TOWARDS A NEUROPHYSIOLOGY
of the
ALEXANDER TECHNIQUE

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DRAFT

15 December 2009

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INTRODUCTION

If all the activity of the human body's six hundred skeletal muscles were consciously controlled, we would get very little 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 intended action and deciding on the best one. The speed, versatility and flexibility of human activity is only possible because most of it relies on reflex muscle actions. Yet much can go wrong with this intricate machinery and the best means of putting it right are not always obvious even with the latest medical diagnostic equipment.

Scientific advance has indeed put an ever-expanding range of increasingly precise measuring tools at the disposal of modern physiology, so that that nowadays the working of individual neurons is readily monitored, but we have not had a corresponding growth in our comprehension of the overall working of the neuromuscular system. Our understanding of the functioning of our neuromuscular system as an integrated totality 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 especially closely at the way the postural reflex systems worked in experimental animals in laboratories. The special concern of this paper is the relevance of these neuroscientific findings 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 properly the functioning of the whole musculature deteriorates with damaging effects on our physical and psychological health, as well as a wide variety of localised joint and muscle problems.

The new and detailed physiological knowledge available to those concerned with health, fitness, and well-being, has enabled the interventions made to deal with problems to become ever more precisely focussed. Fitness programmes and exercise regimes tend to focus on the closely-identified deficiencies of particular body areas and muscle groups. Back and shoulder pains, neck pains and stiffness, weak knees and ankles, stiffening hip joints and the general aches and injuries of ordinary living are treated with a range of analgesics, muscle relaxant drugs such like baclofen, anti-inflammatories such as hydrocortisone, tranquillisers of various kinds, and a range of other medications.

Other weapons in the fight against such problems include heat treatments, rubs, elasticated supports, Transcutaneous Electronic Nerve Stimulation (Tens) machines, neck-traction devices and programmes of strengthening exercises. When hip and knee problems overwhelm the powers of such treatments, they can be dealt with by

joint replacements, while persistent lumbar and neck pains are often treated by fusing the vertebrae. In the vast majority of cases, however, such treatments are carried out without taking into account the larger-scale postural malfunctioning of which these specific problems are symptoms.

This is not to deny the benefits of such interventions. Many of those carrying on healthy and active lives would be on crutches or in wheelchairs were it not for these treatments and their medically-provided replacement joints. But because these interventions treat symptoms rather than causes, the underlying problems may well remain, continuing to interfere with the proper functioning of the body and resurfacing in another way at a later date.

The Alexander Technique addresses these deeper issues. There is nothing esoteric or mysterious about its approach. By creating the conditions in which the postural reflexes are enabled to perform their restorative tasks, and by giving the body time to adjust to a less damaging use of itself, balance, harmony and improved functioning can be restored in a surprising number of cases without the need for aggressive medical or physiological interventions.

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; malfunctioning in this area as any experienced physical therapist will attest, is implicated in a range of ailments from tension-headaches to flat feet. It concludes by showing how the subtle methods of the Alexander Technique are relevant to improvement and maintenance of improved neuromuscular functioning.

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 bedrock of this paper; it also provides some definitions and background on the terms reflex and posture. Section 2 sets out Magnus' findings on the actual functioning of the postural reflexes 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 head-neck area and draws particularly on the proceedings of a major international symposium on the head-neck sensory motor system held in Paris in 1991.

Section 5 provides a brief account of the Alexander Technique. F. M. Alexander, an Australian actor, who was a near contemporary of Sherrington's came to London in 1904. In his earlier development of a method of dealing with his own voice problems he had identified the importance of the head-neck relationship to the overall functioning of the human neuromuscular system. He made it a central concern in what has become known as the Alexander Technique (AT). Nowadays, the AT tends to be associated with the question of posture in a narrow sense but, as Alexander insisted from an early date, it is concerned with the overall use of the body.

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 point was appreciated by Sherrington and in his last book he explicitly praises Alexander and his approach.

Section 5 also looks at some observations on the Technique made by scientific figures who had direct contact with Alexander himself or the AT. These include the anatomist and paleo-anthropologist Raymond Dart, and the developmental biologist George Ellett Coghill who both had personal experience of Alexander and studied his work, as well as Nikolaas Tinbergen who devoted half his 1973 Nobel Prize acceptance speech to praising Alexander and the AT.

The aim of Section 6 is to begin to weave together the available neurophysiological insights into the working of the AT into a broad framework within which it can be discussed and evaluated. One of main the hopes of this paper is that it will contribute to the build-up of a genuine scientific vocabulary within which the practice and theory of the AT can be made accessible to a wider scientifically minded community. The paper is addressed to healthcare scientists and professionals, AT teachers and students, fitness trainers and others interested in the neuroscience behind muscle and joint functioning, exercise and physical fitness.

SECTION 1: BACKGROUND

Understanding of how the nervous system works began to grow rapidly from the middle of the 19th century. Among the contributions made by many notable scientists, the work of Charles Sherrington was outstanding. His 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. The first part of this section looks briefly at the career of both men.

It is also necessary to recognise that any attempt 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 discussion of reflex and posture in this section 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. The time spent in this post 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.

In his long career, he identified the function of the synapse in the nervous system, and coined the name; he introduced the term proprioception; his formulation of the rule that when a group of muscles contracts, its antagonists release became known as Sherrington's Law of Reciprocal Inhibition; 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 he carried out a comprehensive range of experimental studies on the postural functions of the nervous system. He published a total of 320 scientific papers covering nearly every aspect of mammalian nervous functioning.

[1] Cohen (1958)p7

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

Sherrington received just about every major honour open to a scientist. 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. Internationally, he received medals and awards from numerous scientific and academic bodies. He died in 1952 at the age of ninety-five.

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 physiology congress in Brussels 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 in a book of his lectures some years later.[5]

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[2] O. Magnus (2002)p51

[3] Ibid. p66

[4] Ibid. p145

[5] Magnus (1930)p97

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 from Liverpool, Magnus received a letter informing him that he had been nominated as Professor of Pharmacology at the University of Utrecht. He gladly accepted the offer and once in place in Utrecht, he set up a programme to investigate the neurophysiology of 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 fifty-four while on holiday in Switzerland. It had been widely expected that he would be nominated for the Nobel Prize in that year but 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.

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[6] O. Magnus (2002)p143
[7] Magnus (1926a)p531
[8] Prochazka (2000)

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 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, was heavily influenced by Magnus's work. She also had doubts about the use of the term *reflex* and 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]

A reflex, in this sense, can be considered as an innate neural program or sequence of muscular instructions encoded in some fashion in the nervous system. In itself it is not accessible to conscious thought but it can be overridden in whole or in part by voluntary actions. The reflexes discussed in this paper are distinguished from what are called the primitive or infantile reflexes exhibited by new-born babies; these include, for example, the sucking and grasping reflexes. The primitive reflexes disappear within the first six months or so after birth.

In accordance with Sherrington's definition, much of what commonly passes for reflex action is not reflex but, rather, learned behaviour. Certain actions become so thoroughly learned that they are carried out without conscious thought. It is easy to recognise this in the "mindless" or habitual 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 no matter how mindlessly they are performed carry the imprint of learned experience.

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[9] Sherrington (1948)pxvi

[10] Bobath (1985)pxi

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 programming of the neuromuscular system. This is not a distinction between types of muscle behaviour – reflex and voluntary actions are both performed by the voluntary muscles and the muscle contractions are essentially the same – but of whether the muscle actions are carried in accordance with an innate program or are learned.

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 both 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 we do something deliberately, we unconsciously bring into play a huge number of reflex responses, varying from subtle 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 balancing and compensatory 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 most of the associated supporting and complementary muscular contractions and releases happen reflexly, independently of any conscious input from the brain.

It is 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 potential for carrying out these actions which we recognise as voluntary 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 conscious selves. The way in which human learned behaviour interacts, often detrimentally, with 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.

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[11] Sherrington (1946)p89

The question of posture

The word *posture* is used in widely different ways. Many of its meanings are associated with deliberately assumed ways of holding the body. Walking stiffly about, 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, following the usage of Sherrington and Magnus, the word posture refers to the 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 used in movement.

[12] Sherrington (1948)p339

SECTION 2: MAGNUS' RESEARCH

The research task Magnus set himself was a challenging one. As Sherrington had pointed out, posture, far from being a static condition, makes demands that keep the whole of the musculature in a state of flux.

Maintaining postural equilibrium requires that the nervous system deal with an inward, or afferent, flow of impulses from the senses and from within the body itself, and simultaneously make the appropriate adjustments to the outward, or efferent, flow of impulses to the muscles involved in posture. Magnus set out to identify the location and functions of the neurological centres involved in the control and coordination of the whole of the reflex activity involved in posture.

He was assisted in this work by a team of researchers at the University of Utrecht. Among these was the noted otologist – ear specialist – Adriaan de Kleijn who was Magnus' co-author in numerous scientific papers.

The research approach

The research focused on 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 in other words guaranteed to be purely reflex. Although these experiments involved a distressing degree of mutilation of the laboratory animals, these were anaesthetised before being operated upon and the removal of their higher brain centres meant that there was no possibility of them experiencing physical pain during the experimental work.

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 lower brain was allowed to function. They did this by making cuts at successively higher levels in the lower brain, thereby leaving more of the brain in place, and finding out 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]

Although the experimental work was carried out on animals, the neurological structures and basic functioning of the nervous system is similar in all vertebrates and Magnus makes a variety of references in his published work to ways in which his findings shed light on human functioning. 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 a more or less fixed position relative to the force of gravity. The body must also be able to retain its balance when its parts are being 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, 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 otolith organs, together with the semicircular canals, are known as the organs for equilibrium and make up the vestibular apparatus.

The otolith organs consist of two sacs, known as the utricle and the saccule, the walls of which 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". The task of the otolith organs is to provide the nervous system with information on the tilt of the head.

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 movement of the heavy otolithic membrane at the end of the flexible hair cells lags slightly behind that 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 monitoring system, a complex type of spirit level, which responds to the changing tilt of the head from moment to moment.

