TOWARDS A NEUROPHYSIOLOGY
of the
ALEXANDER TECHNIQUE

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INTRODUCTION

The Alexander Technique (AT) deals with the problems caused by the many ways in which people misuse themselves. But rather than focussing on the individual details of joint or muscle malfunctioning, it addresses the wider question of the overall working of the body's neuromuscular system.

There is nothing esoteric or mysterious about the AT though, in contrast with many other approaches, it places the emphasis on "non-doing" rather than "doing". It is primarily a practical discipline but it is ripe for an examination of its scientific underpinnings. This paper is a contribution to that task.

The aim is not to establish the *bona fides* of the AT. Its effectiveness in undoing habits of muscular misuse has been well-attested over more than a hundred years of practical application. Nor is there any doubt about the physical and psychological benefits that such improved use of the body can bring. The problem is that much of the discussion by AT professionals is carried out using its own specialist and at times arcane vocabulary. Discussing the same issues using the common language of science would expand the audience, bring a wider range of insights and open the benefits of the AT to an expanding public. F.M. Alexander, the originator of the AT, firmly believed it should be part of the medical education curriculum.

Despite its popular association with the idea of a "correct" and static posture, the AT is primarily about movement and the way we control the use of our bodies. This is a complex and delicate task. If all the activity of the human body's six hundred skeletal muscles were consciously controlled all the time, 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 conscious human behaviour is only possible because every conscious act is supported by a vast substructure of reflex and habitual muscle activity of which we are wholly unaware.

Yet much can go wrong with this hidden muscular supporting machinery and the consequences can be surprisingly severe. At a minimum, misuse of the muscular system means energy is wasted in awkwardness of movement. Additional friction in the joints brings unnecessary wear and long-term damage. A too-tight thorax means breathing is more laboured than it need be. It is for avoiding such problems in the first place that the AT is best used but it also helps deal with them if they are already present.

Adopting the AT approach is not to decry the benefits of modern medicine. Scientific advance has put an ever-expanding range of increasingly precise measuring and diagnostic tools at the disposal of contemporary physiology. Therapies are increasingly specific and tightly focussed. Fitness training and ordinary health care are ever more precisely targeted.

People now have an ever-increasing choice in how to address back and shoulder pains, neck aches and stiffness, painful knees and ankles, stiffening hip joints and the general strains and injuries of ordinary living. They have a vast array of analgesics, muscle relaxants, anti-inflammatories, tranquillisers, and other medications available over the counter or from their doctor. Large numbers of sufferers put their trust in physiotherapists, osteopaths, chiropractors, massage therapists, and a constantly changing choice of more exotic practitioners.

When hip and knee problems overwhelm the power of such treatments, they can be dealt with by joint replacements, while persistent neck and lumbar pains are often treated by fusing the vertebrae. The result is that large numbers of people who would otherwise be on crutches or in wheelchairs are able to carry on healthy and active lives thanks to the these treatments and the professionals who administer them.

But because these interventions generally treat symptoms rather than causes, the underlying neuromuscular problems may well remain, continuing to interfere with the proper functioning of the body and resurfacing in other ways at a later date. The new detailed knowledge at our disposal and the ability to deliver effective treatments can obscure the importance of preserving the proper functioning of the overall neuromuscular system in the first place or restoring it when it has gone wrong.

When dealing with the aching or damaged parts of the body, it is easy to ignore the interconnections between them and not realise that, for example, neck, back, knee and foot problems may be acting to aggravate each other. It is fundamental to the AT approach that the body functions not as a series of independent elements but as a totality. Lifting an arm involves not just that limb but the neck, the back, the lower limbs and the feet.

Our understanding of the integrated functioning of our neuromuscular system is still based to a surprising extent on the insights of the early pioneers of neuroscience. Sir Charles Sherrington's 1906 work, *The integrative action of the nervous system,* regarded as the founding text of modern neuroscience, was largely devoted to the working of the innate reflex systems of the vertebrate animal. 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 automatic neuromuscular systems that govern movement and posture, .

The best part of a century later, their neurological discoveries and insights retain most of their freshness and relevance. Subsequent work has filled in many of the underlying details but the overall picture of the working of the machinery of the human neuromusculature produced by these great scientists has not been superseded. Their insights provide an essential background to neurophysiological understanding of the AT.

Section 1 of this paper provides a brief history of the AT. F. M. Alexander, an Australian actor, who was a near contemporary of Sherrington's, began his work in London in 1904. In diagnosing and dealing with his own earlier voice problems he had identified the importance of the head-neck relationship to the overall functioning of the human neuromuscular system and made it a central concern in what he called his Technique.

