Alexander Technique scientific briefing

THE ROLE OF THE POSTURAL REFLEXES
in
HEALTH AND WELL-BEING

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DRAFT

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INTRODUCTION

If all the activity of the human body's six hundred skeletal muscles were consciously controlled, very little would get done. Despite its enormous computing capacity, the brain would not be able to handle the task of evaluating all the possible ways of carrying out every action and deciding on the best one. The marvellous speed, versatility and flexibility of human activity is only possible because most of it relies on reflex muscle actions.

Although modern neurophysiology enjoys access to increasingly precise and sophisticated measuring tools so that nowadays the functioning of individual neurons is readily monitored, understanding of the overall behaviour of the neuromuscular system is still based to a surprising extent on the insights of the early pioneers of neuroscience. Sir Charles Sherrington's 1906 work, *The integrative action of the nervous system,* is regarded as the founding text of modern neuroscience and is largely devoted to the working of the innate reflex systems of the vertebrate animal. Within that framework, Sherrington's contemporary, and protégé, Rudolph Magnus, an almost certain Nobel prize-winner were it not for his sudden early death, devoted his research talents to elucidating the postural reflexes. The best part of a century later, their neurological discoveries and insights retain most of their freshness and relevance.

The work of these and other early neuroscientists looked at the overall patterns of neuromuscular functioning in vertebrates. The special concern of this paper is the relevance of this neuroscientific work to human beings. The postural reflexes are not solely concerned with the way we sit and stand. When these reflexes are allowed to do their job properly, they automatically bring about a smooth and harmonious integration of the different parts of the body in all its activities. When they are prevented from working as they should, the functioning of the whole musculature deteriorates, leading to localised joint and muscle problems as well as damaging effects on our physical and psychological health.

In the present-day flood of new and detailed knowledge at the disposal of those concerned with health, fitness, and well-being the need for an integrated view of what is happening in the total neuromuscular system is often overlooked. Fitness programmes and exercise regimes tend to focus on the closely-identified deficiencies of particular body areas and muscle groups. Back and shoulder pains, weak knees and ankles, stiffening hip joints and the general aches and injuries of ordinary living are treated with rubs, supports, painkillers, and programmes of strengthening exercises without taking into account the larger-scale postural malfunctioning which inevitably accompanies these specific problems.

This paper provides a background briefing on the neuroscience of the postural reflexes and explores the relevance of this for the care and maintenance of the overall neuromuscular system. It looks particularly at the role of the head-neck relationship which was highlighted by Magnus and Sherrington and has been the subject of much subsequent study. Malfunctioning in the head-neck area, as any experienced physical therapist will attest, is implicated in a range of ailments from tension-headaches to flat feet.

Section 1 gives a brief introduction to the careers and work of Sir Charles Sherrington and Rudolph Magnus whose neurological research and findings are the main topic of this paper; it also provides some definitions and background on the terms reflex and posture. Section 2 examines Magnus' research findings in some detail. Section 3 attempts to weave together a broader perspective on the significance of the postural reflexes in the overall functioning of the neuromuscular system. Section 4 examines some of the scientific work that has been subsequently carried out on the head-neck relationship the importance of which was highlighted by Magnus. This section draws particularly on the proceedings of an international symposium on the head-neck sensory motor system held in Paris in 1991 at which over two hundred papers were presented.

Section 5 looks at the Alexander Technique. F. M. Alexander, an Australian actor, who was a near contemporary of Sherrington's came to London in 1904. While developing a method of dealing with his own voice problems, he had himself become aware of the importance of the head-neck relationship in neuromuscular functioning He referred to it as *the primary control* making it a central concern in what has become known as the Alexander Technique.

In his last book, Sherrington explicitly praises Alexander and his approach. The final section therefore examines the Alexander Technique through what might be called a "Sherringtonian" or "Magnusian" lens. Alexander was no neuroscientist, and there is no record of him ever using the phrase "postural reflex". But he was a shrewd and meticulous observer and the key aspects of his Technique fit readily within, and are illuminated by, the work of Magnus and Sherrington. This section also looks at some scientific observations on the Technique made by the anatomist and paleo-anthropologist Raymond Dart and the developmental biologist George Ellett Coghill based on their personal experience with Alexander and his writings.

The paper is addressed to healthcare professionals, Alexander Technique teachers, experienced pupils in the Technique and others interested in the neuroscience behind muscle and joint functioning, exercise and physical fitness.

SECTION 1: BACKGROUND

Understanding of the nervous system began to grow rapidly from the middle of the 19th century. Charles Sherrington's experimental studies during the 1890s resulted in some of the key scientific breakthroughs but it was his master-work *The integrative action of the nervous system* published in 1906 which synthesised what had gone before and created the still-existing framework of modern neuroscience. Rudolph Magnus, taking inspiration from Sherrington, began work on the postural reflexes in 1908 and produced the definitive study of their functioning in 1924.

To discuss either *reflex* and *posture* without defining them is inviting trouble. Both words are so encrusted with popular impressions that hardly any two people would agree on what exactly they mean by them. The following discussion is not an attempt to lay down the law on what these terms "should" mean. It is simply to clarify from the beginning how they are used in this paper.

Charles Sherrington and Rudolph Magnus

These two distinguished scientists share the common fate of many great pioneers in their subjects. Their work defined the territory and became so widely and deeply taken for granted that people no longer refer to their original contribution. As this paper is specifically concerned with their findings on the postural reflexes, it is worth putting their findings into context by giving a brief account of their careers.

Charles Sherrington

Sherrington was born in 1857. A bright student, he qualified as a member of the Royal College of Surgeons in 1884 and obtained a medical degree from Cambridge University in 1885.

In 1891, he became the Physician-Superintendent of an animal research centre, called the Brown Institute in the University of London. In the four years he spent there he produced a stream of research papers which began to "build the foundation on which modern neurology is based."[1] He was elected a fellow of the Royal Society in 1893 and became Professor of Physiology at Liverpool University in 1895. This was one of the most productive periods of Sherrington's career. He became professor of Physiology at Oxford in 1913 and remained there until his retirement in 1936 at the age of 79.

He published a total of 320 scientific papers in his career covering nearly every aspect of mammalian nervous functioning. He identified the function of the synapse in the nervous system, and coined the name; he found that reflexes must be regarded as integrated actions of the total organism, not isolated activities of groups of muscles as was believed at the time; and carried out a variety of experimental studies on the postural functions of the nervous system.

Additionally he maintained a broad range of cultural interests. His last book was a life of the 16th century French physician Jean Fernel whom Sherrington saw as a key figure in the emergence of the scientific attitude. This was published as *The Endeavour of Jean Fernel* in 1946. The following year *The integrative action of the nervous system* was republished as a tribute to Sherrington on his ninetieth birthday.

[1] Cohen (1958)p7

He contributed a long new introduction which showed how little the intervening forty years had dimmed his interest and intellectual capacities.

He became President of the Royal Society in 1920, received his knighthood in 1922, the Order of Merit in 1924, and was awarded the Nobel Prize in 1932. In addition he received numerous international honours. He died in 1952.

Rudolph Magnus

It was Rudolph Magnus, rather than Sherrington himself, who carried out the defining studies on the postural reflexes. Magnus was born in Germany in 1873 and studied in the University of Heidelberg where he qualified as a medical doctor with a specialisation in pharmacology in 1898. He then took up a position in the pharmacology department in the University and became an associate professor. At that stage in his career, he was primarily interested in the physiological effects of drugs and kept in touch with the rapid developments in physiology then taking place.

He attended the Third International Physiology Congress in Berne in 1895 where he witnessed an experiment by Sherrington.[2] Three years later at another international physiology congress, this time in Cambridge, he saw an experiment by Sherrington which he described as "elegant.[3] In the meantime, his own reputation in pharmacology was growing and he presented some of the results of his research into the effects of various drugs on intestinal functioning at an international congress in 1904.

Like many of the major scientists of his day, he had a broad classical education and was particularly interested in Goethe and Kant. Round this time, he gained access to the collection of Goethe's scientific experimental equipment at the Goethe Museum in Weimar and persuaded the museum authorities to allow him to repeat the experiments on which Goethe's had based his theory of colour. Arising from this experimental work and his research into the Goethe archives, Magnus delivered a series of lectures on Goethe as a scientist at the University of Heidelberg. These appeared in book form in 1906 and were published in an English translation in 1949.[4]

Magnus remained interested in philosophical issues all his life and was particularly curious about how the nervous system provides us with *a priori* – or innate – knowledge. This was, in fact, to be the subject of a lecture at Stanford University, never delivered because of his death, but which was published some years later.[5] In 1908, he visited Sherrington in Liverpool and spent some time working with him in his laboratory on a problem of muscle excitation. This visit changed the course of Magnus' life.

His biographer comments:

> *… he could not have anticipated that this would be the start of a long series of investigations on posture for which he would gain lasting international recognition.*[6]

On his return to the University of Utrecht, where he had just been appointed Professor of Pharmacology, he set up a programme to investigate the neurophysiology of

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[2] O. Magnus (2002)p51
[3] Ibid. p66
[4] Ibid. p145
[5] Magnus (1930)p97
[6] O. Magnus (2002)p143

posture. It turned out to be a task which occupied the greater part of his scientific talents for the rest of his life. Sherrington, despite his own interest in the subject, was content to leave the bulk of the research on posture to Magnus and his colleagues in Utrecht.

In his contacts with Magnus, Sherrington had clearly converted him to the view that the question of posture was not only more complex than it looked at first sight, but that it also opened up fruitful areas of investigation into the overall functioning of the neuromuscular system. When presenting the results of his work some eighteen years later, Magnus had this to say about why he had chosen posture as his primary research subject

> *Movement affords many points of attack for research because by movement, changes in the condition of the body or its parts occur, which attract the attention of the observer and can be recorded and measured. This is not the case when posture is studied so that our desire for causality is not stimulated, and we therefore do not immediately suppose that active processes are at work. In consequence of this the physiology of posture is of relatively recent date and many facts to be described in these lectures have been discovered by still living scientists among whom Sherrington must be named in the first place. The chief result of these investigations is that posture is an active process, and is the result of the cooperation of a great number of reflexes, many of which have a tonic character.*[7]

The First World War disrupted research activities as well as communication between the two men and it was the mid-1920s before the full fruits of Magnus' work were made public. Not long afterwards, in 1927, he died unexpectedly at the age of 54 while on holiday in Switzerland. Although it was widely expected he would be nominated for the Nobel Prize in that year it is not awarded posthumously.

What is a reflex?

Even among scientists, the term *reflex* is used in a variety of ways. Because of the lack of an agreed definition, some authors have even wondered whether the distinction between reflex and voluntary has any remaining scientific justification.[8] But if care is taken to be clear about what is meant by it, the term *reflex* can fill a need.

For the purpose of the present paper, Sherrington's definition is adopted. In his introduction to the 1947 re-publication of *The integrative action of the nervous system* he wrote:

> *The behaviour of the spider is reported to be entirely reflex; but reflex action, judging by what we can sample of it, would go little way toward meeting the life of external relation of a horse or cat or dog, still less of ourselves. As life develops it would seem that in the field of external relation "conscious" behaviour tends to replace reflex, and conscious acts to bulk larger and larger. Along with this change, and indeed as part of it, would seem an increased role for "habit". Habit*

[7] Magnus (1926a)p531

[8] Prochazka (2000)

> *arises always in conscious action; reflex behaviour never arises in conscious action. Habit is always acquired behaviour, reflex behaviour is always inherent and innately given. Habit is not to be confounded with reflex action.*[9]

Berta Bobath, whose well-known text on *Abnormal postural reflex activity* describes her pioneering approach to the treatment of cerebral palsy and other neurologically based muscular disorders, also had doubts about the use of the term *reflex*. She suggested it would be more useful to refer to *"postural reactions"* or *"responses"* but settled for Sherrington's definition. In the third edition of her text, published in 1985, she says:

> *In keeping with the publications available to us in 1965 and 1971, we used the term 'reflexes' rather loosely. However, we now accept Sherrington's view that a reflex is a stereotyped response, always recurring in the same unchanging manner…*[10]

As Sherrington defined it, much of what commonly passes for reflex action is, in fact, learned behaviour. Certain actions become learned so thoroughly that they are carried out without conscious thought. It is easy to recognise this in the "mindless" routines of household or work tasks; but it is also true of the way athletes and sports people go about many of their activities. Despite the common journalistic description of various rapid sporting responses as *reflex*, no one is born with the ability to return a high-speed tennis serve or respond to a starter's gun in one-hundredth of a second; these are learned skills. Pavlov's so-called "conditioned reflex" is another example of learned behaviour. So also are the distinctive ways in which each one of us walks, sits, breathes, talks and carries out the countless actions of daily life. All these activities carry the imprint of learned experience.