The three semicircular canals also respond to movements of the head but smooth movements are insufficient to stimulate them; they only respond to changes in the rate of movement, either acceleration or deceleration. They are set at right angles to each

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[13] Magnus (1924)p655
[14] Bobath (1985)p
[15] Davson (1990)p678

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 rate of movement of the head changes, the movement of each of the cupulae, because of its inertia and relative flexibility, lags slightly behind that of the head. This bends the hair cells on each of the cristae out of their resting state, causing them to generate nerve impulses. Again, the system is monitoring movement in each of the three dimensions. 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 800 page volume was only translated into English, under the title *Body Posture,* in 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' work was already well-known as a result of his published papers and with the publication of the final report, albeit in German, his full research results were 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. Sherrington, who was at that time President of the Royal Society, was 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 deserved 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 steady muscular tension. This steady muscular tension is usually referred to as "tone", or "tonus" in older publications, and is the degree of tension required to hold a muscle firm but is not sufficient to cause movement of the body parts to which it is attached.

Magnus found that spinal animals, those from which the whole brain had been extirpated, were capable of complex movements when they were placed in a supporting harness and 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 from 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]

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 researchers found that in this condition, 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, it was locked into a stiff and distorted posture.[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]

One of the implications of what he is saying here is that excessive muscle tone, once it has developed, has a tendency to become self-sustaining. This is because when there is excess tension in muscles their own internal sensing organs, their proprioceptors, are stimulated to produce signals to the nervous system which result in that state being maintained. In the case of Magnus' experimental animals, which lacked the higher brain functions required to counteract this excess tension, the result was the permanent state of decerebrate rigidity found by the researchers.

Normal distribution of tone

In normal standing, the extensor and flexor muscles have just the level of tone required to keep them in balance with each other. Magnus found that this occurred when the cut in the lower brain was made above the thalamus leaving it in contact with the spinal cord and 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]

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[16] Magnus (1925)p341
[17] Ibid. p341
[18] Ibid. p341
[19] Ibid. p342

This was a persuasive experimental demonstration that normal standing, including gentle movement around the equilibrium position, even though it involves complex interactions throughout the whole skeletal muscle system, is able to take place in the complete absence of the cerebral cortex. The distribution of tone required for normal standing, in other words, is a wholly reflex phenomenon.

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 of one part of the body changes in relation to the rest. When this happens, the attitudinal reflexes bring about compensatory changes in the muscles in the rest of the body so that the muscular system remains in an overall state of balanced tone. This adjustment of tone throughout the musculature is particularly noticeable when changes in the position of the head take place.

Magnus says:

> *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.*[20]

He 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.*[21]

The point in the above quotation about the 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. He found that, in many cases, when a reflex is evoked in one leg of an animal, a contrary reflex is evoked in the diagonally opposite leg. If reflex extension is induced in the left hind leg, for example, it tends to stimulate a flexion reflex in the right foreleg. This type of crossed reflex is evident, for example, when an animal is walking; it also shows in normal human walking in which the arms and legs exhibit the same crossed pattern. Magnus' observation was that simply turning the head to one side tends to produce a similar crossed-reflex pattern.

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[20] Magnus (1926a)p534

[21] Magnus (1924)p7

Magnus makes the further important point that the attitudinal reflexes evoked by movements of the head 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.*[22]

The fact that these attitudinal tonic reflexes can last for years is, at first sight, remarkable. Yet it is also a matter of commonplace observation that the various humps, stoops, twists and other muscularly-derived postural distortions acquired as a result of accident or faulty habits of bodily use, can become permanent features of people's posture. Walking round in a bent or twisted way is almost certainly more tiring than doing so in a normal manner but, unfortunately, it is not the muscles controlling the muscular distortion that become fatigued – they are able to continue indefinitely.

Magnus' observations on the indefatigable character of these tonic muscular configurations 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 out this feature of the red muscle fibres, was Sherrington's colleague Denney-Brown in a paper to the Royal Society in 1929.[23]

The righting reflexes

The *righting reflexes* restore an animal to its normal posture if it is displaced from this by its own actions or an external force. These reflexes, unlike the tonic attitudinal reflexes, can bring about major movements of the limbs and 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.*[24]

Magnus found that the righting reflexes are best studied in a thalamus animal in which he found that:

> *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*

[22] Magnus (1925)p344
[23] McComas (1996) p191
[24] Sherrington (1948)p340

> *positions, to come back reflexly into the normal position. The reflexes which co-operate in attaining this result are the "righting reflexes."* [25]

In working with a thalamus animal, in which, of course, the visual centres are non-functional, the researchers found that when it 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 remarks *"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."*[26] 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.

Another striking demonstration of the influence of the position of the head on the rest of the body came when Magnus was working with a decerebrate animal lying on its side. He found that when the head was lifted and turned to face forward, the stimulus this provides to the proprioceptive organs in the muscles, tendons and joints of the neck activates reflexes further down the body which bring the thorax back into the normal relationship with the head, thereby untwisting the neck. This, in turn, leaves the 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 relative to the head.

The ability to twist the body into the appropriate position and get up from lying down on the ground is obviously of critical importance to the survival of any animal and Magnus points out that other systems besides the righting reflexes are also involved. The tactile sensors in the skin, for example, are stimulated by the contact with the ground and in the intact animal there is also input from the eyes. Magnus notes 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*

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[25] Magnus (1925)p347

[26] Ibid. p347

> *interference of these reflexes during the movements of various animals in their ordinary life.*[27]

Among all these reflexes, however, it is evident that it is those evoked by the position and movement of the head relative to the rest of the body which have the major influence on the righting reflexes in the rest of the body.

The optical righting reflexes

When working with intact animals, in which the cortex is functioning, the influence of the eyes becomes a major factor in the reflex activity of the animal. Sherrington had written at length about this in *The Integrative action of the nervous system,* well before Magnus had begun his research into the postural reflexes, and had 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 limb or one appendage alone, but of all, so as to maintain an attitude of the body as a whole.*[28]

In the Croonian Lecture Magnus referred to what he called another *extremely well-adjusted central apparatus which governs the positions of the eyes.* He goes on to say:

> *The resting position of the eyes is not a fixed one, but changes according to the different positions of the head. Therefore a fine regulation by means of the eye muscles becomes necessary, which have to be controlled by sensory impulses…*[29]

The position and movements of each eyes in its socket is determined by the action of the six extraocular or extrinsic muscles. These muscles are attached to various points in the socket itself and to different points on the outside of the eyeball, or globe. They provide the eye with its high degree of mobility, enabling it to rotate up, down or sideways. The so-called *"primary position"* of the eyes is when the head is in an erect position and both eyes are both looking horizontally straight ahead and are symmetrically positioned in their sockets.

Various reflex systems are involved. Normal vision requires that the binocular vision the eyes enjoy when they are in their primary position is maintained as the gaze swivels from object to object. This requires the coordination of what are called conjugate movements of the eyes in which the angle between the lines of sight of both eyes remains the same. In addition, the eyes must be able to maintain the same level of coordinated control when the head itself moves about. Normally the coordination of all these eye movements take place reflexly but the presence of the cerebral cortex opens the possibility of, at least partially, controlling them deliberately.

Another set of reflexes which Magnus termed the *optical righting reflexes* also comes into play when the eyes deviate from the primary position. The function of these is to adjust the head, and then the rest of the body, so that the primary position is restored. A sense of what is happening here can be obtained by adopting the primary position

[27] Magnus (1926b)p587
[28] Sherrington (1948)p326
[29] Magnus (1925)p350

and, keeping the head still, paying close attention to what takes place in our musculature as the direction of our gaze shifts. It becomes clear that simply moving the eyes in their sockets primes the muscles for the reflex reactions through the rest of the body that are required to bring our body into alignment with the gaze; and this happens irrespective of whether the eyes are open or shut.

Magnus was interested in the way the eyes exert an influence on the rest of the body via the neck reflexes. This overlaps with the way in which movements of the head influence the rest of the body's musculature. He remarked that

> *…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.*[30]

By a *teleceptor,* Magnus means one of the sense organs which detect objects at a distance; he also refers to them as *distance receptors* or *teleceptive sense organs*. 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. Magnus 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 turn our head to seek the source of the sound or smell. The change in the position of the head, through the medium of the vestibular system and the neck proprioceptors, stimulate the attitudinal reflexes to bring about changes in the muscles in the rest of the body.

He gives the example of 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 as they feed the cat but Magnus analytic mind saw it demonstrating 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.*[31]

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[30] Ibid. p349

[31] Magnus (1926a)p536

Movements of the eyes in their sockets can thus set off various chains of interacting reflex systems. Initially, as the eye movements are made, the optical righting reflexes which work to bring the eyes back to their primary position are evoked. At the same time, the head-righting reflexes in the neck are stimulated to bring the head into alignment with the direction of the gaze. The action of the neck reflexes meanwhile evokes a sequence of reflexes through the rest of the musculature to bring the torso and limbs into alignment with the head. In the normally functioning animal, in which the eyes are constantly flickering about, such chains of reflexes, overlapping and counteracting each other, are constantly taking place.

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.

He summarised their findings as follows:

> *…the principal results of the study are that the <u>centers for the body posture and the labyrinth reflexes are arranged in three great functional groups in the brain stem.</u>*
>
> 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…*[32]

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. This area is sometimes known as the reptilian brain because the functions it controls evolved hundreds of millions of years ago in early reptile life. The important point in the present context is that it is here, rather than in the cortex, that the control centres for the various aspects of posture investigated by Magnus are located.

Magnus had thrown further light on a question which had been intriguing investigators of the nervous system for some time. The segmental nature of the nervous system had been 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.

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[32] Magnus (1924)p632

Posture, requiring a continuing flood of instructions to more or less the whole of the musculature in response to the multitudinous inputs from the external world via the exteroceptors, and the internal world of the body itself via the proprioceptors, is an extreme example of the need for body-wide neuromuscular coordination.

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.* [33]

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...*[34]

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.*[35]

From this it is clear that the term *central apparatus* is something of a misnomer since Magnus' main point was not that the coordination of the postural reflexes was carried out by a specific neurological structure but that their whole complex functioning was controlled from the lower brain rather the cortex. In fact, he was quite explicit about the huge amount of work required to identify what was happening at a detailed level in the neurological system.