Nowadays, the AT tends to be popularly 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. He was no neuroscientist 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 2 provides some scientific background. It 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 often-ambiguous terms “reflex” and “posture”.

Section 3 sets out Magnus’ findings on the actual functioning of the postural reflexes in some detail. Section 4 goes on to explains how they can be co-opted and distorted during the ordinary business of daily life. Although our ability to over-ride our natural neuromuscular systems lies at the heart of our versatility and creativity, it can equally become a source of serious psychophysical malfunctioning.

Section 5 looks at the significance of the head-neck relationship. Much has been learned about this critically important neuromuscular connecting link between the observational and command centres located in the brain and the limbs and organs under its control. Lack of proper communication between the head and the rest of the body has unsurprisingly deleterious consequences for overall body functions. Less obviously, it affects the way the external world is perceived and thus conditions the way in which we respond to it.

Section 6 looks at some observations on the Technique made by scientific figures who had direct contact with Alexander himself or with the AT. These include the anatomist and paleo-anthropologist Raymond Dart, the developmental biologist George Ellett Coghill who both had personal experience of Alexander and studied his work. Nikolaas Tinbergen who was awarded the 1973 Nobel Prize for his work on ethology devoted half his prize-acceptance speech to praising Alexander and the AT.

The aim of Section 7 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 the main 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. It is a continuing effort and any comments or suggestions will be gratefully received.

SECTION 1: 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 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.*[1]

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…* [2]

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.

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. From close examination of himself in an arrangement of mirrors he realised that he had developed habits of tightening his throat and chest and pulling his head backwards and down

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[1] Sherrington (1946)p89
[2] Bloch (2004)p207

when he was reciting. This led to what he called *"shortening in stature"* and in addition to interfering with his voice 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.*[3]

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 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. The marked improvement in his voice 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. Even at this early stage, the emphasis in the Technique was in teaching people how to undo their bad habits and learn how to use themselves properly – hence the reference to pupils – rather than administering a kind of treatment.

It soon turned out that his method of dealing with his voice difficulties paid other health dividends, particularly with breathing-related problems. He began to attract medical attention and a number of influential doctors in Sydney started referring patients with throat and breathing-related 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 pupils, 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 and exercise systems 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 involving the over-development of certain groups of muscles was bound to create more problems than it solved.

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[3] Alexander (1932) p29

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 19th century school of philosophy known as "pragmatism" and was by this time one of America's most prominent intellectuals. When the two met, Dewey was aged fifty-six, in poor health, suffering from severe back pains and other apparently stress-related ailments. Following some lessons, 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, emphasising what he felt was the scientific nature of the Technique.

In his introduction Alexander's second book published in 1923, Dewey wrote

> *…whilst any theory or principle must ultimately be judged by its consequences in operation, whilst it must be verified experimentally by observation of how it works, yet in order to justify a claim to be scientific, it must provide a method for making evident and observable what the consequences are; and this method must be such as to afford a guarantee that the observed consequences actually flow from the principle. And I unhesitatingly assert that, judged by this standard …Mr Alexander's teaching is scientific in the strictest sense of the word.*[4]

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, throughout his life 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.

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

[4] Alexander (1923) pxxvii

available in, for example, Vineyard.[5] 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 how best to look after their health and well-being.

A distinguishing feature of the AT is its insistence that pupils need to get rid of their faulty habits of using themselves before they can hope to start using themselves properly. Much of the work of Alexander teachers is devoted to restoring the bodily awareness, the kinaesthetic sense, of their pupils. This is not as simple as it might seem. The signs of muscular misuse are not always obvious or unambiguous. Most people are quite unaware of how they are misusing themselves. Alexander referred to this inability in people to detect the habitual distortions that have become incorporated into their neuromuscular systems as *faulty sensory awareness* or on other occasions, and more colourfully, as a *debauched kinaesthesia*.

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 often 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 renewal of the proper functioning of the neuromusculature.

The neuromuscular re-education provided by the AT tends to be gradual; long-entrenched habits are not easily discarded. But for some pupils the experience can be more dramatic with many reporting a feeling of lightness or freedom during the lesson. The American writer, Gerald Stanley Lee, described having a lesson with Alexander as being reshaped as though by a sculptor.[6] 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 aim is to cultivate the improved kinesthesia on which an overall improvement in neuromuscular functioning of the person, no matter what the starting point, can be built.

