physicians. In a recent discussion at the Royal Medico-Chirurgical Society (March 29th, 1848), Dr. Baly, with his acknowledged impartiality, referred to the paper of Volkmann which I have mentioned above, and since then has been so kind as to translate some passages for me, *vi â voce*, and to give me a general notion of it. Some of the instances brought forward by that physiologist and myself are quite similar. I may refer to some remarks upon sleep, and the application of them. But (and here I borrow Dr. Baly's own words) "Volkmann refers the prevention of reflex action in certain cases, not to the *will*, but to the state of the mind which he calls "attention."

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