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*

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[33] Magnus (1925)p340

[34] Magnus (1924)p653

[35] Ibid. p676

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...[36]

His concluding words in the second Cameron Prize lecture in 1926 outlined what he saw as 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.[37]

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.[38]

It could have come straight from Magnus himself.

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[36] Ibid. p655
[37] Magnus (1926b)p588
[38] 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 section 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 nevertheless 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 is 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 within their conscious control. 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, performing the action, and then returning the body to its resting state. The postural reflexes are especially involved in the process 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.* [39]

Magnus' conception of human muscular activity thus involves a dynamic interplay between voluntary changes induced by 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.*[40]

These cycles of voluntary 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 full 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 actively restorative background to normal muscular activity.

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.* [41]

The role of the postural reflexes is thus to act after a phasic action has taken place and restore the natural state of relaxed harmony to the muscles so that they are ready to respond to whatever comes next. In the case of Magnus' cat watching the mouse run along the bottom of the wall, for example, the postural reflexes restore its musculature to its balanced and relaxed state after the disappearance of the mouse. The cat is then able to move instantly on to the alert again should the mouse reappear.

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[39] Magnus (1925)p349
[40] Magnus (1926b)p588
[41] 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. Whatever is happening, the postural reflexes play a continuing background role, maintaining a tendency to bring the musculature back into its natural balanced state.

The neuromusculature needs such a reference, or default, state to which it has a tendency to return automatically. Otherwise there would be nothing to prevent patterns of muscular tension remaining as residues of phasic activities, and even accumulating to a level at which the overall functioning of the organism becomes impaired. As long as the postural reflexes are working properly, they override these residual tensions and restore the muscles to their natural, or innate, state of harmonious equilibrium.

Continually recalibrating the senses

Magnus pointed out that the postural reflexes have another critically important role, that of continually 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 shifted. 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.*[42]

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 goes through its various activities:

> *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.*[43]

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

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[42] Magnus (1926b)p588
[43] Ibid. p588

ideas beyond those set down in *Body Posture* are contained in the text of a lecture he was due to give in Stanford University in 1928. His death prevented the delivery of the lecture but Stanford University published it in a book of his lectures in 1930. 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.*[44]

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 responses to events in it, will, of necessity, be different from those of a normal-sighted person. Other examples are the way the shape and state of our ear and hearing-apparatus condition the impulses sent along the cochlear nerve to the brain; or how our sense of taste and smell are affected when we have a cold or flu. At a more general level, he points out that there is no avoiding the limitations 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.*[45]

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

> *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.*[46]

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

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[44] Magnus (1930)p97
[45] Ibid. p99
[46] Ibid. p103

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 the limitations of 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."*[47] 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 on their perception of the world about them and their responses to it.

Magnus' point in relation to humans is more complex. It is quite evident that we are trapped in our own physiological *a priori* in the sense that we are limited to the perceptions that our sensory organs are able to deliver; we do not, for example, have the auditory capabilities of a bat or an owl, nor the visual acuity of an eagle. Most scientists would be prepared to accept this general principle and even go so far as to admit that their day to day perception of the world is indeed affected by their state of health and well-being, though few would be immediately prepared to admit that the results of their work are influenced in any way by the state of functioning of their postural reflexes.

Yet this is precisely what Magnus said and his logic is impeccable: our perception of the external world comes to us through the filter of our senses. If we have impaired the workings of our postural reflexes to an extent that they are not performing their sensory recalibration task effectively, our perceptions will indeed be distorted. Luckily, the normal insistence by scientists on the reproducibility of results by different researchers goes a considerable way to eliminate the dangers of results being distorted by the *a priori* biases or perceptual deficiencies of individual scientists, from whatever cause these may arise.

Magnus not only believed that the effective functioning of the postural reflexes was essential to the proper use of the human body, he was also convinced that we were attuned to detect when this is happening 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.*[48]

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.*[49]

Co-opting and modifying the postural reflexes

Magnus' research on the postural reflexes reveals an aspect of human neuromuscular functioning which still tends to be overlooked in conventional medical and physiological thinking. Following his reasoning it is easy to see how patterns of

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[47] Sherrington (1948)pxiv

[48] Magnus (1925)p346

[49] Magnus (1924)p653

muscular use which deviate greatly from the original use-templates provided by the postural reflexes might have detrimental effects on the long-term functioning of musculoskeletal system. But the question is made more complicated by the fact that humans have a uniquely powerful capacity to co-opt and distort the workings of their postural reflexes.

Sherrington's made an important but rather counter-intuitive point when he said in relation to how the postural reflexes provide the muscles with a *nervous background of active equilibrium* that:

> *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.*[50]

It is easy to see that neuromuscular well-being is best served when the resting position leaves the muscles and joints in a balanced and relaxed state. But what Sherrington is pointing out is that it is also essential that it should be easy to move from this resting state into whatever muscular configuration is required by each moment's changing circumstances.

The ease with which the postural reflexes are superseded by volitional activity varies greatly between animals. Lizards have little room for variations in behaviour within their own distinct endowment of postural reflexes. The volitional urges of cats, dogs and the other animals with which Magnus worked have a greater capacity to overrule their postural reflexes. Humans are more volitional and less reflex in their behaviour than even their nearest animal relations so that the dividing line between reflex and volitional in humans is less rigidly demarcated still.

As Sherrington observes:

> *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. When he was learning how to write, he had to focus on how the individual letters were formed but as the actions involved in this became habitual, he could allow the movements of his wrist and fingers to happen without paying them explicit attention. The physical act of writing then becomes almost unconscious, with habit responding to the cortical impulses to write particular words and the reflexes dealing with the details of the necessary flexing, relaxing and moving of his wrist and fingers.

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[50] Sherrington (1948)p232
[51] Sherrington (1948)p387

In this perspective, there is no conflict between voluntary and reflex; they work in harmony, control swapping automatically between the cortex and the brainstem. Before accepting this idealised picture, however, it is important to remember that Magnus' experimental work 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. The absence of the cerebrum meant that no conflict between the two was possible.

The practical reality, as Sherrington was pointing out, is much more messy and it is useful to turn here to Berta Bobath. Although in her work she was dealing with people with severe pathological conditions such as cerebral palsy, she fully subscribed to the view that in ideal circumstances the cerebrum and the lower-brain systems controlling the postural reflexes swap duties and act in collaboration, 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]

Her experience taught her, however, that the human cortex exercises a much higher degree of control over the postural reflex system than is suggested by Magnus. 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.*[53]

Bobath's work which put her in touch with people in whom brain lesions were disrupting communication between the cortex and the subcortical centres allowed her to explore the interaction between the volitional and the reflex in postural activity more deeply than was possible in Magnus' work. She found that where brain damage was causing imperfect coordination of reflex and volitional activity this tended to lead to what she called *"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*

[52] Bobath (1985)p2
[53] Ibid. p6

reflexes and by the patient's volitional efforts when using their patterns for function.[54]

For her, Magnus' basic findings on the functioning of the postural reflexes retained their validity but by the nature of his work, dealing mainly with decerebrate animals, he had little to say on how the reflexes and the cerebrum worked together in the intact animal. He was, of course, fully aware that there is a high degree of interaction between the cortical and subcortical; the cortex, in other words, could interfere with the workings of the postural reflexes. But the details were outside his frame of reference. Bobath's 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 there is a high degree of interaction between the cerebrum and the subcortical postural control centres.

The conditions being considered in this paper 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 salient fact is that humans have a capacity to co-opt or suppress the postural reflexes in ways which are impossible for other vertebrates. This has a variety of implications for the development of behaviour in humans as they mature and go through their adult lives.

Consequences of suppressing the postural reflexes

In addition to their greater cerebral capacity which enables them to override their postural reflexes, humans 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 their musculature can override their postural reflexes so thoroughly that they are almost completely suppressed.

The positive aspect of this 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, is that it permits 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 performing dogs and bears make poor dancers compared to even a moderately well-coordinated human.

But overriding the postural reflexes can bring problems. After a new mode of using the body has been adopted, it can, in time, become so habitual that the person has no awareness of the extent to which the restorative action of the postural reflexes has been suppressed. Although no brain lesions are involved, this still represents a disruption of proper communication between the cerebrum and the lower brain in which habitual but damaging patterns of muscle use have become impervious to the restorative promptings of the postural reflexes.

Another 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". As a result, the tendency of the postural reflexes to restore the musculature to its innate state of harmony and balance is reduced or eliminated. The

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[54] Ibid. p2

effectiveness of the recalibration of the senses after phasic activity is reduced and completely oblivious to what is happening, the body gradually accumulates a series of distortions in its functioning.

SECTION 4: THE HEAD-NECK RELATIONSHIP

The physiological and neurological sciences have made many advances since the time of Magnus and Sherrington. The fundamental understanding of the postural reflexes as elucidated in the first part of the last century remains intact but many further details have been added.

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.* [55]

This brings into focus the role of the neck which forms the connection between the head and the body. It is reputedly the most complex musculo-skeletal system in the body,[56] which is not surprising once the multiplicity of its tasks is brought to mind.

The neck provides the high degree of mobility and flexibility required for the optimum operation of the exteroceptors located in the head. At the same time it is the connection between the brain, acting as the body's analysis and command centre, and the working neuromuscular systems of the body. Since Magnus' death, a great deal of further scientific investigation has been carried out into the detailed workings of this vital, and vulnerable, connection.

Physiology of the head-neck relationship

Before looking at the working of 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 which form the cervical spine. 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. The head weighs around four kilograms (8 ½ lbs). Lifting four bricks or two bags of sugar in a plastic bag is a useful exercise in that it gives a tangible sense of the task that the neck handles with such delicate precision. The neck is an area of the body that is in constant movement; it is said it moves over six hundred times an hour, whether the person is awake or asleep.[57]

One of the features of the head-neck relationship is that 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 a description of such redundancy:

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[55] Magnus (1926a)p536
[56] Bland and Boushet (1992)p135
[57] Ibid. p135

> *Additionally, the redundancy of the cervical muscle system is well documented. It has been observed that mid-range head orientations common in daily function can be achieved with multiple combinations of movement strategies with motion characteristics of some cervical joints differing substantially depending on starting position and movement pattern.*[58]

This redundancy makes the precise analysis of the functioning of the head-neck relationship difficult, as indicated here:

> *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 outputs must be appropriate for a given task, such as controlling gaze or posture or both simultaneously.*[59]

The authors, in this case, are referring to the control of head movements in a lizard.