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[5] Vineyard (2007)
[6] Lee (1920)p162

The remainder of this paper is devoted to the neuroscience underlying the AT. It is entirely possible to benefit from the AT or to be an excellent AT teacher without any significant knowledge of these neuroscientific underpinnings. But there are many people who feel reassured by the fact that the AT and its beneficial effects are susceptible to conventional scientific analysis and explanation. This, apart from the direct experience of its benefits, is why it has always counted members of the scientific and medical fraternities among its supporters.

SECTION 2: SOME NEUROSCIENTIFIC BACKGROUND

Sir Charles Sherrington and Rudolph Magnus, play a large part in any discussion of the underlying neuroscience of the AT . If they are not much spoken of nowadays, it is not because their work has been superseded. They were two distinguished scientists who 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 contributions. As this paper is specifically concerned with their findings on the postural reflexes and how this fits with the AT, it is worth putting their findings into context by giving a brief account of their careers.

It is also necessary to look at the meanings of the words *reflex* and *posture*. They are fundamental to the discussion which follows and any attempt to go further without defining them is inviting trouble. Both words are so encrusted with popular impressions and preconceptions that hardly any two people would agree on what exactly they mean by them. The discussion here 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.

The emergence of neuroscience

As the nineteenth century progressed, scientific understanding of the workings of living creatures grew rapidly. Anatomists were moving beyond the identification of individual body parts and how they interacted with each other to trying to understand how the totality of a creature worked. Technical advances in microscopy, and techniques of staining different types of tissues enabled scientists to begin to see hitherto invisible nerve fibres and speculate about the roles they filled in the workings of the human body.

The great Spanish anatomist Santiago Ramón y Cajal (1852-1934) is today best remembered for his experimental work in which he developed the technique of using a silver nitrate preparation as a stain to reveal nerve fibres. Scientists of his calibre had nothing ready-made at their disposal; they devised and used their own experimental equipment and interpreted their results. In his use of the silver nitrate preparation, Ramón y Cajal was building on the work of the Italian scientist Camillo Golgi (1843-1926). Though both men disagreed profoundly on the meaning of what was being discovered using their methods, they were jointly awarded the 1906 Nobel Prize in Physiology or Medicine for their work on the nervous system.

Charles Sherrington (1857-1952)

As the 19th century drew to an end, the task of integrating the wave of discoveries emerging from the various laboratories working in the role and functioning of the nervous system, was undertaken by Charles Sherrington. Although he himself was in the forefront of the discoveries being made, Sherrington's particular genius was in the synthesis of all this new knowledge into the conceptual framework which still underpins the modern understanding of the nervous system and how it works. His book *The integrative action of the nervous system* published in 1906 was the founding text of the new discipline of neuroscience.

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 Institution 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."*[7]

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 left Liverpool to became professor of Physiology at Oxford in 1913 where his output of research results continued to be in the forefront of neuroscience. He remained there until his retirement in 1936 at the age of 79. Through his career he was known as a generous and inspiring teacher.

He was responsible for some of the most important discoveries in neuroscience. 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 published a total of 320 scientific papers covering nearly every aspect of mammalian nervous functioning.

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. In the following year when *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 and the UK 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 (1873-1952)

Sherrington was fully aware of the central importance of the postural reflexes, seeing them as central to the overall functioning of the neuromuscular system. But it was Rudolph Magnus, rather than Sherrington himself, who carried out the defining studies on these reflex systems.

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 worldwide developments in physiology then taking place.

He attended the Third International Physiology Congress in Berne in 1895 where he witnessed an experiment by Sherrington.[8] Three years later at another international physiology congress, this time in Cambridge, he saw an experiment by Sherrington

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[7] Cohen (1958)p7
[8] O. Magnus (2002)p51

which he described as "elegant".[9] 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 scientific experimental equipment at the Goethe Museum in Weimar and persuaded the museum authorities to allow him to repeat the experiments on which Goethe 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.[10]

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.[11]

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.*[12]

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 appointment 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 deep and prior 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*

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[9] Ibid.66
[10] Ibid.145
[11] Magnus (1930)p97
[12] O. Magnus (2002)p143

> *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.*[13]

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 a walking holiday in Switzerland. He had been nominated for the Nobel Prize in that year and had been widely expected to gain it but it is not awarded posthumously.

What is a reflex?