In the context of this paper, Sherrington's distinction is important because it draws a line between activities that can be learned and those which are evoked from the innate capacities of the neuromuscular system. This is not a differentiation between types of muscle behaviour – whether reflex or voluntary, muscle contractions are essentially the same – but of whether they are controlled from the cortex or sub-cortically.

In addition to recognising the importance of the distinction between learned and reflex, it is also important to note that there are linkages between our consciously-willed actions and the underlying patterns of reflex and learned behaviour. In a striking passage in his last book, Sherrington says:

> *It is largely the reflex element in the willed movement or posture which, by reason of its unconscious character, defeats our attempts to know the "how" of the doing of even a willed act…Of the proprioceptive reflexes as such, whether of muscles or ear (vestibule) we are unconscious. We have no direct experience of the 'wash' of the labyrinthine fluid or, indeed, of the existence of the labyrinths at all…*[11]

In this passage, Sherrington is pointing out that even our simplest voluntary actions are supported on a dynamic infrastructure of innate reflex muscle activity. Whenever

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[9] Sherrington (1906)pxvi
[10] Bobath (1985)pxi
[11] Sherrington (1946)p89

we do something deliberately, we unconsciously bring into play a huge number of reflex responses, varying from subtle balancing adjustments in the tone, or tension, in the muscles in various parts of the body – these are referred to as “tonic reflexes” – through to the quick and often effortful movements of limbs that take place, for example, when we towel ourselves vigorously after a shower or make a dash for a bus. The important point is that whatever deliberate action we perform and no matter how we concentrate on it, the details of the associated supporting and compensatory muscular contractions and releases happen reflexly, independently of any conscious input from the brain.

It is thus paradoxical that although we readily take responsibility for our conscious acts we do not know exactly how we manage to do them. More interestingly, it is the superstructure of consciousness which enables humans – unlike horses, dogs, and still less spiders – to acquire habits that distort and interfere with the working of their reflexes and undermine the functioning of their own selves. The way in which human learned behaviour interacts, often detrimentally, with the relationship between the deliberate and the reflex is a theme which is developed in the later parts of this paper.

It is also worth making clear that Sherrington had no sympathy with the reductionist view that all activity is reflex, simply the result of automatic neurological responses to external or internal stimuli. Although the reflexes provide the essential underpinning for all the body’s activities, for Sherrington the volitional decision-making mind occupies the primary role in human behaviour.

The question of posture

The word *posture* is also used in widely different ways. Many of its meanings are associated with deliberately assumed ways of holding the body. Walking about, stiffly balancing a book on the head, used to be a common way of training young people in what was supposed to be good posture. In this paper, the word posture refers to the natural, or innate, relationship of the parts of the body to each other in sitting, standing or walking; it is perhaps best approximated by the old-fashioned word “carriage”.

The question of posture, at first sight, seems an unlikely focal point for some of the major advances in neuroscience made in the early decades of the 20th century. Yet from an early date Sherrington had seen how the maintenance of posture was just as complex and demanding of the nervous system as movement.

As he said:

> *…much of the reflex reaction expressed by the skeletal musculature is postural. The bony and other levers of the body are maintained in certain attitudes both in regard to the horizon, to the vertical, and to one another…Innervation and co-ordination are as fully demanded for the maintenance of a posture as for the execution of a movement.* [12]

Far from representing a fixed and rigid configuration of the muscles, posture displays them in action in patterns as dynamic, if not so immediately evident as those of movement.

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[12] Sherrington (1906)p339

SECTION 2: MAGNUS' RESEARCH

The question Magnus posed himself was a challenging one. Posture is in constant flux. The flow of nerve impulses from the nervous system to the muscles is continually changing in response to the sensory inputs from the external world as well as those from the various feedback systems within the body itself.

Magnus set himself the task of identifying the separate functions of the different interacting systems involved in this. He was particularly interested in clarifying the role of the postural reflex systems and distinguishing their activity from that deriving from voluntary or learned patterns of behaviour. He was assisted in this work by a team of researchers – one of these was the noted otologist Adriaan de Kleijn who was Magnus' co-author in numerous scientific papers.

The research approach

Magnus and his associates investigated the postural reflexes in a variety of vertebrate animals including dogs, cats, monkeys and guinea pigs. The experimental methods demanded sophisticated brain surgery and many of the techniques had been developed by Sherrington utilising the skills he had acquired as a medical doctor and surgeon before starting his neuroscientific research career.

In most cases the researchers worked with animals from which the two cerebral hemispheres had been removed; such an animal is called a *decerebrate preparation.* The removal of the cerebral hemispheres in these animals eliminated any element of the voluntary from their activity; their actions were guaranteed to be purely reflex. Although these were distressing experiments, the fact that the animals were anaesthetised before being operated upon and that the higher brain centres were removed meant that the possibility of their feeling any physical pain during the experimental work had been eliminated.

Magnus' approach was to start with the simplest postural functions, as displayed in an animal from which the whole brain, from the top of the spinal cord upward, had been removed or detached from connection with the spinal cord; this was termed a *spinal animal*. Having established which reflexes were controlled from the spinal cord alone, the researchers looked at the behaviour of animals in which more of the brain was allowed to function. They did this by making cuts at successively higher levels in the lower brain and seeing which additional postural capabilities were added as more of the brain became involved. In this way, it was possible to identify which postural functions were located in which parts of the lower brain.

In Magnus' own words:

> *The known functions of the isolated spinal cord served as a starting point. The new functions acquired by the spinal cord when it is connected with the medulla oblongata were then established. After this, the midbrain could be added resulting in the normal distribution of tonus and the righting reflexes as new functional acquisitions. Finally the principal postural functions were found intact after the cerebellum was removed and thus their localization in the brainstem was established.*[13]

[13] Magnus (1924)p655

Although the experimental work was carried out on animals, the neurological structures and basic functioning of the nervous system is similar in all vertebrates. Magnus makes a variety of references in his published work to ways in which his findings shed light on human functioning. The physiologist Berta Bobath, for example, relied on his findings in developing her methods of diagnosis and treatment of children suffering from cerebral palsy and related postural abnormalities as a result of brain damage.[14]

The vestibular apparatus

The balance, or equilibrium, of the body is intimately related to posture. The term *static equilibrium* is often used to refer to when the body is retaining its position relative to the force of gravity. The body must also be able to retain its balance when its parts are moved relative to each other and when the whole body is in motion; this is usually referred to as *dynamic equilibrium*. Both of these aspects of balance are largely controlled by the vestibular apparatus.

Since the vestibular apparatus was the subject of many of Magnus' experiments, it is worth outlining briefly what is involved. The inner ear houses a maze of winding passages, collectively called the labyrinth. The labyrinth is divided into three areas, the vestibule and, projecting above and backwards from it, the three curved ducts known as the semicircular canals; and the cochlea which contains the hearing receptors. Within the vestibule are two sacs, the utricle and saccule, known as the otolith organs. The utricle and the saccule, together with the semicircular canals, are known as the organs for equilibrium and make up the vestibular apparatus.

The otolith organs provide information on the tilt of the head. The walls of both the saccule and the utricle contain a small thickened area called the macula. Each of the two maculae, which are set at right angles to each other, supports a set of tiny hair cells. The hair cells are bathed in a gelatinous layer called the otolithic membrane in which is embedded a layer of dense calcium carbonate crystals called otoliths – otolith literally means "ear-stone".

When the head is in its normal position with the gaze horizontal, the hair cells in the utricle are positioned horizontally and those in the saccule are positioned vertically. When the head is then tilted forward, backward or sideways, the otolithic membrane lags slightly behind the movement of the head. This causes the hair cells to bend, resulting in the transmission of impulses through the utricular and saccular nerves to the vestibular branch of the vestibulocochlear nerve.[15] The otolith organs, in this way, act as a three-dimensional system, a complex type of spirit level, for monitoring the tilt of the head from moment to moment.

The three semicircular canals provide information on movements of the head. They are set at right angles to each other in three planes and consist of ducts filled with a fluid called endolymph. One end of each canal has a small expanded or dilated area called the ampulla. In each ampulla, there is a ridge or swelling upwards from the base of the canal called the crista. On top of the crista, a group of hair cells projects upwards and is covered by a small mass of gelatinous material called the cupula.

When the head moves, the movement of the cupula, because of its inertia, is delayed slightly compared to that of the head. This drags the hair cells on the crista out of

[14] Bobath (1985)p

[15] Davson (1990)p678

their resting position, causing them to generate nerve impulses. Smooth movement is insufficient to stimulate the semicircular canals; there must be a change in the rate of movement, either acceleration or deceleration. These nerve impulses are collected in the ampullary nerves and are also fed into the vestibular branch of the vestibulocochlear nerve.

Magnus' findings

Magnus and his colleagues published numerous scientific papers as their research proceeded so that the scientific world was kept aware of their progress. Their detailed final report covering the findings of the whole research project was published in German under the title *Korperstellung* in 1924. Although this volume was not translated into English until 1987, this was not the problem it would be today since most scientists of Magnus' time were literate in German, which had been regarded as *the language of science* in the 19th century. In 1924, Magnus' scientific reputation was already high as a result of his published papers and with the publication of the final report his full research results would have been accessible to all the leading neuro-physiologists around the world.

The first major public presentation of Magnus' work in English was in the 1925 Croonian Lecture at the Royal Society in London, with Sherrington, who was at that time President of the Royal Society, in the chair. It was probably the most prestigious setting of the time for the public announcement of important scientific work. Magnus also presented his findings in 1926 in the two Cameron Prize Lectures in the University of Edinburgh, both of which were reprinted in *The Lancet* in the same year.

As a starting point for his Royal Society lecture, Magnus identified four aspects of posture which he felt needed to be examined in detail. He termed them, *partial problems* and listed them as *reflex standing, normal distribution of tone, attitude,* and *the righting function*. This division is, of course, artificial since in the intact animal all these aspects of posture are present and interacting all the time. But considering them separately provides additional insights into what is involved in the totality of posture, both when it is working properly and when it malfunctions.

Reflex standing

If an animal is to stand normally, the muscles used in standing must be able to maintain the necessary tone. Magnus found that spinal animals, those in which the whole brain had been extirpated, were capable of complex movements when they were suspended in an upright position. They were, for example, able to make running and walking movements when the pads of their feet were stimulated, showing that these actions are controlled in the spinal cord. But these animals collapsed if they were placed in a standing position.

Magnus remarks:

> *"The centres of the spinal cord can indeed cause and regulate very complicated combinations of movements, but they are unable to give the muscles that steady and enduring tone which is necessary for simple standing."*[16]

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[16] Magnus (1925)p341

Ed When more of the brain was left in place by making the cut further up the brainstem, somewhere between the medulla oblongata and the foremost part of the midbrain, the animal was able to stand. But it did so in a state of what is called *decerebrate rigidity.* The antigravity muscles, the extensors of the limbs, the extensors of the back, the elevators of the neck and tail, and the closing muscles of the jaws, had abnormally high tone, whereas their antagonists, the flexors, had virtually none. The overall result was that, although the animal could stand if it were placed on its feet, the distribution of tone was abnormal and the animal's posture was stiff and distorted.[17]

Magnus makes the additional comment:

> *The stimuli inducing the enduring tone of the standing muscles in decerebrate rigidity arise from different sources, the proprioceptive sense organs in the contracted muscles themselves playing the most prominent role.*[18]

He is pointing out here that excessive muscle tone, once it has developed, has a tendency to become self-sustaining. This is because when there is excess tension in the muscles their own internal sensing organs, their proprioceptors, are stimulated to produce signals to the nervous system which result in that state being maintained.

Normal distribution of tone

In normal standing, the extensor and flexor muscles have the level of tone required to keep them in balance with each other. Magnus found that this occurred when the cut in the brain was made at such a level that the thalamus was included, producing what the researchers called a *mid-brain animal* or a *thalamus animal.* In these creatures, he found that both the distribution of muscle tone and the standing posture were more or less normal.