The neuroanatomy of the lizard 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 neck muscle systems can be used in a variety of ways to achieve the same end-result, though 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 them, 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, in some senses, 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

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[58] Jull et al (2008)p24

[59] Wang et al (1992)p91

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, is said to "flex" 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.[60]

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 these muscles 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 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. The sub-occipital muscles thus 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.

The question then becomes what is the purpose of this intricate muscular arrangement. 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.*[61]

A more detailed account of the relative distribution of muscle spindles in different muscles is provided by Jul et al, discussing the neck muscles:

> *The density of muscle spindles is highest in the suboccipital muscles and, even more specifically, in the deeper sections of these muscles. The average number of muscle spindles found per gram of muscle is: 242 in the obliquus capitis inferior; 190 in the obliquus capitis*

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[60] See, for example, Stone and Stone (pp 62, 68, 69)

[61] McComas (1996) p48

> *superior; 98 in the rectus capitis posterior minor; …For comparison, the first lumbrical in the hand has 16 and the superficial trapezius muscle has 2 muscle spindles per gram of muscle.*[62]

The muscles in the sub-occipital area are a hundred or more times more sensitive to stretching than those in other parts of the body. Thus, though they can only play a minimum role in moving the head, they possess the necessary neurological characteristics and are positioned to act as extremely sensitive strain gauges in the task of monitoring the muscular state of the head-neck relationship. Their major function is more likely to be proprioceptive rather than contributing to the task of moving the head and this, indeed, is suggested by Gray's Anatomy.

> *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]

Their role in other words appears to include the provision of feedback on the relative positions of the head and neck to the postural control centres in the brainstem.

The coordinating role of the neck

The head houses the exteroceptors, the eyes, ears and nose, which provide information about the external surroundings. It 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 the 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 functioning of the teleceptors 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. The neck, in short, plays a crucial linking and coordinating role in the overall functioning of the body.

Take the functioning of 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 head 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 postural reflexes adjust the disposition of muscular tone from the head down to soles of the feet.

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[62] Jull et al (2008)p60

[63] Williams (1995) p813

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 extreme delicacy in both the horizontal and vertical dimensions. At the same time, in most cases, when a sound has been consciously or unconsciously registered as requiring attention, 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.[64] 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.*[65]

Most of the necessary coordination between the head and the body is provided by the neck. The perhaps paradoxical conclusion when the complexity of what is involved is considered is that for the most part it is too complex to be controlled consciously. In normal conditions, therefore, the neck does its job almost entirely reflexly and, in the absence of injury or physical decline, the head-neck-body relationship remains unproblematic. In the case of humans, however, the scope for malfunctioning is increased immeasurably by the fact that they can distort their evolutionary reflex heritage by inventing and imposing on their head-neck system a variety of new modes of behaviour, some of which can leave permanent and damaging marks on its functioning.

Effects of disrupting normal head-neck functioning

There are various ways of disrupting the delicate working mechanisms in the head-neck area. Over-tense or excessively developed neck and shoulder muscles; glasses, contact lenses and laser surgery; ear-phones plugged deep into the auditory meatus of each ear; these all 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.

The most obvious, and commonest, way of disrupting the postural reflexes and the natural working of the body's wider neuromusculature is through excessive neck tension. If the head is unable to provide the level of subtle and delicate adjustment required by the eyes and ears, for example, they cannot function to their optimum and people find themselves straining to see or hear. Habits of staring or "trying" do hear can do little, if anything, to improve sight or vision but are usually associated with characteristic postural distortions.

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[64] Taylor (1992)p488

[65] Mittelstaedt and Mittelstaedt (1992)p369

But the most common result, and the one most germane to the present discussion, is the way undue neck tension 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 excessively contracted, so that the head is pulled backward and down on 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. In many people this is an habitual feature of their overall posture. As a result, there is little or no stretching of the sub-occipital muscles and they no longer perform their proper strain-gauge function of monitoring the head-neck relationship.

This, in turn, means that 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 from the brain to the postural muscles, in turn, must 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 bound to be impaired to a greater or less extent.

Long-term effects

The long-term effects of malfunctioning in this crucial area of the musculature are visible everywhere. Because the corrective or restorative function of the postural reflexes is impaired, there is no check on the accumulation of distortions in the working of the musculature. The effects 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 into a wide variety of ways of walking depending on the influences to which the developing child and adult are subjected. Marching with the chest puffed out, 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 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 the damaging muscle-use patterns they have acquired in their habitual way of using themselves than they are to restore the proper functioning of the postural reflexes. It is also noticeable that many people who rely on such "fitness" regimes tend to show a heightened level of muscular tone and, especially in the case of sports-people, a greater susceptibility to muscular and joint injuries.

Damage in the head-neck area

The critical role of the head-neck relationship helps explain why damage in the cervical area from whiplash or other injuries can have such widespread effects on body-functioning, especially on the sense of balance. 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.*[66]

While few would be surprised that widespread effects might be felt after moderate to severe neck injury, the author also mentions *"mild non-concussive head trauma"* and *"neck manipulation"* as also bringing the risk of long-lasting dizziness. He goes on to mention some of the other, surprisingly wide range of symptoms which can come from such mild-to-severe neck damage; these include 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.[67]

People who have suffered whip-lash injury sometimes find that though they appear to have recovered completely from its direct effects they still find themselves afflicted by headaches and other symptoms. Magnus' findings, especially in relation to the non-fatiguability of attitudinal tonic reflexes, can help explain some of these long-lasting effects.

One of the longer-term effects of a whip-lash or other neck injury is likely to be a slight habitual positioning of the head away from its optimum position of balance on the top of the spinal column, perhaps as a subconscious attempt to deal with chronic pain. As Magnus found, such a change in the position of the head can alter the distribution of tone in the whole of the musculature, an effect which can last as long as the position of the head is away from its optimum.[68] These imbalances of tone evoke compensatory distortions in other muscle areas so that the musculature becomes locked in malposture and its attendant pains. Since the tonic attitudinal reflexes are almost indefatigable, the long-term effects of anything that causes even minor damage in the head-neck area should not underestimated.

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[66] Brown (1992)p645

[67] Ibid. p645

[68] Magnus (1926a)p534

It is nonetheless surprising to see therapeutic neck manipulation listed among the risk-factors for neck-damage, but this has long been a subject around which there has been controversy. This is particularly the case with chiropractic against which some chiropractors themselves have warned.[69] The following provides a commentary on this particular debate:

> *The contemporary debate is the use or not of high-velocity manipulative thrust techniques in the cervical region where there are risks, albeit probably small, of serious or dire adverse effects. Most notable among these is trauma to the vertebral artery with the risk of stroke or even death. Incidence of rupture of cervical disks have also been reported with cervical manipulation. Protagonists for the continued use of high-velocity thrust techniques strongly argue the relative risk of cervical manipulation but equally as strongly, others can find no justification for their use.*[70]

The author, Samuel Homola, is a long-time practising chiropractor and the "dynamic thrust" he refers to in the above is described as a *"Chiropractic adjustment delivered suddenly and forcefully to move vertebrae, often resulting in a popping sound."*[71]

Without venturing further into the details of such debates, it is, at a minimum, safe to say that damage or 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 wider neuromuscular system. This suggests that a necessary condition for overcoming the effects of neck damage, in addition to whatever medical "repairs" are required, is to ensure that the proper workings of the sub-occipital muscles and other proprioceptive systems in the head-neck area are restored.

If through an habitual adjustment to the injury, manipulative treatment 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.

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[69] Homola (1999)p86
[70] Jull et al (2008)p195
[71] Homola (1999)p239

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 lives of both men paralleled each other for the next fifty years but it is interesting to note how few of those scientists who recognise the magnitude of Sherrington's achievements have shown any curiosity about his knowledge of Alexander and sympathy with his work.

Yet Sherrington himself was 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 medical and scientific thinking.

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

> *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.*[72]

The personal reference, embedded in a longer passage which is noticeably redolent of Alexander's thinking, 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 from 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...* [73]

Sherrington's remarks appear to come from a clear 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.

Origins of the Alexander Technique

Frederick Matthias 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 and other dramatic 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 to his voice problems and he set about developing his own approach, 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

[72] Sherrington (1946)p89
[73] Bloch (2004)p207

tightening his throat and chest and pulling his head backwards and down when he was reciting. This tightening in the head-neck area led to what he called *"shortening in stature"* and he realised it had effects through the rest of the body.

This is how he described his discovery, saying he had found:

> *…that the functioning of the organs of speech was influenced by my manner of using the whole torso, and that the pulling of the head back and down was not, as I had presumed, merely a misuse of the specific parts concerned, but one that was inseparably bound up with the misuse of other mechanisms which involved the shortening of the stature.*[74]

Having identified the cause of his voice problem, he set about correcting it. By careful inspection of what he was doing, using an arrangement of mirrors, he was able to devise a way of reciting which did not involve pulling his head back and down. But instead of being the permanent cure he was seeking this brought him up against another and more intractable problem. He then found that as soon as he stopped thinking specifically about this new way of organising his head-neck relationship while he was reciting, the damaging habits reasserted themselves and the hoarseness recurred. He was up against the fact 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, what he later called his Technique. The marked improvement in his voice performances was noticed by his fellows in the Australian acting world and he found himself giving an increasing number of lessons in his voice retraining method to these other performers.

It soon turned out that his method of dealing with his voice difficulties paid other health dividends, particularly with breathing-related problems. Alexander began to attract 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. Sir Henry Irving and his son H. B. Irving, as well as the actor-manager Herbert Beerbohm Tree who went on to found the Royal Academy of Dramatic Art (RADA) were among his early well-known supporters. 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-

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[74] Alexander (1932) p29

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 had come to fame as one of the prime exponents of the influential school of philosophy known as "pragmatism" and was by this time one of America's most prominent intellectuals. When he met Alexander, he was aged fifty-six, 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.