Even among scientists, the word *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.[14]

But Sherrington was very clear about what he meant by the term. He saw it as an innate muscular response to a stimulus. In his Introduction to the 1947 re-publication of *The integrative action of the nervous system* he gave an expanded explanation:

> *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.*[15]

Sherrington thus had no sympathy with the extreme reductionist view that all activity is reflex, simply the result of automatic neurological responses to external or internal stimuli. He contrasted reflexes with habits, to which they bear a superficial resemblance, but distinguishes them clearly. Although the reflexes provide an innate underpinning for the body's activities, the volitional decision-making mind determines the immediately purposeful and habitual actions characteristic of each individual.

The pioneering physiotherapist Berta Bobath is nowadays best known for the approach she and her husband Karel developed for the treatment of cerebral palsy and other neurologically based muscular disorders. In her book *Abnormal postural reflex activity caused by brain lesions* she expresses some doubts about the use of the term *reflex* and suggests it would be more useful to refer to "*postural reactions"* or "*responses"* but settles for Sherrington's definition. In the third edition of her text, published in 1985, she said:

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[13] Magnus (1926a)p531
[14] Prochazka (2000)
[15] Sherrington (1948)pxvi

> *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…*[16]

A used in this paper the term reflex refers to 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 individual or habitual voluntary actions. The reflexes discussed here are also 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.

Much of what is commonly described as reflex action, even in scientific writing, is not reflex in the sense used here but, rather, learned or voluntary behaviour. In normal living, 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 daily activities and 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 service 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.

The same skeletal muscles used in voluntary and reflex activities. This means that, in normal activity, here is a high degree of overlap between the reflex and the voluntary. In many cases, since the distinction hinges on whether the muscle actions are carried out in accordance with an innate program or one that has been learned, it is impossible to know. It is only in the absence of the cerebral cortex, the thinking part of the brain, that it is possible to designate an action as unequivocally reflex.

Sherrington was, of course, aware of the mingling of reflex and voluntary in normal activity. In a striking passage in his last book, he 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…*[17]

He was 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

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[16] Bobath (1985)pxi
[17] Sherrington (1946)p89

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.

The behaviour of purely reflex creatures, like the spider, is in principle totally predictable; each time it responds in the same way to the same stimulus. It is the potential for an encroaching of the voluntary on the reflex that creates the possibility of modifying behaviour. In the case of horses, dogs and cats their innate responses to certain stimuli can be considerably modified; it is usually called "training". Humans have by far the greatest capacity to learn new responses to familiar stimuli; it is the source of a great deal, if not all, of their creativity. It also allows them to develop habits that undermine and distort the functioning not just of their reflex systems but also their consciously functioning selves. It is a theme which is developed in the later parts of this paper.

The question of posture

The question of posture is central to the discussion in this paper but just as with the word reflex, there is ample room for misunderstanding unless it is clear what is meant when the word *posture* is used. In common use, it tends to be 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 it 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 in *The integrative action of the nervous system*:

> *…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.* [18]

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

[18] Sherrington (1948)p339

SECTION 3: MAGNUS' RESEARCH

The research task Magnus set himself was a challenging one. As Sherrington had pointed out, a standing posture, far from being a fixed 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 into the brain from the senses and from within the body itself, and simultaneously make the appropriate adjustments to the outward, or efferent, flow of impulses from the brain 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. The most prominent 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 and nerve 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.

Most of the research work was carried out on 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, they 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.

In his Cameron Prize Lecture, Magnus gave a vivid example of the complexity of the problem of understanding the workings of the postural reflexes. He said:

> *The limbs of mammals, as of other vertebrates, are built up of bony segments, linked by a complicated arrangement of ligaments and moved and fixed by muscles…The whole system is easily movable in different directions. Our problem is to explain how such a movable limb is at times used as an instrument for very different purposes(such as scraping, scratching, fighting &c.) and moved freely at all joints, whereas at other times it is transformed into a stiff and strong pillar, which gives the impression of being one solid column, able to carry the weight of the body.*[19]

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 rest of the body; this was termed a *spinal animal*. This enabled the researchers to establish which reflexes were

[19] Magnus (1926a)p531

controlled from the spinal cord alone. Next, by making surgical cuts at successively higher levels in the lower brain, or brainstem, they established which additional reflexes came into action as more of the brain was left in place. In this way, they were able to identify in which parts of the lower brain the control centres for the various postural functions were located.