He says:

> *In the thalamus animal the extensors of the limbs just have sufficient tension to balance the weight of the body against gravity, so that every force tending to raise or lower the body can easily move it in one or the other direction.*[19]

This was a persuasive experimental demonstration that in the case of these animals normal standing, including gentle movement around the equilibrium position, even though it involves complex interactions throughout the whole skeletal muscle system, was working as a wholly reflex activity and was able to take place in the absence of the cerebral cortex.

Attitude

Magnus uses the term *attitude* to refer to how the parts of the body relate positionally to each other. The *attitudinal reflexes* come into action when the position or the tone in one part changes in relation to the rest of the body. An example of this is when a part of the body is braced or stiffened. As this happens, the attitudinal reflexes bring about compensatory changes in the rest of the body so that the muscular system remains in an overall state of balanced tone.

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[17] Ibid. p341
[18] Ibid. p341
[19] Ibid. p342

Magnus remarks:

> *It is noteworthy that these reflexes are most easily evoked from the foremost part of the body, from the head, in which the teleceptive sense organs are situated, so that distance stimuli influencing the position of the head can in this way also impress different attitudes upon the whole body. One can, in fact, in the decerebrate animal, by simply changing the position of the head, give to the body a great number of attitudes, resembling closely the normal harmonious attitudes of the intact animal.*[20]

By the *teleceptive sense organs,* Magnus means those sense organs which detect objects at a distance, as opposed to the proprioceptors which detect changes inside the body. The eyes are the most important teleceptors in humans and many other animals; but hearing and the sense of smell are equally or more important in others. He is pointing out that when these teleceptive organs detect an object it tends to evoke changes in the position of the head; we look towards the object the eyes have detected or seek the source of the smell. The change in the position of the head, through the medium of the vestibular system and the neck proprioceptors, brings about reflex changes in the muscles in the rest of the body.

As Magnus describes it:

> *It is possible, by giving to the head different positions, to change the distribution of tone in the whole body musculature… The most striking reactions appear in the extensors of the limbs and in the neck muscles. The effects observed are the result of combined reflexes from the labyrinths and from proprioceptive neck receptors, and … in this way, it is possible to impress upon the whole body different adapted attitudes by changing only the position of the head.*[21]

As an example of the attitudinal reflexes at work in an intact animal, Magnus instances a cat standing in the middle of a room. A mouse runs along the foot of one wall, attracting the cat's attention. The simple act of turning its head to watch the mouse evokes a series of attitudinal reflexes which automatically put the cat into a posture of readiness, with the weight on three paws, and the other slightly lifted and ready to move. The result is that if a signal to pounce were to come from its cortex, the cat is perfectly poised for action.

Magnus' description of what is taking place here is a model of meticulous observation and analysis:

> *The distribution of excitability in the motor centres of the spinal cord is rearranged by the turning of the neck, so that, if for some reason running movements begin, the limb which has no static function will always make the first step. In this way, the moving mouse impresses on the cat, through the mediation of tonic neck reflexes an attitude, by which the cat is focussed towards the mouse and made ready for movement. The only thing the cat has to do is to decide: to jump or not to jump; all other things have been prepared beforehand reflexly under*

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[20] Ibid. p342
[21] Magnus (1926a)p534

> *the influence of the mouse, which will be the object of the resulting jump.*[22]

Even when the eyes are not involved, the attitudinal reflexes can be evoked by simply moving the head. Magnus was able to demonstrate this by working with decerebrate animals in which any influence of the eyes is negated by the absence of the visual cortex. He found that by altering the position of the head the distribution of tension or tone (often referred to as tonus in older texts) was changed through the entire musculature. These experiments also showed that the distribution of tone remained constant as long as the position of the head remained the same.

He says:

> *The changed distribution of tonus in the extensor muscles of the limbs continues as long as the head retains its specific relation to the trunk, making way for another distribution of tension immediately upon alteration of the position of the head with respect to the trunk. It has been found that for most changes of the relation of the head to the body either the extremities on the right and left side, or of the fore and hind limbs react in an opposite way.*[23]

The point in the above quotation about limbs on the right and left sides reacting in an opposite way refers to what Sherrington called the *crossed reflex* which he examined in considerable detail. Sherrington found that many of the leg reflexes in animals evoked a contrary reflex in the opposite sense and in the opposite leg. If reflex extension is induced in left hind leg, for example, it tends to stimulate a flexion reflex in the right foreleg; such a pattern of reflexes is evident, for example, in walking. Magnus was pointing out that simply turning the head to one side tends to produce a similar crossed-reflex pattern.

He also makes the point that the attitudinal reflexes can maintain a particular attitude for a very long time without the muscles becoming tired. He says:

> *These reflexes are called tonic, because they last as long as the head keeps a certain position; and that not only for minutes and hours, but for days, months and even years…We are accustomed to believe that muscular action is liable to fatigue, and this, of course, is true for movements, and especially for movements performed against resistance. But muscular action concerned in keeping some part of the body in constant and unchanging position gives rise to much less fatigue, and the attitudinal tonic reflexes evoked from the head appear to be practically indefatigable.*[24]

The fact that these attitudinal tonic reflexes can last for years is indeed remarkable. Magnus' observations prefigure the findings by later scientists that it is the non-fatiguable red fibres in muscles that are primarily involved in posture. One of the earliest to point this out, in a paper to the Royal Society in 1929, was Sherrington's colleague Denney-Brown.[25]

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[22] Magnus (1925)p345
[23] Magnus (1924)p7
[24] Magnus (1925)p344
[25] McComas (1996) p191

The righting reflexes

The *righting reflexes* restore an animal to its normal posture if it is displaced from this by its own actions or by an external force. These reflexes, unlike the tonic attitudinal reflexes, can bring about major movements of the body. The two types of reflex, however, tend to shade seamlessly into each other and in the normal intact animal there is no clear demarcation between them.

As Sherrington said:

> *Naturally, the distinction between reflexes of attitude and reflexes of movement is not in all cases sharp and abrupt. Between a short lasting attitude and a slowly progressing movement the difference is hardly more than one of degree.*[26]

Magnus remarks that the righting reflexes are best studied in a animal in which the cut in the brain has been made at a level which leaves the thalamus in place. In this case, Magnus says:

> *Not only is the distribution of tone a normal one, but also the righting function is fully developed, and the animal is able, from all abnormal positions, to come back reflexly into the normal position. The reflexes which co-operate in attaining this result are the "righting reflexes." They can best be studied in the mid-brain or thalamus animal, in which the fore-brain has been removed, so that no voluntary corrections of abnormal sensations are possible.*[27]

When a thalamus animal is lifted by the body and held in space with the head and neck free, the head retains its position no matter how the rest of the body is moved about. As Magnus observes *"Whatever situation one gives to the hind part of the body, the head is kept, as by a magic force, in its normal position in space."*[28] He describes these reflexes which bring about the automatic preservation of the normal orientation of the head as the *"head righting reflexes"*.

In other experiments of this kind, however, Magnus found that if the labyrinths are extirpated, the head shows no tendency to hold its position when the body is moved. In this case, the position and orientation of the head are determined by what is happening in the rest of the body. Without the labyrinths, in other words, the nervous system is deprived of an absolute measure of the relationship of the head to the horizontal or vertical. In everyday human life a hint of this may be experienced as the feeling of impaired balance that sometimes accompanies an inner ear infection; the reason is that the infection has interfered with the working of the labyrinths and their role in detecting changes in the position and orientation of the head.

If the head is displaced from its normal position and the labyrinths are in place, the head righting reflexes bring about a cascade of further reflexes through the body. Magnus demonstrated this using a decerebrate animal lying on its side. When the head is lifted and turned to face forward, a twist is induced in the neck. As a result, the proprioceptive sense organs in the muscles, tendons and joints of the neck are stimulated; this activates the reflexes which bring the thorax back into the normal relationship with the head, thereby untwisting the neck. This, in turn, leaves the

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[26] Sherrington (1906)p340
[27] Magnus (1925)p347
[28] Ibid. p347

lumbar area twisted relative to the thorax, which brings further reflexes into action, causing the lower body to untwist itself, so that the whole body is now brought into its normal position.

This is a simplified description of what happens in practice since the tactile sensors in the skin are also stimulated by the contact with the floor and provide further input to the various reflex systems. In the intact animal, there is also input from the eyes. Magnus fully recognises this and points out that there is a considerable degree of redundancy, or duplication, in the way the righting reflexes are stimulated and carry out their tasks, saying:

> *The integrity of every single factor of this complicated function is doubly ensured. The head is righted by labyrinthine, tactile, and optical stimuli; the body by proprioceptive and tactile stimuli. The tactile stimuli act separately upon the body and upon the head. The orientation of the head and of the body takes place in relation to gravity, sustaining surface (ground etc), distant environment (optical), and to the different parts of the body – a very complex combination of reflexes. It is indeed an interesting task to watch the cooperation and interference of these reflexes during the movements of various animals in their ordinary life.*[29]

The ability to twist the body into the appropriate position and get up from the ground is obviously of critical importance to the survival of any animal and this is why it is *"doubly ensured"* by the reflex system. But among the various systems involved it is particularly notable how changes in the position of the head relative to the rest of the body, through the mediation of the neck, have major effects throughout the whole of the body's musculature.

The optical righting reflexes

A further set of reflexes explored by Magnus are known as the *optical righting reflexes*; these are triggered by movements of the eyes in their sockets. Since the visual centres in the cortex are involved in the processing of nerve impulses coming from the retina of the eye, these reflexes are only found when the cerebral cortex is present.

The way in which movements of the eyes can influence the whole functioning of the body was a subject which interested Sherrington greatly. He had written at length about it in *The Integrative action of the nervous system,* well before Magnus began his research into the postural reflexes. Sherrington remarked on how the movements of the eyes have a

> *…tendency to work or control the musculature of the animal as a whole – as a single machine – to impel locomotion or to cut it short by the assumption of some total posture, some attitude which involves steady posture not of one limb or one appendage alone, but of all, so as to maintain an attitude of the body as a whole.*[30]

An obvious example of this is the cat watching the mouse described above by Magnus. If we pay close attention to what is happening in ourselves as the direction of our gaze shifts, we can also notice the way our body gradually adapts to the

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[29] Magnus (1926b)p587

[30] Sherrington (1906)p326

direction of the gaze, most evidently when we are following an object with close attention – when bird-watching for example – but also in the way minute changes occur in the muscles throughout the body as the gaze flickers about in normal activity.

Discussing the same question of the way the eyes influence the rest of the body, Magnus said:

> *…if the attention of the animal is attracted by something in its environment, and it therefore fixes the latter with its eyes, the head is immediately brought to the normal position and kept so as long as the optical attention is focussed on the object. So a telereceptor has gained influence upon the righting apparatus. This is the only righting reflex having its centre not in the brainstem but higher up in the cortex cerebri.*[31]

He goes on to describe what happens when food is held in front of an animal and lowered so that the animal bends its head downwards towards the belly, in the ventral direction, or lifted so that animal moves its head backwards, in the dorsal direction. This is an everyday sequence of actions to which the great majority of people would give little thought. But to Magnus it was a matter of major significance which showed that by means of

> *… stimuli transferred to the animal by the distance receptors (eye, ear, nose), it is possible to impress upon the body of the animal different attitudes from distant points of the environment. A cat which sees some food lying on the ground flexes the head in the ventral direction and this causes the fore-limbs to relax so that the snout is moved towards the food; but if a piece of meat be held high in the air the optic stimulus causes dorsiflexion of the head. This evokes strong extension of the fore-limbs without marked extension of the hind-limbs. The body of the animal is not only focused on the meat, but is also brought into a position which is optimum for the springing reflex, so that by a strong sudden simultaneous extension of the hind-limbs the animal can reach the meat.*[32]

It is evident that a great deal of neurological and muscular activity is involved in such simple actions. Taking just the eyes, the position of each in its socket is determined by the action of six extraocular or extrinsic muscles. These provide the eye with a high degree of mobility enabling it to rotate up, down or sideways. They must also work in a meticulously coordinated way to ensure that the binocular vision they enjoy when they are in their resting position, centralised in their sockets and looking straight ahead, is maintained as the eyes swivel from object to object. Added to that, the eyes must be able to maintain this level of coordinated control as the head itself moves about. Magnus describes the system which controls this as an "*…extremely well-adjusted central apparatus which governs <u>the positions of the eyes.</u>*"[33]

Characteristically, he was intent on disentangling the various systems involved in the workings of this central apparatus. He carried out a long series of experiments by means of which he was able to separate the different and complementary responses to

[31] Magnus (1925)p349
[32] Magnus (1926a)p536
[33] Magnus (1925)p350

eye movements evoked by the vestibular system and by the neck proprioceptors. From this work he was able to conclude that when

> *…the animal brings its head into a new position, it makes a movement, and, in doing this stimulates the ampullae of the semicircular canals, which gives rise to short-lasting motor reflexes acting on the eye muscles. …The canals begin, the otoliths and neck receptors complete and steady the reaction: a very finely adapted mechanism indeed.*[34]

Magnus' research sheds light on the complexity of the interactions between the eyes and the muscles involved in posture. A simple impression of some of the factors involved can be obtained by standing quietly and observing how much easier it is to stay in balance when the eyes are open than when they are kept closed.