In these introductions, Dewey emphasised what he felt was the scientific nature of the Technique. In his introduction Alexander's second book he 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.*[75]

This particularly pleased Alexander who never felt there was anything esoteric about his approach and was particularly opposed to quackery and fringe medical cults and, indeed, over the years enjoyed the support of a variety of medical friends and pupils. A letter supporting him from a group of nineteen doctors, for example, was published in the *British Medical Journal* in May 1937. He himself firmly believed that the principles of his Technique should be integrated into the normal training of medical practitioners.

By the early 1920s, Alexander had become a well-known and successful teacher of his Technique in the USA and Britain. His pupils over the years included William Temple, the Archbishop of Canterbury; Joseph Rowntree, the chocolate manufacturer and philanthropist; Lord Lytton, the Governor of Bengal and for a time Viceroy of India; George Bernard Shaw; Aldous Huxley; Sir Adrian Boult; Sir Stafford and Lady Cripps; and many others.

In the early 1930s, Alexander set up a school for training teachers in his Technique, while maintaining a large private practice. He 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.

Some scientific supporters of the AT

Many medical doctors and scientists have derived personal benefit from the Alexander Technique and it is generally regarded with favour, or at least benignly, in

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[75] Alexander (1923) pxxvii

the medical profession. Among the prominent scientists who publicly gave their backing to Alexander and his approach were the anatomist and paleo-anthropologist Raymond Dart and the developmental neurophysiologist George Ellett Coghill. Nikolaas Tinbergen who won the Nobel Prize for his role in establishing the science of ethology, or animal behaviour, devoted half his 1973 Nobel Prize acceptance speech to extolling the benefits of the AT.

Frank Pierce Jones was an exception in that he did not begin his career in the sciences; like earlier generations of scientists, his initial grounding was in the classics. But his encounter with the AT so impressed him he retrained himself in medical research, was appointed a Research Associate at Tufts University in Boston and carried out a series of studies on the AT during the 1950s, publishing his results in the scientific literature. David Garlick (1933-2002) was a sports medicine scientist at the University of New South Wales. He became interested in the AT and went on to become an AT teacher as well as doing much to publicise it around the world.

Brief accounts of the backgrounds and work of these scientific supporters of the AT are given below. Their insights into the underlying science of the AT are also woven into the broader neuroscientific overview of the AT in Section 6.

Raymond Dart

Raymond Dart (1893-1988) was born in Australia. He studied medicine and after graduating from Queensland University in 1917 he joined the Royal Australian Medical Corps and served with it in France until the end of the First World War. On demobilisation, he became senior demonstrator in anatomy in University College, London under Sir Grafton Elliot Smith. He moved to South Africa in 1922 when he was appointed Professor of Medicine in Johannesburg University. He later become Dean of the Faculty of Medicine there and served 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. He read Alexander's books, remarking in a later paper that

> *Alexander's terminology of 'primary control' and 'head-neck relationship' on the one side, and the work of Sherrington and Magnus on segmental and suprasegmental reflexes on the other side, had riveted my attention...*[76]

In 1943, Dart had a short but intense period of AT lessons with Irene Tasker a close associate of Alexander who happened to be in South Africa but was shortly leaving for England.

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[76] Dart (1996) p33

Apart from a single lesson from Alexander, in London in 1949, 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.

In this aspect of his thought, Dart was influenced by the now-discredited "recapitulation theory" of the German anatomist Ernst Haeckel (1834-1919) who was an early supporter of Darwin and evolution. Haeckel coined the phrase "Ontogeny recapitulates phylogeny" reflecting his belief that the human embryo passes through different developmental stages in which it not only resembles but has the characteristics of a fish, a reptile, an early mammal and finally a human. Looking at his grievously underdeveloped son, the undeniable fact for Dart was that the child had failed to complete all the normal stages of embryological development. The various exercise and movement programmes he devised for the boy owed some of their inspiration to the stages of phylogenic development he had supposedly missed in the womb but were ultimately justified on their day-to-day efficacy in promoting his childhood development.

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.[77]

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.*[78]

In this analysis, 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 activity. 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*

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[77] Ibid. p

[78] Ibid. p85

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.[79]

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 classical painting or sculpture.[80] He was also keen to get away from the notion of posture as a posed or static configuration of the musculature, suggesting the use of the word "poise" instead. He also pointed out that exercising, as a means of promoting the 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 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 by developing new habits based on the conscious control of the body is that of Matthias Alexander…[81]

Dart remained a strong supporter of Alexander's approach and 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.[82]

He 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.[83] These involved observations by Coghill and his assistants of the developing responsiveness of the

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[79] Ibid. p90
[80] Ibid. p85
[81] Ibid. p91
[82] Ibid. p55
[83] Herrick (1949)p34

neurological system of the *amblystoma* at fifteen minute intervals for the first sixty hours after hatching.[84] 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 in book form under the title *Anatomy and the problem of behaviour.*[85]

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.*[86]

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 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.*[87]

Just as in the case of Sherrington, Alexander's insistence on looking at the totality of the behaviour of the organism resonated with Coghill's thinking. 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*

[85] Coghill (1929)
[86] Ibid. p89
[87] Barlow (1978)p257

of Amblystoma in embryonic and larval stages, and they appear to hold good for other vertebrates as well.[88]

He goes on to discuss the way in which the total pattern provides a characteristic mode of behaviour for an animal 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.*[89]

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 which are determined by the conditions at any given time, 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, remarking:

> *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.*[90]

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 acquired habits being "antagonistic" to the total pattern.

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

Frank Pierce Jones

Frank Pierce Jones (1905-1970) was born in Wisconsin. He received a degree and then a Masters in Stanford University and began studying for a PhD in classics at

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[88] Alexander (1946)p xix

[89] Ibid. pxxiii

[90] Ibid. pxxxiv

Wisconsin University. In 1932, he was diagnosed with tuberculosis. He spent some time at a sanatorium and after an apparent recovery resumed his studies. He suffered a relapse and returned to the sanatorium on total bed-rest for a year; the doctors told his wife who had just had their second child that he might die. He made a recovery and resumed his doctorate studies but remained very delicate.

After he was awarded his PhD, he was appointed a classics instructor at Brown University in Rhode Island but continued to suffer from breathing problems, fatigue and muscular aches. He heard of the Alexander Technique from colleagues at the University and had some lessons in Boston in 1938. The lessons gave him such relief that he discarded the allergy medications he had been taking and for the first time found himself able to live a normal life without pain and tiredness. He met and became friendly with Alexander who was teaching part of the time in Boston.

Jones was so impressed with his health improvements that he took leave of absence from his academic post and asked Alexander to train him as a teacher of the Technique. After he had completed his training in 1944, he began teaching the AT in Boston, and in New York where he met John Dewey. Both he and Dewey were keen to identify a scientific basis for the AT to get it more widely accepted and they had many discussions about this.

Jones said:

> *My own attitude at this time coincided with Dewey's. It was increasingly frustrating for me that I was unable to produce any objective evidence for a principle that my senses told me was true and my experience convinced me was of fundamental importance. I did not consider myself qualified by temperament or training to undertake a scientific investigation, but no one else seemed prepared to undertake one and I found myself gradually propelled in that direction.*[91]

In autumn 1949, a pupil who had recovered from a serious heart condition gave him $500 which he decided to spend on a piece of research at the Institute for Applied Experimental Psychology in Tufts University in Massachusetts. It was a fairly modest piece of work on electromyography – the study of electrical impulses in muscles. As he said himself, he was beginning at the beginning and his main research experience up to that time had been into Greek grammar.

He was lucky in that he had an AT pupil at the time called Harold Schlosberg who was an experimental psychologist and an experienced researcher into sensory-motor phenomena. Another of his pupils was Dr Grayson McCouch who was professor of neurophysiology at the University of Pennsylvania Medical College and had worked with both Sherrington and Magnus. They themselves were not interested in researching the Technique but were happy to advise him, introduce him to people and suggest what he should read.

He used some other gifts from grateful pupils to set up a research project at Tufts University where he was appointed a Research Associate. This led to a grant from the Carnegie Corporation and then to support from the US Public Health Service for seven years. After that ended, as he put it himself, he accepted a professorship in classics at Tufts and continued his research through government contracts and gifts

[91] Jones (1976)p105

from pupils.[92] Up to the time of Alexander's death in 1955, he and Jones remained in correspondence.

In considering his research approach, Jones considered doing before and after studies on the effects of the AT, using treatment and control groups and looking for the difference between them after a certain number of lessons. While he did not dismiss this kind of study, he felt that any positive results could be explained by external factors such as improved motivation or something else. Negative results, on the other hand might be because the pupil had simply failed to learn the Technique. He rightly felt that correlation in the absence of an understanding of the causal factors involved can never be fully convincing – though it is now the basis for the evaluation and licensing of a high proportion of drugs and medical treatments.

Jones therefore decided it would be scientifically more convincing if he could identify the immediate physiological effects of applying the AT in practice. He decided to see if he could correlate the subjective feelings people experienced when performing certain actions, like walking or getting out of a chair, in an Alexandrian way and a non-Alexandrian way, with observable physiological effects. He summed this up as studying *"the physiological correlates of the kinaesthetic effects that can be produced in a single lesson."*[93]

Jones produced some twenty four published scientific papers as well as numerous articles on the AT as a result of his work. A paper entitled *Method for changing stereotyped response patterns by the inhibition of certain postural sets* published in the *Psychological Review* in 1965 perhaps best sums up how far he had reached. It is reprinted in a posthumous collection of his work published in 1998.[94]

Earlier, in his own book entitled *Freedom to change,* he summarised his views on the working of the AT as follows:

> *In malposture, muscles in various combinations and degrees of tension have shortened, displacing the head or holding it in a fixed position. Head displacement would have an adverse effect on the rest of the body partly because of the added weight and strain put on muscles and ligaments, but largely, I believe, because of interference in the righting reflexes by abnormal pressure on the joints of the neck. What is basically an incomplete response to gravity would in time come to feel natural, and the muscles contributing to it would be strengthened by exercise. The procedures used in the Alexander Technique establish a new dynamic balance among the forces acting on the head so as to allow more of the postural work to be done by disks and ligaments and by muscles acting at their optimal length.*[95]

Jones died of brain cancer in 1975 at the age of seventy before he had completed the last chapter of this book.