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.*[20]

The experimental work was carried out on animals and so it might be wondered how relevant the results are to humans. It happens that 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 were relevant to 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.[21]

The vestibular apparatus

The balance, or equilibrium, of the body is intimately related to posture. The term *static equilibrium* is often used when the body is maintaining 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 monitored 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 which contains the otolith organs; the three curved ducts known as the semicircular canals which project upwards and backwards from the vestibule; and the cochlea which contains the hearing receptors. 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.

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[20] Magnus (1924)p655
[21] Bobath (1985)p

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 by which the hair cells are surrounded 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.[22] 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 semi-circular canals also provide a response to movements of the head but only to those which involve changes in the rate at which the head-movement is occurring, either acceleration or deceleration. The canals are set at right angles to each other in three planes and consist of ducts filled with a fluid called endolymph. One end of each canal has a small expanded or dilated area called the ampulla. In each ampulla, there is a ridge or swelling upwards from the base of the canal called the crista. On top of the crista, a group of hair cells projects upwards and is covered by a small mass of gelatinous material called the cupula.

When the 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; the result is that the system is monitoring changes in the rate of 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. 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 neurophysiologists around the world. In recognition of the enduring importance of Magnus' work, an English translation entitled *Body Posture* was produced under the auspices of the National Library of Medicine in the US in 1987.

Following the publication of *Korperstellung,* 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 the two Cameron Prize Lectures in the University of Edinburgh in 1926 and both of these 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*

[22] Davson (1990)p678

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 is artificially restricted or disrupted.

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; it 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."*[23]

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, 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.[24]

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.*[25]

This is an important observation in the context of the present paper. If signals from the proprioceptors in muscles with excess tone play a prominent role in maintaining that same excess tone, it means that excessive tone, once it has developed, has a tendency to become self-sustaining. Muscles in such a state cannot fix themselves. Neurological impulses, from a source above the transection in the brain, are required to undo or inhibit the state of permanent decerebrate rigidity found by the researchers.

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[23] Magnus (1925)p341
[24] Ibid.341
[25] Ibid.341

Normal distribution of tone

When an animal is standing normally, 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 transection 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, Magnus 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.*[26]

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 the way in which 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.*[27]

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*

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[26] Ibid.342
[27] Magnus (1926a)p534

extremities on the right and left side, or of the fore and hind limbs react in an opposite way.[28]

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 pattern of tonic reflexes.

Magnus makes the further important point that the tonic 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.[29]

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 this out was Sherrington's colleague Denney-Brown in a paper to the Royal Society in 1929.[30] This helps explain how it is that malposture, as exemplified in the various humps, stoops, twists and other muscularly-derived postural distortions that people acquire as a result of faulty habits of bodily use or injuries, tend to become permanent features of their posture. The muscles pulling these people out of shape never tire.

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

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[28] Magnus (1924)p7
[29] Magnus (1925)p344
[30] McComas (1996) p191

> *attitude and a slowly progressing movement the difference is hardly more than one of degree.*[31]

Magnus found that the righting reflexes could best be 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 positions, to come back reflexly into the normal position. The reflexes which co-operate in attaining this result are the "righting reflexes."* [32]

He found that when such an animal is lifted by the body and held in space with the head and neck free, the head retains its position no matter how the rest of the body is moved about. He 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."*[33] He describes these reflexes which bring about the automatic preservation of the normal orientation of the head as the *"head righting reflexes"*. It is noteworthy that this behaviour is independent of the eyes since in the thalamus animal the visual centres which are located in the cortex are necessarily non-functional.

In other experiments of this kind, 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 explanation is that the infection has interfered with the working of the labyrinths and their role in detecting changes in the 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 provided to the proprioceptive organs in the muscles, tendons and joints of the neck activated the reflexes further down the body which bring the thorax back into the normal relationship with the head, thereby untwisting the neck. This, in turn, left the lumbar area twisted relative to the thorax, which brought further reflexes into action, causing the lower body to untwist itself, so that the whole body was finally brought into its normal position relative to the head. In normal living, these reflexes are most noticeably mobilised when an animal is getting up from lying on the ground, a process that is obviously critically important to the survival of all vertebrate animals. The head leads upwards and the rest of the animal sequentially twists itself into its normal upright posture.