A central nervous apparatus

At the conclusion of some fifteen years of intensive laboratory research, Magnus and his team had experimented and reasoned their way from the top of the spinal cord upwards through the brainstem and midbrain. He could confidently say they had identified the locations and functions of the main neural centres controlling the postural reflexes.

Magnus summarised their findings as follows:

> *…the principal results of the study are that the centers for the body posture and the labyrinth reflexes are arranged in three great functional groups in the brain stem.*
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> 1. *From the entrance of the vestibular nerve backward to the upper cervical cord; the centers for the labyrinth and neck reflexes on the whole body musculature with the exception of the righting reflexes.*
> 2. *Between the entrance of the eighth nerve and the eye muscle nuclei; the centers for the labyrinth reflexes on the eyes.*
> 3. *In the midbrain: the centers for the righting reflexes…*[35]

This region of the brain from the top of the spinal cord up to, and including, the midbrain is not just concerned with posture; it is densely packed with other functions. Here, for example, are found the centres for the twelve cranial nerves which control the visual, auditory and gustatory systems, as well as the detailed functioning of the eyelids, lips, forehead and general facial muscles. It is sometimes known as the reptilian brain. It is here, rather than in the cortex, that the control centres for the various aspects of posture investigated by Magnus are located.

The segmental nature of the nervous system was well-investigated long before Magnus began his work. Scientists knew that each segment of the vertebrate neuromuscular system was controlled by the nerves entering and leaving the spinal cord through the gap between the vertebrae at the level of the segment. Sherrington's puzzle, to which he had devoted *The integrative action of the nervous system* was how the neuromuscular system managed to ensure that this assembly of segments was able to act in a coordinated way. Posture, requiring the coordination of a continuing flood of instructions to more or less the whole of the musculature in response to the

[34] Ibid. p351
[35] Magnus (1924)p632

multitudinous inputs from the proprioceptors and the exteroceptors, those organs sensing the external world, was an extreme example.

This is how Magnus put it in the Croonian Lecture in 1925:

> *The lower centres for the muscles of the different parts of the body are arranged segmentally in the spinal cord; the higher centres in the brainstem put them into combined action and in this way govern the posture of the animal as a whole. We have here a very good example of what Sherrington has called the "integrative action of the nervous system". And integration is particularly necessary in the case of posture, because nervous excitations arising from different sense organs are flowing towards the postural centres in the brain-stem, and must be combined so that a harmonising effect will result.* [36]

In *Body Posture* he summarises his conclusions:

> *The result of the present study is that in the brain stem, from the upper cervical cord to the midbrain, lies a complicated central nervous apparatus that governs the entire body posture in a coordinated manner. It unites the musculature of the whole body in a common performance…*[37]

But although he was happy that he had identified this area of the lower brain as the location of the key nerve centres necessary for the normal functioning of the postural reflexes, he saw this conclusion as the starting point for further investigation. As he said:

> *…at least a beginning has been made with the anatomic-physiologic disentangling of the central apparatus for the body posture. Apart from establishing the general arrangements of centers and pathways in various parts of the brain stem, it has been possible to ascertain the function (or a part of the function) of at least one anatomically known nucleus, and to determine the anatomic position of the centers for a few physiologic functions.*[38]

The recognised that the amount of work required to identify what was happening at a detailed level was huge. He outlined the task in the following words:

> *For the majority of reflexes it is not yet known what anatomically known structures (nuclei), localized physiologically in specific regions are involved, in which anatomically known pathways the afferent and efferent excitation runs in the central nervous system, and by which neurones these pathways are formed. For many reflexes it is still not known whether the pathways run on one or both sides, whether and where they cross, etc. There is, therefore, much work to be done before the structure of the central apparatus for body posture will be known in all details…*[39]

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[36] Magnus (1925)p340
[37] Magnus (1924)p653
[38] Ibid. p676
[39] Ibid. p655

His concluding words in the second Cameron Prize lecture in 1926 outlined the future challenge:

> *All these things have not yet been worked out in detail, and as these lectures are addressed to an audience of students I am glad to say: There is work enough for you to do.*[40]

Much of the detail of what Magnus called the *central apparatus* thus remained to be explored and his early death meant he never had the opportunity to extend his researches in the way he suggested. His research achievement, nevertheless, was to have disentangled the main underlying reflex mechanisms used by the vertebrate neurological system to handle the complex business of keeping the functioning organism in postural harmony with itself.

Magus' enduring legacy is the comprehensive and unified understanding he was able to develop of what is involved in animal posture. It is noteworthy how well his work has endured and the extent to which it has become the commonplace of neuroscience. A modern textbook on the central nervous system, for example, nowhere refers to Magnus by name but describes the postural reflexes and their role as follows:

> *The tasks of these reflexes are to maintain an appropriate posture of the body, to help regain equilibrium when it has been disturbed, and to ensure the optimal starting positions for the execution of specific movements. Postural reflexes produce the automatic movements that help us regain equilibrium quickly, for example, when slipping on ice. It is a common experience that these compensatory movements happen so rapidly that only afterwards are we aware of the movements we performed.*[41]

It could have come straight from Magnus himself.

[40] Magnus (1926b)p588
[41] Brodal (1998) p353

SECTION 3: THE SIGNIFICANCE OF THE POSTURAL REFLEXES

Magnus' work, focusing principally on the reflex systems of decerebrate animals, had the narrow focus which profound scientific discovery often requires. It enabled him to identify the main reflex systems that control vertebrate posture.

This chapter looks at the wider significance of Magnus' work and what it tells us about the normal working of the postural reflexes in human beings. Some of his research results were counter-intuitive: it is not immediately obvious, for example, why the postural reflexes should be outside the conscious control of the cerebrum. Nor was it evident before his work that the postural reflexes are involved in creating the baseline to which so much normal sensory experience is referred. Such discoveries, and the fact that the postural reflexes can easily be suppressed or distorted, turn out to have unexpectedly wide implications for human health and functioning.

Relating the research findings on the postural reflexes to such wider questions of human functioning was of major interest to both Magnus and Sherrington. Following the publication of his research results, Magnus' was already searching beyond his discoveries and looking at their further implications for human beings. Indeed, his last published work took him back to Immanuel Kant and induced him to raise the question of how the state of our neurological system can have an *a priori* influence on our understanding of the world.

It is regrettable that Magnus did not live to develop his thinking further. But Sherrington, who had stimulated Magnus' interest in the postural reflexes in the first place, lived and worked for another thirty years, bringing further development of his own and Magnus' ideas. There is much still to be explored in the rich legacy of their work.

Outside conscious control

One of Magnus' most arresting findings is that the postural reflexes are not only outside the scope of the conscious brain, they function perfectly in the complete absence of the cerebral cortex. This might appear uncontentious in the case of cats, rabbits and dogs, but it is somewhat unexpected when applied to humans.

It is normally taken for granted that the cortex should be involved in the more important activities of human beings. Given the importance people attribute to "good posture", it would seem obvious that it should be subject to the conscious control of the cortex. All those people who make valiant efforts to improve their own or their children's posture are certainly working on the assumption that getting their posture "right" is a matter of conscious will and paying close attention to what they are doing.

Magnus argued precisely the opposite, saying

> *It seems to be of the greatest importance, that the whole central apparatus for the righting function (with the only exception of that for the optical righting reflexes) is placed subcortically in the brainstem and by this means withdrawn from all voluntary action.*

He goes on to explain this. The movements and activities which the body performs in responses to signals from the cerebral cortex are technically referred to as phasic. This means they go through a cycle, beginning by changing the body away from its normal resting condition, then, after the action has been completed, returning it to its resting state. The postural reflexes are involved in the final stage of restoring the body to its balanced resting state.

As Magnus puts it:

> *The cortex cerebri evokes during ordinary life a succession of phasic movements, which tend over and over again to disturb the normal resting posture. The brain-stem centres will in the meantime restore the disturbance and bring the body back into the normal posture, so that the next cortical impulse will find the body prepared to start again. It is also an essential condition for the right interpretation of all sensory impressions reaching the cortex, that the body be always brought into the normal position by a purely automatic subcortical arrangement, which controls the spacial relation of the body to its environment.* [42]

Magnus' conception of human muscular activity thus involves a dynamic and subtle interplay between the influence of the volitional changes induced by the motor instructions from cortex and the restorative responses of the postural reflexes activated from the postural control centres in the brainstem. Using slightly different terms, this is how he put it in the conclusion to the second Cameron Prize lecture in 1926:

> *The 'normal' position in man or animal is continually being disturbed by different arbitrary movements evoked by the cerebral cortex, but the subcortical mechanism of the 'righting reflexes' counteracts these disturbances and restores the body again to the normal position.*[43]

These cycles of muscular activation and return to the resting state are overlapping and interacting throughout the body during every waking moment with a speed and complexity beyond any possibility of conscious awareness or control. Here, Magnus echoes and amplifies what Sherrington had said some twenty years earlier when he pointed out that it is the task of the postural reflexes to provide a continued and active restorative background to normal muscular activity. Sherrington also pointed out that, far from the postural reflexes having an overriding or dominant role, it is essential that they should be easily disturbed.

In Sherrington's words:

> *One great function of the tonic reflexes is to maintain habitual attitudes and postures. They form, therefore, a nervous background of active equilibrium. It is of obvious advantage that this background should be easily upset, so that the animal may respond agilely to the passing events that break upon it as intercurrent stimuli.*[44]

In simple terms, this arrangement ensures that in the case of the cat, after it has dealt with the mouse-alert, the postural reflexes restore its musculature to its balanced and relaxed state – from which it is instantly able to move again to the alert should the mouse reappear.

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[42] Magnus (1925)p349
[43] Magnus (1926b)p588
[44] Sherrington (1948)p232

But the activity of the postural reflexes is not restricted to the aftermath of a clearly defined phasic action. Human activities shade from one into the other, sometimes bringing large swathes of muscles into vigorous activity, sometimes involving no more than minor movements of body parts or simply a local change in muscular tone. The postural reflexes play a continuing background role, maintaining a tendency to bring the musculature back into its natural balanced state. If the neuromusculature had no such reference, or default, state to which it automatically had a tendency to return, there would be nothing to prevent neuromuscular patterns of tension remaining as residues of phasic activities, and even accumulating to a level at which the overall functioning of the organism becomes impaired.

Continually recalibrating the senses

Magnus pointed out that the postural reflexes have another critically important role, that of constantly recalibrating the senses. This is necessary because, in the course of any particular phasic action, not only is the normal resting relationship between the body parts changed, but the body's relationship to the external world is also altered. Magnus says that the postural reflexes restore the normal or baseline conditions to which the exteroceptive and proprioceptive sense organs refer.

In his conclusion to the second Cameron Lecture he puts it this way:

> *By the action of the subcortical mechanisms described in these lectures the different sense organs are always brought into the normal relation with the external world. For the nerve endings in the skin this is accomplished by the above described attitudinal and righting reflexes. In the case of the eyes a very complicated reflex mechanism has been developed differing in various species of animals, which regulates the position of the eyes in relation to the environment. Here also labyrinthine and neck reflexes come into play.*[45]

He then adds some further explanatory words, re-emphasising the importance of this function of the postural reflexes in continually recalibrating the sensory organs as the body performs its activities, whether voluntary or reflex:

> *The result of all these arrangements is that the sense organs are righted in relation to the external world, so that every sensory impression, before being transmitted to the cortex cerebri, has already acquired a certain special condition (local sign) depending on the previous righting function acting on the whole body or parts of it. In this way the action of involuntary brain-stem centres plays a very important part in conscious activities, especially as regards spatial sensations.*[46]

No one knows how Magnus would have carried forward his work on the postural reflexes. But some tantalising hints of how he might have developed some of his ideas beyond those set down in *Body Posture* are contained in the draft of a lecture he was due to give in Stanford University in 1928. His death prevented the finalisation and delivery of the lecture but Stanford University published it in a book in 1930.