[92] Ibid. p108
[93] Ibid. p148
[94] Jones (1998)p249
[95] Ibid. p148

Nikolaas Tinbergen

Nikolaas (Niko) Tinbergen (1907-1988) was born in Holland. Even as a child, he was interested in wildlife and he went on to study zoology in Leiden University where he received a doctorate in 1932.

In the following years, he devoted himself to exploring animals in the wild and devising ways of carrying out scientific experiments to elucidate why they behaved as they did. Although the laboratory work of Sherrington, Magnus, Coghill and a host of other scientists had uncovered vast amounts of important information on the physiological and neurological working of animals, little was known about why they behaved as they did in their natural surroundings. Tinbergen was the leader in the developing field of animal behaviour or ethology as it was later to be called.

Hans Kruuk, a former student of Tinbergen, and his biographer, said that Tinbergen believed that:

> *Behaviour has a purpose, even though animals do not know that, and it has been selected in evolution because it has a biological function that contributes to the preservation of the individual and the species.*[96]

According to Kruuk, Tinbergen saw it as his task to carry out a systematic investigation of such behaviour which he believed was based on an

> *…hierarchical system…of nervous centres, the higher centres controlling a number of centres at a next lower level, each of these in their turn controlling a number of lower centres…*[97]

He modestly described his research method as "watching and wondering" but as his publications list lengthened and his scientific papers were noticed around the world, his reputation grew. In 1950, he became Head of the Department of Zoology in Oxford University. The following year his major work, *The study of instinct* was published and established his international scientific reputation. He was appointed a Fellow of the Royal Society in 1972 and delivered the Croonian Lecture in 1972. In 1973, together with Konrad Lorentz and Karl von Frisch, he was awarded the Nobel Prize; the citation called them *"the most eminent founders of a new science, called 'the comparative study of 'behaviour' or 'ethology'"*.

Just before the Nobel Prize, in about 1973, his daughter, a cello player, had been suffering from back and neck problems and had had some AT lessons. She felt they helped her and Tinbergen and his wife signed up for lessons with a well-known AT teacher in Oxford called Elisabeth Walker. He was about sixty five when he had his first lessons and he became an immediate and highly enthusiastic convert.

He had had about 15 lessons when it came to the Nobel Prize acceptance speech. In this, instead of bringing the assembled dignitaries up to date on his ethology work he told them he wanted to give them two examples of how the techniques of *"watching and wondering"* could contribute to the relief of human suffering.

His first example was devoted to the problem of childhood autism on which he and his wife and been working. He then turned to the AT saying:

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[96] Kruuk (2003)p146

[97] Ibid. p146

My second example of the usefulness of an ethological approach to Medicine has quite a different history. It concerns the work of a very remarkable man, the late F. M. Alexander. His research started some fifty years before the revival of Ethology, for which we are now being honoured, yet his procedure was very similar to modern observational methods, and we believe that his achievements and those of his pupils deserve close attention.[98]

He went on to say:

We discovered that the therapy is based on exceptionally sophisticated observation, not only by means of vision but also to a surprising extent by using the sense of touch. It consists in essence of no more than a very gentle, first exploratory, and then corrective manipulation of the entire muscular system. This starts with the head and neck, then very soon the shoulders and chest are involved, and finally the pelvis, legs and feet, until the whole body is under scrutiny and treatment."

He continued by saying that between the three of them, his wife, daughter and himself, they had already noticed striking improvements in high blood pressure, breathing, depth of sleep, overall cheerfulness and mental alertness, resilience against outside pressures, and also in such a refined skill as playing a stringed instrument.

No doubt deferring to his scientific audience he said:

Once one knows that an empirically developed therapy has demonstrable effects, one likes to know how it could work – what its physiological explanation could be.

And continued by saying that

…some recent discoveries in the borderline field between neurophysiology and ethology can make some aspects of the Alexander therapy more understanding and more plausible than they could have been in Sherrington's time.

One of these new discoveries concerns the key-concept of 're-afference'. There are many strong indications that, at various levels of integration, from single muscle units up to complex behaviours, the correct performance of many movements is continuously checked by the brain. It does this by comparing a feedback report that says "orders carried out" with the feedback expectation for which, with the initiation of each movement, the brain has been alerted. Only when the expected feedback and the actual feedback match does the brain stop sending out commands for corrective action.[99]

Tinbergen then goes on to say that

……what Alexander has discovered is that a lifelong mis-use of the body-muscles (such as caused by, for instance, too much sitting and too little walking) can make the entire system go wrong. As a consequence, reports that "all is correct" are received by the brain (or

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[98] Tinbergen (1973)
[99] Ibid. p125

> *perhaps interpreted as correct) when in fact all is very wrong. A person can feel at ease, for example, when slouching in front of a television set, when in fact he is grossly abusing his body.*[100]

The speech caused some upset in scientific circles and led to a rather acrimonious correspondence in the *New Scientist* magazine the following year. Tinbergen was undeterred and delivered the 1976 Alexander Memorial Lecture in London.

In his fairly hagiographic biography of Tinbergen, Hans Kruuk, although he had no personal experience of the AT, was clearly embarrassed by Tinbergen's involvement with it. He said Tinbergen's interest in it gradually petered out *"…and after a couple of years it was conceded that the Alexander technique did not do a great deal for him…All in all, perhaps the Nobel lecture would be best forgotten."*[101]

I wondered about this myself and checked with Tinbergen's daughter who said her father stayed interested in the Technique at least until he had a stroke in 1983. In her own autobiography, Elisabeth Walker warmly recalled her friendship with Tinbergen and of his continued interest in the AT after he won the Nobel Prize:

> *When Niko won a shared Nobel Prize for Physiology or Medicine in 1973, he spoke of the Alexander principles in his acceptance speech. Niko continued to have lessons for another nine years finding it of use for a time to relieve his depression, from which he had suffered for some time. In 1980 we stayed with them in their idyllic holiday cottage…Niko was a keen photographer and he and I exchanged many photos.*[102]

After he had a stroke in 1983, Tinbergen became quite feeble and he died in 1988.

David Garlick

David Garlick (1933-2002) was born in Sydney in 1933. He qualified as a doctor of medicine in Sydney University and went on to study for a doctorate which he was awarded in 1963. After spells in Duke University in North Carolina and the University of Copenhagen in Denmark, he took up a position in the Department of Physiology and Pharmacology in the University of New South Wales.

He was interested in running and other forms of physical exercise and this, combined with his physiology work, increasingly led him into sports medicine. He was keen on educating doctors and health professionals in this area and developed a Masters course aimed at clinicians. This was later expanded into an undergraduate degree course in Health and Sports Science.

His introduction to the AT came when he read Tinbergen's Nobel Prize acceptance speech. As a result, he had AT lessons and became increasingly interested in the relevance of the Technique to sports medicine. He eventually decided to train as an Alexander teacher and qualified in 1994.

Garlick's published work on the AT is fairly thin. His main publication is a booklet entitled *The Lost Sixth Sense: a medical scientist looks at the Alexander Technique* which was published by the University of New South Wales in 1990. He also

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[100] Ibid. p126
[101] Kruuk (2003)p283
[102] Walker (2009)p138

involved himself publicly in promoting the AT and became a well-known public speaker on it. He also produced a series of twenty articles dealing with neurological and physiological aspects of the Technique for the specialist AT publication, *Direction Journal,*[103] which has reprinted them as a special issue.

One of the themes dealt with by Garlick is the different characteristics of the red and white muscle fibres, the red fibres being non-fatigable whereas the white fibres are fatigable. Achieving the appropriate balance between the fibres in their muscles is a matter of major concern for top-class athletes since endurance sports such as marathon-running depend mainly on red fibres in comparison with the explosive requirements of sprinting which depends primarily on white fibres.[104]

In one of his short pieces for *Direction Journal* Garlick suggests how tension in the neck area can switch the recruitment of muscle fibres from the red, which are naturally more appropriate to postural tasks, to the fatigable white fibres, with detrimental effects on the patterns overall muscle use.

> *One observation I find suggestive, is that the experimentally induced contraction of neck muscles may result in the non-fatigable red fibres not being used in posture and simple movements. If muscle fibres are used then, they will be the fatigable white fibres. The person will tend to avoid using these and hence bad posture could be the consequence.*[105]

As a medical scientist with a research position in a major university, Garlick was well-positioned to act as an influential advocate for the AT and chose to do so. He had planned a study into the workings of the multifidus muscle, one of the deep postural muscles which works to stabilise the joints at each segmental level in the spine and hence has a major role in posture. But he died of cancer in 2002 at the age of sixty-nine.

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103 http://www.directionjournal.com/about/

104 See further discussion in my paper *Muscles and their red and white fibres* at http://www.geraldfoley.co.uk/MUSCLES%20Feb%2008a.pdf

105 Garlick (D1-1)p7

SECTION 6: A NEUROPHYSIOLOGICAL OVERVIEW

Alexander was extremely anxious that his work should be regarded as scientific. But during his lifetime, and since then, a comprehensive scientific framework within which it can be discussed and analysed satisfactorily has been lacking. Considerable progress has, nonetheless, been made.

The background provided by the pioneering discoveries of Magnus and Sherrington, the specific contributions made by scientists such as Dart and Coghill, together with the work of Jones, Tinbergen and others inside and outside the AT profession provide a variety of insights into the workings of the AT. This section attempts to assemble these insights into a preliminary neurophysiological overview within which the AT can usefully be considered.

What did Alexander discover?

Perhaps the most useful starting place for this discussion is to deal with a misunderstanding on the part of Alexander. His often-reiterated belief that what he called the "primary control" and what Magnus had referred to as a "central apparatus" in the brainstem were the same thing, was mistaken.