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[45] Magnus (1926b)p588
[46] Ibid. p588

The lecture was entitled *The physiological a priori* which harks back to Magnus' interest in Kant.

In his introduction to the lecture, Magnus makes reference to Kant's *Critique of pure reason,* and says:

> *In this book Kant showed that in all our observations and in the conclusions we draw from them, in short, that in everything we know of the outer world, there are numerous elements which are given a priori, and which we are therefore compelled to employ in any experience in thinking and in drawing our conclusions.*[47]

One of the examples he takes is colour-blindness. He points out that if a person is colour-blind, their perceptions of the outside world, and their response to it, will, of necessity, be different from those of a normal-sighted person. At a more general level, he points out that there is no avoiding the constraint imposed on our perception of the world by the mode of functioning of our sensory systems. He remarks:

> *We cannot free ourselves from this constraint; we are, as it were, imprisoned in the system…The nature of our sensory impressions is thus determined a priori, i.e. before any experience, by this physiological apparatus of our senses, sensory nerves and sensory nerve centres… Here we have to do with fixed mechanisms of our body, with permanent states of our sensory and nervous apparatus, and these will determine the nature of our observations and experiences… But beside these, other "active" processes (reflexes), acting through the central nervous system, also influence our sensory observations and help to determine them a priori.*[48]

He summarises his arguments in the conclusion to the lecture, remarking:

> *We possess numerous mechanisms acting unconsciously and partly sub-cortically which prepare the work beforehand for our psyche, and the results of which are a priori present before sensory observation and its psychological appreciation start. Since all study, analysis, and understanding of the events in the outer world are conducted through the medium of the senses, a scientific worker surely ought to know what are the fundamental mechanisms of his body and of his nervous system which determine the results of his work.*[49]

It is evident in the case of the "lower" animals, those with a less developed cerebrum, that the degree of innate or *a priori* conditioning of their sensory observations leaves them little room for behavioural manoeuvre; a lizard is a prisoner of its *a priori* and largely reflex lizardness. Higher up the cerebral scale, the scope for a wider range of volitional action becomes greater. Discussing Descartes idea of animals, not including humans, as machines or automata, responding automatically to stimuli, Sherrington dryly remarks *"…it lets us feel Descartes can never have kept an animal pet."*[50] But even the most devoted dog-owners are able to recognise the boundaries of their pets' canine nature and the *a priori* limits it imposes.

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[47] Magnus (1930)p97
[48] Ibid. p99
[49] Ibid. p103
[50] Sherrington (1906)pxiv

Magnus is taking the point a step further and pointing out that humans are also trapped in their own physiological *a priori*. Most of Magnus' scientific colleagues would probably find it difficult to accept his observation that the results of their work are influenced in any way by the state of functioning of their postural reflexes. At the same time, few would deny that their general perception of the world is indeed affected by their state of health and well-being.

Co-opting and modifying the postural reflexes

It is easy to accept that Sherrington's spider is all reflex, and Magnus' cat, at least when it comes to responding to the sight of a mouse is little different. In both cases, their behaviour is firmly, and predictably, determined by their reflex systems. Humans, however, are more volitional and less reflex in their behaviour than even their nearest animal relations; the human capacity for long-term planning is an obvious example.

Moreover, the dividing line between reflex and volitional in humans is not rigidly demarcated. As Sherrington says:

> *The transition from reflex action to volitional is not abrupt and sharp. Familiar instances of individual acquisition of motor coordination are furnished by cases in which short, simple movements, whether reflex or not, are by practice under volition combined into new sequences and become in time habitual in the sense that they no longer require concentration of attention upon them for their execution. As I write, my mind is not preoccupied with how my fingers form the letters; my attention is simply fixed on the thoughts the words express. But there was a time when the formation of letters, as each one was written, would have occupied my whole attention.*[51]

Sherrington is here describing the way in which the cortex can co-opt elements of the postural reflexes into new patterns of activity. He takes the example of handwriting, a far from innate ability, in which his cortex directs his writing hand into the formation of the letters, while his reflexes deal with the details of the necessary flexing, relaxing and movements of his wrist and fingers.

In her work with brain-damaged people, Bobath fully subscribed to this view of the interaction of the cerebrum with the lower brain systems controlling the postural reflexes, as in the following:

> *A large part of our voluntary movements is automatic and outside consciousness, and this applies especially to the postural adjustment of the various parts of the body which accompany them. For the maintenance of posture and equilibrium, the nervous system utilises lower centres of integration with their phylogenetically and ontogenetically older patterns of coordination. These centres are in the brainstem, cerebellum, midbrain and basal ganglia.*[52]

There are thus important differences between the roles of postural reflexes in humans and in Magnus' laboratory animals. Humans are able to co-opt or bypass the postural reflexes in ways which impossible for other vertebrates. This has a variety of

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[51] Ibid. p387

[52] Bobath (1985)p2

implications for the development of behaviour in humans as they mature and go through their adult lives.

Consequences of suppressing the postural reflexes

Magnus believed that the postural reflexes played an important role in overall human functioning and behaviour. He was an admirer of classical art and its depictions of human grace and beauty, and remarked that:

> *Many masterpieces of painting or sculpture representing human beings are consistent with the laws of attitudinal reflexes.*[53]

Elsewhere, he put it almost fancifully, saying that the postural reflex system could be seen as providing

> *… the apparatus on which the cerebral cortex plays, as complicated melodies are played on a piano, according to principles which are partly known and which now can be investigated from a new point of view.*[54]

In this idealised perspective, there is no conflict between voluntary and reflex; the postural reflexes are, as it were, providing a model to which voluntary behaviour conforms. Magnus experimental work, however, was almost entirely concerned with the behaviour of animals from which the cerebrum had been removed. Apart from his experiments on the optical righting reflexes, which require the presence of the cerebrum, none of his investigations dealt with the interaction between the voluntary and the reflex.

Bobath, although she still explicitly based her analysis on the work of Magnus[55], takes a more complex view. She argues that the highly developed human cortex exercises a much higher degree of control over the postural reflex system than happens in the animals on which Magnus worked. Discussing Magnus' finding that normal standing takes place in decerebrate animals as long as the thalamus is present, she says:

> *This state of normal muscle tone and normal righting ability in the absence of cortical control does not hold good for man. Here the development of the cerebral cortex has led to an inhibition of the activity of subcortical centres. They have lost their autonomy and become relegated into the background of human motor activity. In the process of evolution man has become dependent on intact cortical activity for the maintenance of the upright posture in standing and walking, and for the complex activities of arms and legs in prehension and skilled movements.*[56]

In her work, she was dealing with the people in which pathological conditions, such as cerebral palsy, have caused a disruption in proper communication between the higher and lower brain centres. Her relevance to the present discussion is that her work provides an intermediate case between Magnus' work in which the cerebrum is absent and that of the intact and properly-functioning human brain in which the cerebrum is effective in co-opting the postural reflexes as required.

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[53] Magnus (1925)p346

[54] Magnus (1924)p653

[55] Bobath (1985)pix

[56] Ibid. p6

As Bobath found, when the damaged cerebrum leads to an imperfect coordination of reflex and volitional activity, this can result in what she calls "*abnormal postural activity*". She goes on to point out that

> *…it is difficult to isolate the various postural reflexes, as the picture is usually complicated by the simultaneous action of a number of these reflexes and by the patient's volitional efforts when using their patterns for function.*[57]

The conditions being considered here are much less dramatic than those studied by Magnus and Bobath but are still concerned with the relationship between the cerebrum and the lower brain centres. The problem for humans arises because, in addition to their greater cerebral capacity which enables them to override their postural reflexes, they also have a neuromuscular system with a higher degree of plasticity than probably any other vertebrate. Some of the new ways people devise of using the musculature can override their postural reflexes so thoroughly that they are almost completely suppressed. Although no brain lesions are involved, this still represents a disruption of proper communication between the upper and lower brain in which the volitional, or habitual, patterns of muscle use have become impervious to the restorative promptings of the postural reflexes.

The capacity of humans to relegate their postural reflexes to the background or co-opt them into new patterns of activity in a way and to a degree impossible for any other vertebrate creature goes a long way to explain the extraordinary versatility of human behaviour. It is why people are able to learn new skills and adapt themselves to a huge variety of different patterns of action, from gymnastics and ballet dancing to spending their days slumped crookedly in front of a computer screen. It is why dogs and bears make poor dancers compared to even a moderately well-coordinated human.

Overriding the postural reflexes can also bring problems. In time, after a new mode of using the body has been adopted, it can become so habitual that the person has no awareness of the extent to which the restorative action of the postural reflexes has been suppressed. One way of describing what has happened is to say the "setting" of the physiological *a priori* has been changed so that any reversion to allowing the postural reflexes to function properly feels wrong and the cortex steps in to ensure it is quickly "corrected". The tendency to restore the musculature to its innate state of harmony and balance is reduced or eliminated. The effectiveness of the recalibration of the senses after phasic activity is reduced and the body gradually accumulates a series of distortions in its functioning.

This subtle but cumulative malfunctioning of the relationship between the voluntary and the reflex systems produces distorted patterns of activity that are visible everywhere. A prime example is walking. The ability to walk is an innate capacity in humans, manifesting itself in normal children from around the end of their first year. From this stage onwards, this essentially reflex activity can be co-opted in a wide variety of ways of walking depending on the influences to which the developing child and adult are subjected. Marching, slouching, shuffling, sticking the head forward, teetering on high heels, any number of new and often profoundly damaging muscular patterns can be learned and adopted permanently. These distortions of the natural gait

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[57] Ibid. p2

are often so distinctive that many people can be recognised by their idiosyncratic way of walking.

The intensive training regimes to which gymnasts and ballet dancers subject themselves enable them to display extraordinary grace and skill in their performances. But the same training can cause many of these talented people to lose touch with their postural reflex systems. The result is that they no longer benefit from the restorative powers of these reflexes so that spinal and postural problems become increasingly common as they grow older. The habitual walk with turned-out toes which some ballet dancers develop, nick-named the “ballerina’s waddle,” which can lead in time to a wide variety of back and other problems, is but one of the symptoms of a training regime in which the postural reflexes are suppressed.

Apart from extreme training regimes, normal life has its own wide range of hazards. People who spend most of their lives in front of computers, like the scribes and scholars of earlier times, often sit with their heads thrust forward and chests pulled inwards, and carry the same habits into the rest of their daily activities. Excessive travel in cars and planes weakens and distorts the normal postural muscles and many people living such a life attempt to compensate for this with intensive “fitness training”. Unless very carefully carried out, such bursts of vigorous physical activity are more likely to reinforce damaging muscle use patterns they have acquired than they are to restore the proper functioning of the postural reflexes.

From wherever it comes, the blunted sensibility of so many people to the way in which they are suppressing the natural functioning of their postural reflexes leads eventually to the neck-aches, back-pains, and damaged spinal disks from which they find themselves suffering, and the braces, bandages and hip and knee replacements which they so often find themselves requiring.

SECTION 4: THE HEAD-NECK RELATIONSHIP

In drawing his results together, towards the end of *Body Posture* Magnus particularly noted the critical role exercised by the positioning and movement of the head in governing the total activity of the body:

> *The mechanism as a whole acts in such a way that the head leads and the body follows.* [58]

The neck, reputedly the most complex musculo-skeletal system in the body[59], is the linkage between the head and the rest of the body. Much work has been done since Magnus' death on the detailed workings of this vital, and vulnerable, connection between the body's analysis and command centre in the head and the neuromuscular system in the rest of the body.

Physiology of the head-neck relationship

In looking at the head-neck relationship in detail, it is useful to start with some basic physiology. The bony structure of the neck is a continuation of the spinal column, rising out of the trunk in the form of the seven cervical vertebrae. This cervical column is stabilised by the scalenus (ladder) muscles which run from the two upper ribs to the transverse processes of the cervical vertebrae. Outside these muscles which help assure the relationship of the cervical vertebrae to each other, come the larger muscles which provide the neck and head with their various flexion, extension and rotatory movements; among others, these muscles include the sternocleidomastoid, the trapezius, and the levator scapulae.