In fact he came late to his usage of the term "primary control". The first time he employed it appears to have been in a lecture he gave to the Child-Study Society in February 1925 when he was already a well-known and successful teacher of his Technique in England and the USA. 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.*[106]

In a letter dated 9 July 1932, published in the British Medical Journal, for example, Alexander 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:

> *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.*[107]

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[106] Alexander (1995)p148
[107] Alexander (1995)p134

It is quite evident that this “primary control” cannot be identical with Magnus’ “central apparatus”, if for no other reason than because Magnus’ central apparatus is wholly beyond any possibility of conscious control whereas Alexander refers in the above quotation and various other places to the need for a certain conscious and continued “employment” of the “primary control”

Though this is a valid point, is of no practical significance outside the world of experimental neuroscience. In the absence of brain-surgery to remove the cortex, Magnus’ “central apparatus” does not exist as an independent entity. Muscular functioning in the everyday behaviour of humans and intact laboratory animals, as Berta Bobath pointed out (p15), always represents a compromise between the reflex and the voluntary. The relevant point, and Alexander’s incontrovertible common ground with Magnus, was that they had both identified the critically important role of the head-neck relationship in the body’s overall neuromuscular organisation of itself.

The importance of the head-neck relationship

In his experimental studies, Magnus amply demonstrated the importance of the various attitudinal and righting reflexes to the functioning of the rest of the body. All these reflexes are directly or indirectly mediated by the working of the head-neck relationship. As he summed it up in *Body Posture*:

> *The mechanism as a whole acts in such a way that the head leads and the body follows.* [108]

In his own studies on himself, confirmed by his years of work on his pupils, Alexander had empirically come to the same conclusion about the crucially important influence of the head-neck relationship. Unless this was working properly and freely, the functioning of rest of the musculature was inevitably compromised.

His achievement was to have devised a non-surgical and consciously controllable means of reducing habitual interference with the proper working of the head-neck relationship, thereby permitting the rest of the neuromusculature to begin again to function as it should. The paradox, and undoubtedly the cause of some confusion, 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.

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, recognised that this is what was happening. In a pamphlet first published in 1950, when he was still working closely with Alexander, Carrington observed in relation to Alexander’s work:

> *The essence of his discovery is that by means of a certain manner of employment of the different parts of the organism which are susceptible to voluntary control, it is possible to eliminate interference with the functioning of the integrating mechanisms and thus restore normality. The whole basis of Mr Alexander’s Technique is the*

[108] Magnus (1926a)p536

teaching of how to eliminate interference with the autonomic functioning of the organism.[109]

The "integrating mechanisms" to which Carrington refers here are, of course, the reflexes as described by Sherrington in *The integrative action of the nervous system.* Subsequent neuroscience has teased out additional details on the role of the sub-occipital muscles in the overall postural functioning of the body which strengthens the case Carrington was making about the nature of Alexander's findings. If excessive tension in the head-neck area denies these spindle-rich muscles the opportunity to work as they should, the neuromusculature is deprived of one of its key feedback mechanisms and is almost inevitably condemned to some degree of functional degradation.

Carrington's comment stood the test of his own vast experience. After another forty-five years teaching, lecturing, and writing about the Technique, he was happy to have the same pamphlet reprinted without alteration in 1994.

Dealing with the persistence of habit

Identifying a problem is, however, just the first step. Though he was convinced that habitual misuse of the musculature in the head-neck area was causing the problems with his voice, Alexander found that changing these habits was a far from easy matter. He was up against the persistence of habits.

There are, of course, good reasons why habits are persistent and why we spend so much time, consciously and unconsciously cultivating them. Life would become impossible if our habits deserted us. We are only able to carry out complex tasks like speaking our native language, walking up and down stairs, brushing our teeth, driving a car or tying our shoelaces because we do so with only a minimal awareness of what we are doing and none of how exactly how we are doing it.

At the same, the very unconsciousness of our habits means they can as easily be damaging as beneficial. Once we move from reflex to voluntary action, the plasticity of our neuromuscular system means we have little protection against the acquisition of harmful habits of doing things. Sherrington put it well:

> *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.*[110]

Homeostasis[111] is a relevant concept here. It can be defined as the dynamic process by which an organism keeps its own internal conditions constant despite changing external circumstances. Since, at the same time, change is the essence of human existence, the workings of homeostasis occur within a dynamic context, ensuring that

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[109] Carrington (1994)p52

[110] Sherrington (1946)p89

[111] The derivation is from the Greek *homos = same* and *stasis = standing still.*

individually and, within whatever combination they are occurring, the body's processes stay within certain limits. There is, in fact, nothing of stasis here; the biologist and neuroscientist, Steven Rose, has suggested that homeostasis should be replaced with "*…a richer concept, that of homeodynamics.*"[112]

Although the exact details of how homeostasis works in any particular instance may be rather mysterious, there is no mystery about it principle. It is, in fact, almost tautological. Stable biological systems cannot evolve unless, from a very early stage, they develop the self-correcting mechanisms required to keep them functioning within their own safe limits. The result for the human organism is that a vast range of compensating or corrective responses are ready to come into action when anything internal or external begins to threaten its functioning equilibrium.

None of this is remotely controversial in relation to the normal working of the body. It is, however, somewhat counter-intuitive to apply it to beneficial change. Nevertheless, this is also true. Homeostasis is not a process which evaluates the functions of the body on moral, aesthetic, health or any other grounds; it deals with, and resists, deviations from the established functioning norms. Homeostasis simply resists change in the established order.

In his textbook on the central nervous system, Brodal quotes a definition of stress as *something perceived by the individual as a threat to the homeostasis of the organism* and goes on to say that

> *The function of the stress reaction is to maintain homeostasis in a wide sense, and it can be initiated by the stressful event or by the expectation of it. The hypothalamus obviously plays a central role in our ability to cope with stressful events; that is, the stress reactions are largely expressed through the hypothalamic influences on the endocrine, autonomic, and somatic effector systems.*[113]

Here, the homeostatic defences are being mobilised not in response to an actual change but merely to the thought of one. The fact is that any potentially effective intervention, whether "physical" or "mental", into the way in which the body normally functions is automatically resisted.

Alexander was acutely aware of the fact that habitual actions dominate our daily living. This is not a problem as long as these habitual actions are being performed in a non-damaging way. The difficulty emerges when we recognize that a particular well-established habit is damaging and we want to change it. The problem arises, for example, when a golfer or tennis player decides there is a need to change their swing or service.

As Alexander put it:

> *My reader must not fail to remember that mental conceptions are the stimuli to the ideo-motor centre which passes on the subconscious or conscious guiding orders to the mechanism. In dealing with human defects or imperfections we must consider the inherited subconscious conceptions associated with the mechanisms involved, and also the conceptions which are to be the forerunners of the ideo-motor guiding*

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[112] Rose (p17)
[113] Brodal (p548)

> *orders connected with the new and correct use of the different mechanisms.*[114]

Alexander found that even when he had devised a new and improved way of reciting, his old damaging habitual response always emerged when his attention was diverted from the new way of performing the action. His empirical solution to this dilemma when preparing to perform an act was: to consider doing it, inhibit the tendency to do anything, and then project the new way of doing it. This is how he put it:

> *In order to establish successfully the latter (correct conception), we must first inhibit the former (incorrect conception), and from the ideo-motor centre project the new and different directing orders which are to influence the complexes involved, gradually eradicating the tendency to employ the incorrect the incorrect ones, and steadily building up those which are correct and reliable.*[115]

This is not an instant solution; it demands long and careful repetition to overwrite the old faulty habit. It is interesting how closely Magnus had come to the same idea in his thinking on the physiological *a priori.* As he saw it, the faulty working of the postural reflexes and the consequent failure to recalibrate the senses, was bound to lead to a faulty conception of not just how one used one's body but to a distorted understanding of how the body is functioning. Whether the problem is seen as rooted in homeostasis, a distorted physiological *a priori,* or faulty sensory awareness, it was Alexander who proposed a pragmatic means of putting things right.

Some key concepts in the AT

Alexander's intention in his writing was always to make it as clear as he possible what exactly he meant, though he did not always avoid the dangers of excessive explanation. He also defined some of the terms he used so that they have their own specialised meaning within the context of the AT. The many changes in linguistic usage, as well as scientific vocabulary, in the century or so since he began to develop his terminology make it useful to provide a contemporary gloss on some key concepts in the AT and the language used to describe them.

The primary control

Even if Alexander's *primary control* cannot be identified with Magnus *central apparatus* the question of what exactly he did mean by it still remains. One of the problems for readers of Alexander's books is that he uses term in variety of ways in his writings from 1925 onwards. J.M.O. Fisher, a leading authority on the AT, has compiled a full set of references to the various uses of the term in Alexander's books; a link to this listing is given below.[116]

Sometimes Alexander appears to apply the term to 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, for example, he said that after long experimentation he found:

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[114] Alexander (1910)p131
[115] Ibid. p131
[116] http://www.mouritz.co.uk/6.31.quo.primary.control.html

... that to lengthen 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.[117]

More often, he uses the term to mean a particular way of using his body in which he consciously avoids pulling his head back and down and thereby compressing his neck. Here he describes what he means in 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 as a whole 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 as a whole, involving control in process 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.[118]

The common factor in all of these attempts by Alexander to pin down exactly what it was he had discovered was his insistence on the importance of the dynamics of the head-neck relationship and how its effects were felt through the whole of his body. If he distorted the head-neck relationship, for example by pulling his head back and down, this was invariably associated with a decline in his overall bodily functioning. It was the pervasive influence of the head-neck relationship on the whole functioning of the psychophysical unity of the human being fully that provided him with the justification for terming it the *primary control.*

Another important step in the development of his Technique was Alexander's realization that the proper working of the head-neck relationship, as he had empirically established it, could also be used as a diagnostic criterion for the whole of the neuromusculature. If the overall functioning of the neuromusculature was faulty, he realized that this would inevitably show in the malfunctioning of the head-neck relationship. As he put it:

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.[119]

With his identification of the primacy of the head-neck relationship in the organisation of the neuromusculature, Alexander was able to develop a coherent approach to dealing with human ills as he identified them. Perhaps he was over-optimistic in believing that once people got their head-neck relationship functioning properly the world would become a better place. But he was surely right in

[117] Alexander (1932) p30
[118] Alexander (1946)p8
[119] Ibid. p8

recognising the psychological and physical benefits of an harmoniously-functioning neuromusculature.

Direction

The term "direction" is perhaps the most commonly used in the Alexander lexicon. Again, it must be said that Alexander uses it in wide variety of ways and J.M.O. Fisher has also compiled a full set of references to its uses in Alexander's books.[120] Just one of these uses, which fits well with some observations by Sherrington is discussed here.