The cervical spine comprises thirty-seven separate joints whose function is to provide for the movements of the head in relation to the body. These movements meet the direction-seeking needs of the teleceptors, the eyes, ears and nose, as well as providing for the optimum balance of the head on the top of the cervical spine. It is an area of the body that is in constant movement; it is said the neck moves over six hundred times an hour, whether the person is asleep or awake.[60]

At a mechanical level, the head-neck relationship poses technically difficult problems of analysis since there is a high degree of redundancy in the system, in the sense that many of the movements it makes can be achieved in a variety of different ways. Here is an outline of the analytic problems involved:

> *There are some difficult problems in understanding the control of head movements. The head-neck system is multijointed and the posture and movement of the head can be controlled by different pairs of muscles that may subserve similar functions or help to mediate a given task. The behavioural degrees of freedom are few, yet simple movements such as rotating the head may result from the contraction of many muscles acting in a coordinated manner, indicating the necessity for some constraints. Another problem is that different tasks may need to be performed and the organisation of the sensory inputs and the motor*

[58] Magnus (1926a)p536
[59] Bland and Boushet (1992)p135
[60] Ibid. p

> *outputs must be appropriate for a given task, such as controlling gaze or posture or both simultaneously.*[61]

The authors, in this case, are referring to the control of head movements in a lizard. The neuroanatomy is similar to that of the human being but is much simpler. The text nevertheless indicates clearly the complexity of the mechanisms involved, in particular the fact that the muscle systems can be used in a variety of ways, performing different tasks separately, or in combination, such as controlling the gaze and posture. The actual freedom enjoyed by the lizard in how it performs its tasks is heavily constrained by its mainly reflex nature. Human beings, in comparison, enjoy a much wider range of choice, including that of misusing their head-neck systems to a degree which is impossible for lizards.

The sub-occipital muscles

In addition to the muscles controlling the movement of the head, and the flexure, extension and rotation of the neck, there is a set of smaller muscles at the top of the cervical column. These are collectively known as the sub-occipital muscles and have a particularly important role in providing feedback to the postural control apparatus on the relative positions of the head and the neck.

These muscles are attached in various configurations to the occipital bone and the atlas and axis vertebrae. Two of these muscles, the *rectus capitis posterior minor* and the *obliquus capitis superior,* connect the nuchal line of the skull to the atlas vertebra. The *rectus capitis posterior major* connects the nuchal line of the skull to the axis vertebra. The *obliquus capitis inferior* connects the atlas and the axis vertebrae. These are all posterior to the cervical column.

In addition, forward of the occipital condyles, and therefore acting antagonistically to the posterior sub-occipital muscles, there is a further set of muscles known as the small anterior sub-occipital muscles. Among these, the *rectus capitis anterior* and the *rectus capitis lateralis* insert into the base of the occipital bone forward of the foramen magnum and connect into the atlas vertebra. The *longus colli* runs from the front of the atlas vertebra, connecting all the cervical vertebrae with the top three thoracic vertebrae. The *longus capitis* connects the occipital bone, anterior to the foramen magnum, with the third to the sixth vertebrae.

In anatomy books, the "actions" of the posterior and anterior sub-occipital muscles are normally listed as producing the various nodding and rotatory movements with which they are evidently associated. The rectus capitis anterior, for example, "flexes" the head and the rectus capitis posterior minor "extends" the head, rocking it backward on the occipital condyles; the obliquus capitis superior "rotates" the atlas vertebra, and with it the head, about the upward projection of the dens from the axis vertebra.[62]

It is obviously true that the sub-occipital and small anterior vertebral muscles are involved in such movements of the skull and the top two cervical vertebrae since they lengthen and shorten as the distances between their points of attachment change with the movements of the head. But mechanically they can make little real contribution to the actions of flexing, extending and rotating the head. These muscles are small, even tiny, in comparison with some of the large muscles surrounding them; as a result, the

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[61] Wang(1992)p91
[62] See, for example, Stone and Stone (pp 62, 68, 69)

forces they are able to exert on the large mass of the head are relatively minor. The fact that they are inside the lines of action of the larger muscles also means that they are closer to the fulcrum of the condyles and the rotation point of the dens so that the leverage, or turning moments, they are able to exert on the movements of the head are minute in comparison with those of, for example, the trapezius or the sternocleidomastoid.

Thus the sub-occipital muscles cannot play a major part as prime movers of the heavy weight of the head, though they could well have a role in fine-tuning its movements. Their major function is thus most likely to be proprioceptive; Gray's Anatomy, for example, links a number of them to posture:

> *Obliquus capitis superior and the two recti are probably more important as postural muscles than as prime movers, but this is difficult to confirm by direct observation.*[63]

It is noteworthy, in this context, that the sub-occipital muscles are particularly rich in spindles, the tiny sensors in muscle fibres, the role of which is to send proprioceptive information on the degree of stretch in the muscle fibre to the central nervous system. McComas provides some data on the relative density of spindles in various muscles, remarking:

> *The muscles at the back of the neck and the small muscles of the hand have the richest supply of spindles, and the large muscles of the arm and leg are least well endowed. This difference in density is probably related to the ability to carry out small movements of the head and fingers rapidly and accurately.*[64]

Among the muscles listed by McComas, the obliquus capitis superior has the highest density of spindles at 42.7/gram, followed by the rectus capitis posterior major at 30.5/gram. These figures can be compared with the 1.4/gram typical of larger muscles such as the latissimus dorsi and biceps brachii, making the posterior and anterior sub-occipital muscles twenty to thirty times more sensitive to stretching than the larger muscles. The sub-occipital muscles thus possess the neurological characteristics and are positioned to act as extremely sensitive strain gauges with the main task of monitoring the state of the head-neck relationship.

A problem of coordination

The head houses the exteroceptors, the eyes, ears and nose, which provide information about the external surroundings. It also accommodates the vestibular apparatus which monitors its orientation and movement. It is the receiving centre for the exteroceptive flows from the skin, the largest exteroceptive organ of all, as well as from the body's various proprioceptive sensors. It is the seat of the postural control centres in the brainstem, where the coordination of the efferent, or outgoing, and afferent, or incoming, neural impulses governing posture takes place. It is where the volitional brain resides.

The neck is a conduit for the streams of nervous impulses which flow between the brain and the rest of the body. But it is a great deal more than a passive conductor of nerve impulses since it provides vital under-pinning to the workings of the teleceptors

[63] Williams (1995) p813
[64] McComas (1996) p48

and influences how well they work. It is, itself, richly endowed with its own muscles and proprioceptors, and as Magnus demonstrated, mediates the attitudinal and righting reflex systems.

Take the eyes, the most obvious teleceptors. It is not an exaggeration to say that the simple act of bringing the eyes to bear on an object involves virtually the whole of the body's muscular systems. As attention is given to an object, the extraocular muscles swivel both eyes to point towards it. This evokes the optical righting reflexes which mobilise the appropriate neck muscles to bring the head round so that the eyes assume their normal position in the eye-sockets. This twisting of the neck, in turn, mobilises the remaining righting reflexes to bring the rest of the body into adjustment with the changed position of the head.

The proper functioning of the ears also requires a surprisingly complex series of muscular actions in the head-neck area and beyond. The main reason for this is that the nervous system uses the minute difference in the timing of the sounds entering each ear as a means of identifying the direction from which the sound is coming, demanding an ability to manoeuvre the head with extraordinary delicacy in both the horizontal and vertical dimensions. At the same time, in most cases, the eyes carry out a complementary search for the source of the sound in the direction indicated by the ears.

Nor is it enough just to know the location of an object relative to the head; in order to interact with an object – using the hands to pick up an object from a table, for example – it is also essential to know its location relative to the rest of the body.[65] Thus the arrangement of head, neck and trunk poses a three-dimensional problem of coordination that every vertebrate must solve, as outlined in the following:

> *When the sense organs that inform an animal through light, sound or gravity about its orientation in space are situated in the head and the motor apparatus that controls that orientation is situated in the trunk then, apparently of necessity, the control system must somehow account for the position of the head relative to the trunk.*[66]

In normal conditions, most of the necessary coordination is provided at a reflex level and, in the absence of injury or physical decline, the head-neck relationship remains unproblematic. In the case of humans, however, the complexity of the issues involved is increased immeasurably by the fact that they can distort their evolutionary heritage by inventing and imposing on their head-neck systems a variety of new modes of behaviour, some of which may leave a permanent mark on its functioning. Over-developed neck and shoulder muscles; glasses and contact lenses; ear-phones plugged deep into the auditory meatus of each ear; all these interfere with the way in which people receive and calibrate information from their environment and have corresponding impacts on the way they respond to it in a reflex or volitional manner.

Effects of chronic excessive tension in the head-neck area

Chronic excessive tension in the head neck area has effects on the functioning of the body's whole neuromusculature. If the head is unable to provide the level of subtle and delicate adjustment required by the eyes and ears, for example, they cannot

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65 Taylor (1992)p488

66 Mittelstaedt and Mittelstaedt (1992)p369

function to their optimum. But the most common result, and the one most germane to the present discussion, is the way it interferes with the effective functioning of the sub-occipital muscles in their proprioceptive or strain-gauge role.

When the large shoulder-neck muscles such as the trapezius, sternocleidomastoid and so forth are contracted, so that the head is pulled backward and down on to the cervical column, the relative movement of the head and neck in the sub-occipital area is restricted or may not take place at all. As a result, there is little or no stretching of the sub-occipital muscles and they no longer perform their proper strain-gauge function.

This, in turn, means Magnus' *"central apparatus"* in the brain-stem is working on incomplete or distorted afferent information on the state of the head-neck relationship and hence on the relationship of the rest of the body to the head. The efferent signals to the postural muscles are bound to reflect the sub-optimal character of the afferent signals on which they are based, a clear case of a self-imposed and detrimental physiological *a priori*. In simplistic terms, if the brain does not "know" exactly where rest of the body is in relation to head, its control of the body's movements is likely to be to a greater or less extent impaired.

This helps explain why even mild damage in the cervical area can have such widespread effects on body-functioning, especially the sense of balance. Sometimes the effects of even mild trauma can persist for a very long time. These effects have long been medically noted and can produce a syndrome known as *cervical vertigo.* The following are some comments from a review of the subject:

> *Many patients who have experienced whiplash injury, neck manipulation, or mild non-concussive head trauma complain of persistent symptoms of dizziness for months to years after their incident. …the unfortunate term "cervical vertigo" was proposed by Ryan and Cope in 1955 based on five cases of dizziness following neck trauma, postulated to be the result of damage to upper cervical joint receptors.*[67]

The author of the above goes on to list some of the symptoms of damage in the head-neck area. The range is surprisingly wide and includes neck pain and stiffness, with occasional radiation of the pain into the temporal area or arms; feelings of imbalance or vertigo; headache, which tends to be posterior, with a "*… band-like radiation round the head suggesting muscle contraction*"; and even hearing problems.[68]

It is particularly relevant in the present context that it is not just severe neck trauma that can cause such problems; they may also result from mild head trauma or even the widely practised neck manipulation that takes place in various forms of physiotherapy and chiropractic – against which some chiropractors themselves have warned.[69] Thus, people who have suffered a whip-lash injury from which they feel they have recovered completely may still find them themselves afflicted by headaches and other symptoms; the probability is that they are still experiencing the effects of their injury.

Magnus' findings, especially in relation to the non-fatiguability of attitudinal tonic reflexes, can help explain such long-lasting effects. One of the results of a whip-lash

[67] Brown (1992)p645
[68] Ibid. p645
[69] Homola (1999)p86

or other neck injury can be a slight habitual malpositioning of the head away from its optimum position of balance on the top of the spinal column. Nor does it need to be a injury – habitual misuse of the body in front of a computer can have the same effect.

The point is that the distorted position of the head evokes corrective righting reflexes which are able to last as long as the head is away from its optimum position. If through an habitual adjustment to the injury, or surgical intervention, the righting reflexes are unable to restore the head to its proper position, they will nevertheless persist indefinitely in their corrective tendency. If this causes pain or has other distorting effects on the neck and wider musculature, the damaging effects can last a lifetime.

In summary, chronic contraction in the head-neck area is likely to have broad repercussions on the functioning of the postural reflexes and the general musculature. The most obvious effect is to weaken or distort the restorative action of the postural reflexes after a phasic action, leading over time to a gradual deterioration in the functioning of the postural reflexes and the wider neuromuscular system.

SECTION 5: THE ALEXANDER TECHNIQUE

F.M. Alexander, the originator of the Alexander Technique, came to London from his native Australia in 1904, just before the publication of Sherrington's *The integrative action of the nervous system.* The two men were close contemporaries yet few of those, especially scientists, who recognise the magnitude of Sherrington's achievements have shown any curiosity about his involvement with Alexander.

Sherrington was nonetheless quite happy to link his name publicly with Alexander's. The occasion was his last book, *The Endeavour of Jean Fernel*, published in 1946, in which Sherrington displayed his wide-ranging erudition in tracing the life and work of the 16th century physician, Jean Fernel, whom he admired as a reformer and important precursor of modern medicine.

In a striking passage on the underlying reflex element in what he termed "*willed movement or posture*" Sherrington wrote:

> *Breathing, standing, walking, sitting, although innate, along with our growth, are apt, as movements, to suffer from defects in our ways of doing them. A chair unsuited to a child can quickly induce special and bad habits of sitting, and of breathing. In urbanized and industrialised communities bad habits in our motor acts are especially common. But verbal instructions as to how to correct wrong habits of movement and posture is very difficult. The scantiness of our sensory perception of how we do them makes it so. The faults tend to escape our direct observation and recognition.*[70]

Continuing, he then quite surprisingly refers to Alexander and his work, remarking:

> *Mr Alexander has done a service to the subject by insistently treating each act as involving the whole integrated individual, the whole psychophysical man. To take a step is an affair, not of this or that limb solely, but of the total neuro-muscular activity of the moment – not least of the head and neck.*[71]

The whole passage is redolent of Alexander's thinking and, together with the personal reference, came as a pleasant surprise to Alexander when it was brought to his attention. He wrote to Sherrington thanking him and Alexander's biographer quotes Sherrington's reply:

> *I need not repeat to you that I appreciate the value of your teaching and observations. I was glad to take the opportunity to say so in print. I know some of the difficulties which attach to putting your ideas across to those less well-versed in the study than yourself…* [72]

Sherrington's remarks appear to come from a sympathetic understanding of some of the main elements of Alexander's teaching. It seems as though he saw Alexander's work as both beneficial and compatible with his own thinking. It is therefore worth examining in some detail what Alexander was about.

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[70] Sherrington (1946)p89
[71] Ibid. p89
[72] Bloch (2004)p207

Origins of the Alexander Technique

Alexander was born to a farming family in Tasmania in 1869. He grew up a sickly bookish child and embarked on a career as a public reciter of Shakespearean monologues. This was initially successful but Alexander found himself increasingly afflicted by hoarseness when he was performing. His consultations with doctors failed to yield a lasting solution and he set about developing his own approach to dealing with his voice problems, and saving his career as a reciter.

In his autobiographical writings, Alexander dated the development of the essential elements of what he came to call his Technique from about 1894. It was then he realised that his voice difficulties were a result of habits he had developed of tightening his throat and chest and pulling his head backwards and down when he was reciting. Having identified these damaging habits, he set about correcting them.

By careful inspection of what he was doing, using an arrangement of mirrors, he was able to devise a way of reciting which eliminated the defects in his delivery that seemed to be causing his hoarseness to develop. But he then found that as soon as he stopped thinking specifically about what he was doing, the damaging habits reasserted themselves. The problem was that deeply engrained habits function at a level well below that of conscious thought, acting effectively as though they are reflexes. After much trial and error, Alexander devised a way of eliminating his tendency to regress into these habits of misusing himself and this became the centrepiece of his method of retraining his voice.

The marked improvement in his voice performances brought others in the Australian acting world to him and he found himself giving an increasing number of lessons in his Technique to these other performers. It soon turned out that his method of dealing with voice difficulties paid other health dividends, particularly with breathing-related problems. Alexander found himself attracting medical attention and a number of influential doctors in Sydney began referring patients with throat and other problems to him. In 1904, he was able to come to London with letters of recommendation to a number of prominent members of the English medical profession.

Alexander quickly established a successful teaching practice with many distinguished clients, especially in the acting and musical professions. During the following years he moved well beyond voice-teaching and emphasised what he called the *psychophysical unity* of the human being, focussing his teaching on the total functioning of the neuromuscular system. He was strongly against the ideas on physical fitness current at the time and made popular in the writings of people such as the “strong man” Eugen Sandow (1867- 1925). These usually involved the development of particular muscles by specific exercises and the cultivation of “deep-breathing” to all of which Alexander was adamantly opposed. He believed that any programme that involved the over-development of certain groups of muscles was bound to create more problems than it solved.

In 1914 he went to the US and was introduced to John Dewey who was professor of philosophy at Columbia University. Dewey who was aged fifty-six at the time was in poor health, suffering from severe back pains and other apparently stress-related ailments. Following some lessons with Alexander his health improved dramatically and he became an enthusiastic friend and supporter of Alexander up to his own death nearly forty years later in 1952. During that time he contributed enthusiastic introductions to three of Alexander’s books.

Alexander never felt that there was anything esoteric about his approach; he strongly believed that it should be integrated into normal medical practice and he had a variety of prominent medical friends who publicly supported him. He was particularly opposed to quackery and fringe medical cults and was extremely pleased that Dewey emphasised the scientific nature of his Technique.

In his introduction to one of Alexander's books, Dewey wrote

> *…whilst any theory or principle must ultimately be judged by its consequences in operation, whilst it must be verified experimentally by observation of how it works, yet in order to justify a claim to be scientific, it must provide a method for making evident and observable what the consequences are; and this method must be such as to afford a guarantee that the observed consequences actually flow from the principle. And I unhesitatingly assert that, judged by this standard …Mr Alexander's teaching is scientific in the strictest sense of the word.*[73]

Alexander continued teaching and training teachers in his methods until his death in 1955 just short of his eighty-seventh birthday. His Technique continues to be widely taught and is particularly strongly supported in the performing arts.

What did Alexander discover?

By the early 1920s, Alexander had become a well-known and successful teacher of his Technique in the USA and Britain. When he learned, in 1925, that Magnus had identified a "*central apparatus*" in the brainstem which controlled posture, it seems to have crystallised his thinking about his own methods. He began to refer to the head-neck relationship as *the primary control* of the proper use of body. His first employment of the term appears to have been in a lecture he gave to the Child-Study Society in February 1925. He also uses the term *central control* in this lecture but subsequently *primary control* was his preferred usage.

In the course of this lecture, Alexander says:

> *Regarding the central control: in the technique I am using, it will interest you to know that during the past fifteen years, Magnus has worked to explain the scientific significance – as has been brought to our notice recently by Sir Charles Sherrington – in connection with that very control which I have been using for twenty five years. The direction of the head and neck being of primary importance, he found, as I found, that if we get the right direction from this primary control, the control of the rest of the organism is a simple matter.*[74]

Alexander reiterated his belief that he and Magnus were talking about the same thing on various other occasions. In a letter dated 9 July 1932, published in the British Medical Journal, he challenged "medical men" to submit his procedures to whatever *"tests as are consistent with their knowledge of physiology, anatomy and psychology."*

He goes on to say:

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[73] Alexander (1923) pxxvii
[74] Alexander (1995)p148

On the strength of forty years' practical experience I am bold enough to believe that this would result in proof of the soundness of my technique as conclusive as has been the case with regard to my employment of the primary control, the existence of which has been conclusively proved by the experimentation of the late Rudolph Magnus of Utrecht.[75]

It is nevertheless difficult to pin down what Alexander actually meant when he talked of this *primary control.* Sometimes it appears to be an action he performed, as when he talks of putting his head forward and up to prevent himself from pulling himself down, or as he put it "shortening in stature", when he started to recite. In his account of how he developed his Technique, he said that after long experimentation he found:

… that to lengthen <u>I must put my head forward and up. As is shewn by what follows, this proved to be the primary control of my use in all my activities.</u>[76]

More often, he uses the term to mean a particular way of using his body in which he was not pulling his head down and compressing his neck. Here he describes what he means in copious, if rather impenetrable, detail

…I discovered that a certain use of the head in relation to the neck, and of the head and neck in relation to the torso and the other parts of the organism, if consciously and continually employed, ensures, as was shown in my own case, the establishment of a manner of use of the self <u>as a whole</u> which provides the best conditions for raising the standard of functioning of the various mechanisms, organs and systems. I found that in practice this use of the parts, beginning with the use of the head in relation to the neck, constituted a primary control of the mechanisms <u>as a whole</u>, involving control <u>in process</u> right through the organism, and that when I interfered with the employment of the primary control of my manner of use, this was always associated with a lowering of the standard of my general functioning. This brought me to realize that I had found a way by which we can judge whether the influence of our manner of use is affecting our general functioning adversely or otherwise, the criterion being whether or not this manner of use is interfering with the correct employment of the primary control.[77]

Alexander was obviously mistaken in his belief that what he called the "primary control" was identical with the "central apparatus" described by Magnus since this latter is completely beyond any possibility of conscious control. But this is of little practical importance outside the world of neuroscience. The important point in the context of everyday human behaviour is that without brain-surgery such as Magnus carried out, the "central apparatus" does not exist as an independent entity and is always subject to interference by the cortex. Indeed, the term "central apparatus" is something of a misnomer since Magnus' main point was that the coordination of the postural reflexes, complex though it is, is a function of the lower brain rather the cortex.

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75 Alexander (1995)p134
76 Alexander (1932) p30
77 Alexander (1946)p8

Alexander's achievement was to have devised a non-surgical and consciously controllable means of reducing habitual interference with the postural reflexes enabling them to resume their proper role of recalibrating the senses and contributing to the optimum functioning of the neuromuscular system. The common ground between Magnus and Alexander was their awareness of the critically important role of the head-neck relationship in the body's overall organisation of itself. The paradox is that it requires a sophisticated exercise of conscious control of the muscular system, especially in the head-neck area, to avoid interfering with the functioning of the entirely sub-cortically-controlled postural reflexes.

This was recognised by Walter Carrington, who worked with Alexander from 1936 through to Alexander's death in 1955, and was the foremost practitioner of the Technique until his own death in 2005. In a pamphlet first published in 1950, when Carrington was still working closely with Alexander, he observed that

> *The whole basis of Mr Alexander's Technique is the teaching of how to eliminate interference with the autonomic functioning of the organism.*[78]

This judgement stood the test of experience. After another forty-five years teaching, lecturing, and writing about the Technique, Carrington was happy to have same pamphlet reprinted without alteration in 1994.

How does the Alexander Technique work?

In its practical application, the Alexander Technique is primarily empirical and achieves its results by means of individual lessons given by Alexander teachers who learn their skills through long practical training and experience. Thus, no attempt is made here to describe the detailed practice or teaching of the Alexander Technique. Many books have been written about them and an excellent contemporary coverage is available in, for example, Vineyard.[79] It is, nevertheless, useful to relate some of the practical aspects of the Technique to the work of Magnus, Sherrington and others discussed here.

Magnus' research established the role of the postural reflexes and the fact that they operate subcortically. The cortex thus cannot supply the subtle guidance and control of the neuromusculature provided by Magnus' *"elaborate central apparatus"* in the brainstem. This is why it is impossible to bring a body which has fallen into damaging patterns of misuse into a state of healthy functioning solely by means of deliberate exercise programmes.

The reason for this emerges clearly from the work of Sherrington and Magnus. The ability to suppress or interfere with the postural reflexes is essential to all purposeful activity and to the learning and development of skills. The problem arises when these volitional patterns of muscle use become such deeply engrained habits that the postural reflexes are prevented from functioning effectively. When these habits involve stiffening the neck and pulling the head backwards and down, compressing the cervical vertebrae, and interfering with the functioning of the attitudinal and righting reflexes that the effects are most pernicious.

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[78] Carrington (1994)p52
[79] Vineyard (2007)

The problem is compounded by the fact that people with over-tense muscles in the head-neck area and elsewhere, tend to have reduced awareness of what they are doing to themselves. Many, for example, do not realise the extent to which they are habitually clenching their jaws, lifting their shoulders, tightening their fists, or nervously tapping their feet or fingers. Effectively, they are suffering from a wholly inappropriate increase in muscle tone throughout the whole body, affecting the whole functioning of the neuromuscular system.

The precise habits of muscular misuse are, of course, particular to each individual. But whatever they are, long-enduring righting reflexes contribute to their permanent adoption. As they do so, the natural processes of cell replacement in bones and muscles gradually adapt the body to whatever distorted and malfunctioning conditions it may have developed. People grow into the muscular and postural distortions they have adopted.