In his book, *The use of the self,* in which he describes in detail how he developed his Technique, Alexander says:

> *When I employ the words 'direction' and 'directed' with 'use' in such phrases as 'direction of my use' and 'I directed the use,' etc., I wish to indicate the process involved in projecting messages from the brain to the mechanisms and in conducting the energy necessary to the use of these mechanisms.*[121]

Alexander's use of the concept of "direction" in this example can be compared to Sherrington's discussion of the way in which the brain brings attention to bear on particular actions. Towards the end of the chapter in *The integrative action of the nervous system* in which he is discussing how reflexes interfere and reinforce each other so that among the many potential impulses which might affect a muscle, it is restricted to one at a time with the result that:

> *The resultant singleness of action from moment to moment is a keystone in the construction of the individual whose unity it is the specific office of the nervous system to perfect. The interference of unlike reflexes and the alliance of like reflexes in their action upon their common paths seem to lie at the very root of the great psychical process of 'attention.*[122]

It is evident that though they are approaching it from widely different standpoints, both men are looking at the same idea of focusing the attention on a particular course of action. The process of 'directing' in Alexander's sense, or mobilising *the great psychical process of attention* in Sherrington's words, involves a narrowing of mental focus, a centring on one particular course of action out of the multiplicity of possibilities thrown up by the senses and the nervous system.

Alexander ideas were, of course, rooted in his day to day observations of himself and his pupils. He was seeking to change the behaviour of his pupils and he based his didactic method on the entirely reasonable premise that behaviour can be consciously controlled. As he said:

> *The method is based firstly on the understanding of the co-ordinated uses of the muscular mechanisms, and secondly, on the complete*

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[120] http://www.mouritz.co.uk/6.03.quo.direction.html
[121] Alexander (1932) p35
[122] Sherrington (1948)p234

acceptance of the hypothesis that each and every movement can be consciously directed and controlled.[123]

His insightful, and indeed, crucial observation was that conscious control is always in danger of being undermined by habit and faulty sensory perception. For a high proportion of the time when people think they are entirely in control of what they are doing, they are merely responding to habit.

Inhibition

Freud's use of the term "inhibition", coupled with its co-option into the vocabulary of popular psychology, means that any use of the word in an unambiguous sense is now difficult. For Alexander, however, inhibition was at the core of what he was doing. Nowadays, it is necessary to peel away some of the accumulated layers of meaning to get a sense of what Alexander meant by inhibition.

Alexander said himself that in his Technique

> *…the process of inhibition – that is the act of refusing to respond to the primary desire to gain an end – becomes the act of responding (volitionary act) to the conscious reasoned desire to employ the means whereby that end may be gained.*[124]

Here again there is an interesting overlap with Sherrington whose concept of inhibition was central to his formulation of the working of the neurological system. His observation that when a group of muscles contracts, its antagonists automatically release became known as Sherrington's Law of Reciprocal Inhibition.

Alexander, in fact, quotes from *The Brain and its Mechanism,* the Rede Lecture which Sherrington delivered in Cambridge in 1933, in which he said:

> *I may seem to stress the preoccupation of the brain with muscle. Can we stress too much that preoccupation when any path we trace in the brain leads directly or indirectly to muscle? The brain seems a thoroughfare for nerve action passing on its way to the motor animal. It has been remarked that Life's aim is an act not a thought. Today the dictum must be modified to admit that, often to refrain from an act is no less an act than to commit one, because inhibition is co-equally with excitation a nervous activity.*[125] [126]

Just before this quotation Sherrington, had been speculating on how the outside world, acting through the brain of an animal can produce the huge variety of activity in which it engages. He says of the animal that:

> *Its motor instrument is essentially separable into a great number of small units which it can use individually and in a great number of different combinations. Each unit has a single nerve-thread, which springs from a wide nerve-net. In the nerve-nets there occur at the nodal points two kinds of nerve-action, one which fires the nerve-thread (and so the motor unit), the other which impedes or prevents*

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[123] Alexander (1910)p124
[124] Alexander (1946)p85
[125] Ibid. p85
[126] Sherrington (1933)p10

the firing of the nerve-thread. On any of these nerve-threads one or other of these two opposed nerve-influences can be exerted. Conjointly they quantitatively neutralize one the other. The variety and delicacy of the motor activity of the animal are largely due to conjoint use of the two opposed processes upon the units of the motor system. The brain with its nerve-nets additional to and superimposed on the nerve-net exerts through them a management of supreme delicacy and width over the whole complex of motor units. The animal's motor behaviour where the brain-nets are large excels in variety and nicety. But it fails to offer anything radically different from that of reflex action elsewhere.[127]

Sherrington never shies away from the true complexity of what is happening. His willingness not to over-simplify is what makes his exposition so satisfying; there are no obvious loose ends or unaddressed objections. But it can make demands on the non-technical reader. Here he is talking of the delicate alternations of the activating and inhibitory influences which the nervous system exerts on the individual motor units in the musculature. It is this which underpins what he calls the *management of supreme delicacy and width* exercised over the musculature.

Alexander had no detailed knowledge of neuroscience at the scale with which Sherrington was familiar but his sense of how people actually behaved was undoubtedly much more developed than Sherrington's. He was translating into practical working terms the observation that the workings of habit tend to surge into the foreground in any activity unless they are consciously inhibited. Alexander's achievement was to devise a practical means of inhibiting habit and allowing it to be replaced by consciously directed activity.

The AT in practice

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. 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.[128] The best way, by far, to gain an understanding of what is involved is to have a few lessons.

The starting point for most people's involvement with the Technique is an awareness that their body is not functioning as well as they believe it could and should. The popularity of gyms and fitness clubs, health and well-being magazines and books, personal trainers, jogging and exercise programmes, fitness diets and vitamin supplements, are all testimony to the deep unease felt by many people about best to look after their health and well-being.

At the same time, the incidence of aches, pains and stiffness, especially in the neck and back, seems if, anything, to increase. Hip and knee replacements are coming to be seen as the inevitable consequence of middle age just as excessive muscular tension seems to accompany a job that involves long hours sitting in front of a

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128 Vineyard (2007)

computer screen. Even among top athletes and sports people, subject to the best available care and training, serious injuries seem, if anything, to be more common. Gyms make a sizable proportion of their income from people who quickly give up using them.

There is a growing awareness that conventional fitness programmes can exacerbate the problems from which people find themselves suffering. If a person has become tense from a day's stressful work at a supermarket checkout or a stock-market dealing-screen, going to the gym for a workout is almost guaranteed to strengthen the already tense muscles. If they are using a weights-machine, the likelihood is that they will bulk-up the white fibres in their upper body, bypassing the red-fibre postural muscles in the back. One of the results of this is that people with well-developed upper-body strength are frequently unable to sit upright in a chair for ten minutes without their lumbar area beginning to ache.

This is not to denigrate the whole idea of exercise. A reasonable amount of exercise is obviously necessary for health; muscles that are not used quickly waste away. The point is to make sure that whatever exercise is taken is not going to make existing neuromuscular problems worse or create new ones. If a person has aspirations to run a marathon; or would like to counteract some of the ill-effects of a totally sedentary lifestyle; exercise is essential but taking it must not it create more problems than it solves.

Another problem is 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; in scientific terms, the proprioceptive capacities of muscles are impaired by excess habitual tension. They 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. They are suffering from a wholly inappropriate increase in muscle tone throughout the whole body, affecting the whole functioning of the neuromuscular system – and are completely unaware of it.

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*. What it means, in Magnus' terms, is that their blunted sensibility to the way they are suppressing the natural functioning of their postural reflexes leads them eventually to the neck-aches, back-pains, and damaged spinal discs from which they find themselves suffering, and the braces, bandages and hip and knee replacements they so often find themselves requiring.

The further engrained habits of misuse become, the more difficult it is to undo them. It is the postural reflex system that rebalances the musculature and recalibrates the senses after phasic actions. These functions are subject to the control of the *elaborate central apparatus* in the brainstem identified by Magnus. 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 first step has to be learning how to stop the wrong use of themselves.

Much of the work of Alexander teachers 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.

The signs of muscular misuse are not always obvious or unambiguous. The ability to detect how people are misusing their neuromuscular system through observation and gently guiding them through a series of simple movements requires a well developed kinaesthetic sense on the part of the teacher. Clear-sighted introspection is a prerequisite for detecting and putting right the flaws in teachers themselves before they can consider putting their pupils right. Here is a very clear example of when Magnus' physiological *a priori* needs to recognised.

As time passes and the harmful habits persist, the natural processes of cell replacement in bones and muscles gradually adapt the body to whatever distorted and malfunctioning conditions it may have developed. In a surprisingly short time, 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.

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.

A considerable amount of skill and patience on the part of the Alexander teacher is usually required to bring people back to an awareness of how they are misusing themselves and how to stop doing so. 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.

As well as the skill of the teacher, the efficacy of AT lessons depends on the willingness of pupils to accept the need to be less driven and determined in their self-improvement. Restoring the proper functioning of their neuromuscular system is far more a question of stopping misusing themselves than driving themselves into new forms of exercise. Under the ministrations of a skilful Alexander teacher, coupled with a substantial degree of calm thoughtfulness on the part of the pupil, acquired muscular distortions can be persuaded to give way to a renewed functioning of the postural reflexes.

The immediate effect of an AT lesson can be quite marked, with people often experiencing a feeling of lightness or freedom. The American writer, Gerald Stanley Lee, described having a lesson from Alexander as being reshaped as though by a

sculptor.[129] Such sensations can often be traced to physiological changes in the head-neck area as Frank Pierce Jones showed. But the aim of AT lessons is not to provide such sensations which pleasurable though they may be can easily turn out to be ephemeral. The long term purpose is to cultivate an improved manner of use in which the postural reflexes are allowed to function as they should. If we can achieve this, we have created a platform on which an overall improvement in neuromuscular functioning, no matter what the starting point, can be built.

[129] Lee (1920)p162

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Acknowledgements

This paper is based on talks given at the Constructive Teaching Centre in London. Grateful thanks are due to Lanna Foley, Tanya Shoop and especially to Kri Ackers for all their comments and suggestions.