Any attempt to restore the former less harmful mode of using the neuromuscular system feels wrong and people who attempt such change tend to regress to the habitual distortions with which they have become comfortable and which therefore feel right. Alexander referred to this inability in people to detect the habitual distortions that have become incorporated into their neuromuscular systems as “faulty sensory perception” or on other occasions, and more colourfully, as a “debauched kinaesthesia”. In time, people’s acquired twists, humps, asymmetries and other bodily distortions become permanent features of their appearance and their way of using their bodies.

Much of the work of an Alexander teacher is devoted to restoring the kinaesthetic sense of their pupils. As this happens, it becomes possible for people to detect how they are misusing themselves and, gradually, to develop the ability to stop doing so. Liberated from the domination of habit, the postural reflexes gradually begin to function properly again. Freeing the neck so that the head-neck relationship can function properly again is a primary focus of this gentle persuasion. In time, it leads to a restoration of the proper activity of the postural reflexes and an improvement in the overall functioning of the musculature.

A considerable amount of skill and patience on the part of the teacher is usually required to bring about the requisite state. Simply instructing people to reduce the level of tension in their neck muscles, for example, tends to result in a state of complete relaxation of the cervical column or, surprisingly often, a tightening of the neck muscles as the pupil concentrates on “trying” to make them free. The first can result in a substantial degree of postural collapse; the second tends to immobilise the neck and interfere with the proprioceptive functioning of the sub-occipital muscles as well as immobilising the neck righting reflexes.

Along with a restoration of the postural reflexes, indeed as part of it, it is also essential that the neuromuscular system is gradually restored to a state in which it can respond to the promptings of the postural reflexes. This is not possible if people have acquired habits of holding themselves rigidly in certain areas. Fears of a protruding stomach, for example, motivate many people to develop habits of tightly held buttock and stomach muscles. Computer users, especially those using laptops develop a posture in which the chest is pulled in and the head thrust forward; attempts to counteract this by pulling the shoulders back tend to compound the malposture with excessive lordosis.

Under the ministrations of a skilful Alexander teacher, acquired muscular distortions can be persuaded to give way to a renewed functioning of the postural reflexes. The American writer, Gerald Stanley Lee, described having a lesson from Alexander as being reshaped as though by a sculptor.[80]

Other scientific perspectives

Many medical doctors and scientists have derived personal benefit from the Alexander Technique. One of the most prominent scientists was Niklaas Tinbergen who devoted half his 1973 Nobel Prize acceptance speech to extolling its benefits. Few of these doctors or scientists have, however, made any major contribution to developing a scientific perspective on what takes place in Alexander lessons.

Two exceptions to this were the anatomist and paleo-anthropologist Raymond Dart and the developmental neurophysiologist George Ellett Coghill. Both had personal contact with Alexander and were impressed by his work. Their views on the Technique complement those in the previous sections of this paper.

Raymond Dart

Dart, who was Australian by birth, trained in medicine and served in the First World War. On demobilisation, he specialised in anatomy and became senior demonstrator in anatomy in University College, London under Sir Grafton Elliot Smith. He moved to South Africa in 1922 to become Professor of Medicine in Johannesburg University. He later become Dean of the Faculty of Medicine and served the University with distinction for thirty-six years until his retirement in 1958.

Raymond Dart's enduring fame rests on his discovery of the *Australepithecus africanus* fossil at Taung, near Johannesburg, in 1924. Dart's claim that it was an upright anthropoid ape and a precursor of *homo sapiens* was widely resisted by paleoanthropologists for the next two decades but Dart was finally and fully vindicated after the end of the Second World War.

He came across the Alexander Technique when he was trying to find ways of dealing with the severe spasticity and lack of muscular coordination in his son who was born prematurely, weighing only a kilogram at birth. In 1943, Dart had a short but intense period of lessons with Irene Tasker a close associate of Alexander's who happened to be in South Africa but was shortly leaving for England. Apart from a single lesson from Alexander, in London, Dart received no further lessons in the Alexander Technique, but he continued to think about it and to work on integrating it into his own ideas, especially those on developmental physiology. He believed that many of his son's difficulties arose because he had not gone through the full developmental process in the womb which meant that he was forced into trying to cope with the physical demands of life before his neuromuscular system had developed the requisite capacity to do so.

Dart wrote three Alexander-influenced papers which were published in South African medical journals during the 1940s and 1950 and reproduced in a 1996 publication. The most relevant in the present context is a paper on the postural aspects of malocclusion first published in the *Official Journal of the Dental Association of South Africa* in 1946.[81]

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[80] Lee (1920)p162
[81] Dart (1996) p

In relation to posture, Dart echoes Magnus' view of the postural reflexes as a subcortical system underpinning the voluntary use of the musculature. He remarks

> *The forebrain is neither an initiator nor regulator of posture; it follows immediate objectives as consciousness of them awakens, and employs the apparatus of movement momentarily at its disposal, whatever the postural development of the apparatus may be. When the postural development of the individual is such as to place at the forebrain's disposal a perfectly poised apparatus, the conscious and subconscious aspects of movement are happily integrated. Unfortunately, conscious objectives so outstrip postural evolution as to produce bodily disharmony more frequently than body poise.*[82]

In this, Dart was clearly influenced by his son's plight. He saw the child's difficulties arising from a mismatch between the role of the postural reflexes and the capacity of his under-developed musculature to respond to the demands made by these reflexes upon it. In this, Dart prefigures some of Bobath's thinking though she makes no reference to him.

Dart also pointed out that the human musculature can be envisaged as having a double spiral arrangement, from skull to feet, which makes possible the smooth execution of the various torsional movements involved in almost every human movement. In all of this, poised on the top of the cervical spine, the head plays a crucial role. He remarks

> *… if the head containing the balancing organs is not the prime mover, if it is incorrectly placed and maintained for equilibrated execution of the movements planned, the movements will be unbalanced and, in brief, caricatures of what these movements should be…The vast majority of people, relying more on one torsional sheet than the other, develop a right-handed twist or asymmetry of movement.*[83]

He also believed, with Magnus, that a proper functioning of the postural reflexes underlies the skilled utilisation of the neuromuscular system in a sport such as golf or the poise illustrated in a painter's masterpiece.[84] He pointed out that exercising, as a means of improving bodily poise and promoting skilled employment of the muscular system, will be counter-productive if the underlying musculature is not already working in a poised and balanced way.

> *Nor is any royal road to the acquisition of undeveloped body poise known at the present time because no technique is as yet generally applicable whereby the underlying attitudinal and body-righting reflexes can be spontaneously unmasked and allowed to do their symmetrical work reflex work without interference……unless the underlying integration between these self-operating reflexes and the purposive movements essential to bodily poise has already been established, physical exercises of a routine nature and strenuous bodily sports carried out by an asymmetrical body merely emphasize the existing asymmetry by neglecting balance. As far as I am aware, the only technique aimed at integrating the activities of the individual*

[82] Ibid. p85
[83] Ibid. p90
[84] Ibid. p85

by developing new habits based on the conscious control of the body is that of Matthias Alexander…[85]

Although he made no further contribution to the neurophysiology of the Alexander Technique after the end of the 1940s, Dart remained a strong supporter of Alexander's approach. He delivered the 1970 F.M. Alexander Memorial Lecture to the Society of Teachers of the Alexander Technique in London. In this address, he remarked:

The electronic facilities of the '60s have confirmed Alexander's insight and authenticated the technique he discovered in the 1890s of teaching both average and skilled adult individuals how to become aware of their wrong body use, to eliminate handicaps and thus achieve better, i.e. increasingly skilled, use of themselves both physically and mentally.[86]

Dart died in 1988 at the age of ninety-five.

George Ellett Coghill

George Ellett Coghill (1872-1941) was an American neurobiologist who made his scientific reputation with a series of studies of the early neurological development of the *amblystoma,* a small American newt. As part of his research, he conducted a classic series of observations at the University of Chicago in 1922.[87] These involved observations by Coghill and his assistants of the developing responsiveness of the neurological system of the *amblystoma* at fifteen minute intervals for the first sixty hours after hatching.[88] It was an extraordinary experimental endeavour and the results evoked widespread scientific interest. Coghill gave a series of lectures on his findings at London University in 1928 which were published under the title *Anatomy and the problem of behaviour.*[89]

One of Coghill's major themes was what he called *"the total pattern."* For him, behaviour in an animal was not an accretion of random responses to the environment but emerged from an innate pattern of responses in which there was, from the beginning, an organic unity. He said:

This principle is thoroughly demonstrated for Amblystoma, a typical vertebrate, and there is nothing in our knowledge of the development of behaviour to indicate that the principle does not prevail universally in vertebrates, including man. There is no direct evidence for the hypothesis that behaviour, in so far as the form of the pattern is concerned, is simply a combination or co-ordination of reflexes. On the contrary, there is conclusive evidence of a dominant organic unity from the beginning.[90]

An American journalist, Arthur F. Busch, who had been receiving Alexander lessons in New York was struck by what he felt were the parallels between Coghill's and Alexander's thinking and published an article on the subject in a New York newspaper

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[85] Ibid. p91
[86] Ibid. p55
[87] Herrick (1949)p34

[89] Coghill (1929)
[90] Ibid. p89

in 1939. This led to a correspondence between Coghill and Alexander as a result of which Alexander sent copies of his books to Coghill.

In his reply, Coghill thanked him saying:

> *I am reading these with a great deal of interest and profit, amazed to see how you, years ago, discovered in human physiology and psychology the same principles which I worked out in the behaviour of lower vertebrates.*[91]

Just as in the case of Sherrington, Alexander's insistence on looking at the totality of the behaviour of the organism resonated with Coghill. Alexander visited the US shortly afterwards and met Coghill who was by then extremely ill with severe arthritis and heart problems. Alexander spent a weekend with him in Florida and the two obviously got on well. In spite of his illness, Coghill wrote an Appreciation for the book, *Constructive conscious control of the individual,* which Alexander was just completing at the time.

In this Appreciation, Coghill wrote that the Alexander's technique was based on

> *…three well established biological principles: the integration of the whole organism in the performance of particular functions; proprioceptive sensitivity as a factor in determining posture; and the primary importance of posture in determining muscular action. These principles I have established through forty years in anatomical study of Amblystoma in embryonic and larval stages, and they appear to hold good for other vertebrates as well.*[92]

He goes on to discuss the way in which the total pattern provides a characteristic mode of behaviour within which local partial patterns can operate as the immediate needs dictate, saying:

> *In my study of the development of locomotion I have found that in vertebrates the locomotor function involves two patterns: a total pattern which establishes the gait; and partial patterns (reflexes) which act with reference to the surface on which locomotion occurs. The sloth, for instance, has the same total pattern (gait) of walking that the dog has, but employs a wholly different partial pattern (reflexes), for he supports himself in suspension with his flexor muscles. Now the reflexes may be, and naturally are, in harmony with the total pattern, in which case they facilitate the mechanism of the total pattern (gait), or they by force of habit become more or less antagonistic to it. In the later case they make for inefficiency in locomotion.*[93]

The terminology differs slightly from that of Magnus and Sherrington, and Coghill is describing the behaviour of intact rather than decerebrate animals but, from the perspective of the present paper, the essential point is the same. What Coghill describes as the "total pattern" is equivalent to the innate pattern of postural reflexes which underlie and determine the overall and characteristic gait of a sloth, an amblystoma or a human being. This might also be described in Magnus' terms as the *"physiological a priori"*. Within that total pattern there is a further set of movements

[91] Barlow (1978)p257
[92] Alexander (1946)p xix
[93] Ibid. pxxiii

which are determined by the particular conditions, for example, the surface on which the walking is taking place. Coghill refers to this particular response as a partial pattern of reflexes which is naturally in harmony with the total pattern.

Coghill points to the possibility of a conflict between the total pattern and the partial pattern as a result of acquired habits. It should be noted that in his use of the phrase "partial pattern of reflexes" Coghill has departed from Sherrington's definition of reflex and is using it in the sense of an acquired or learned habit. The important point is that he is talking of such habits being "antagonistic" to the total pattern.

In other words, acquired habits of muscular misuse are interfering with the innate postural reflexes. Coghill goes on to remark that:

> *It is my opinion that the habitual use of improper reflex mechanisms in sitting, standing and walking introduces conflict in the nervous system, and that this conflict is the cause of fatigue and nervous strain, which bring many ills in their train.*[94]

As he was writing these words, Coghill, unfortunately, had little time left to live. He finished the Appreciation just a few weeks before he died in June 1941; the book itself was published a few months later.

[94] Ibid. pxxxiv

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