The righting reflexes are, of course, not concerned solely with rising from a lying down position. They come into action whenever one part of the body is moved relative to the rest. 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:

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[31] Sherrington (1948)p340
[32] Magnus (1925)p347
[33] Ibid.347

> *The integrity of every single factor of this complicated function is doubly ensured. The head is righted by labyrinthine, tactile, and optical stimuli; the body by proprioceptive and tactile stimuli. The tactile stimuli act separately upon the body and upon the head. The orientation of the head and of the body takes place in relation to gravity, sustaining surface (ground etc), distant environment (optical), and to the different parts of the body – a very complex combination of reflexes. It is indeed an interesting task to watch the cooperation and interference of these reflexes during the movements of various animals in their ordinary life.*[34]

It can be seen nevertheless that the relationship between the head and the neck is central to the working of this complex set of reflexes. Few if any activities can take place without some change in the head neck relationship and it is these changes that are normally the trigger for the sequences of reflexes involved in keeping the body in harmony with itself as it goes about its daily activities.

The optical righting reflexes

The role of the eyes was necessarily excluded from all these experiments on decerebrate animals. Magnus was, of course, well aware of the importance of the eyes in relation to posture and general neuromuscular functioning. Leaving the cortex in place, so that the influence of the eyes on posture and movement can be explored, however, hugely complicates the experimental task since it is no longer possible to guarantee a separation between the reflex and the volitional.

Moreover, the muscular systems involved are highly complex. The movements of each eye in its socket are 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 symmetrically positioned in their sockets and looking horizontally straight ahead.

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 demands the coordination of what are called conjugate movements of the eyes. Take, for example, the case of the eyes following an object moving from right to left across the field of vision. This requires that the left eye twist outwards or laterally in its socket while the right eye twists inwards or medially. These conjugate movements must therefore mobilise different combinations of the extraocular muscles in each eye.

Added to this is the fact that control of eye movements needs to take into account the movements of the head. In the Croonian Lecture Magnus remarked:

> *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…*[35]

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[34] Magnus (1926b)p587
[35] Magnus (1925)p350

A further set of reflexes external to the eyes which Magnus termed the *optical righting reflexes* also comes into play when the eyes deviate from the primary position. In this case, a series of neck reflexes comes into action to adjust the position of the head so that the primary position of the eyes is restored. It is thus evident that a variety of complex reflex systems which can be overridden by voluntary actions are involved in the control of eye movement. Magnus summarised the position by saying there was an:

> *… extremely well-adjusted central apparatus which governs the positions of the eyes.*[36]

Nor, of course, is control of the eyes a self-contained function. Changes in the position of the eyes, via alterations in the head-neck relationship, as noted earlier, have a ripple effect through the rest of the musculature.

The eyes as exteroceptors

A final complication in which Magnus was keenly interested is the role of the eyes as exteroceptors. The exteroceptors are those sense organs which detect objects at a distance; they are also referred to *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. The point is that these sense organs produce an internal image of the external world to which the musculature responds at both the reflex and voluntary levels.

Magnus saw the neck reflexes paying a bridging role between movements of the eyes and the behaviour of the rest of the musculature. He observed of one experiment in which food was held out to an animal:

> *…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.*[37]

Magnus is pointing out that when an object is detected by the eyes or nose, the head turns towards it. The change in the position of the head brings into play the vestibular organs and the neck proprioceptors resulting in the triggering of the neck reflexes and the adjustment of the overall musculature in accordance with the new position of the head.

He further describes what happens when the food is lowered so that the animal bends its head downwards towards the belly, in the ventral direction, or is 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 or dog 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*

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[36] Ibid.350
[37] Ibid.349

> *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.*[38]

None of this would have been surprising to Sherrington who had written at length about the influence of the eyes on the rest of the musculature in *The Integrative action of the nervous system,* well before Magnus had begun his research into the postural reflexes. Sherrington had remarked on how the movements of the eyes have a

> *…tendency to work or control the musculature of the animal as a <u>whole</u> – as a single machine – to impel locomotion or to cut it short by the assumption of some <u>total</u> 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.*[39]

Magnus' work provided a great deal more detailed information on the way the eyes exercise such control over the rest of the body's musculature. His experiments showed, for example, how the deviation of the eyes to the right evokes the optical righting reflexes which stimulate the neck muscles to twist the head into the direction of the gaze. The neck is now twisted relative to the torso and evokes the cascade of reflexes through the whole body discussed earlier which brings the pelvis, legs and feet into alignment with the gaze. 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 sense of the influence of the eyes on the rest of the musculature can be obtained by standing upright and relaxed, adopting the primary position of the eyes, keeping the head still, and paying close attention to what takes place in the musculature throughout the body when the direction of the gaze is shifted. 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 the body into alignment with the gaze. It is noticeable that this happens irrespective of whether the eyes are open or shut.

A central nervous apparatus

In the years since he had begun his researches on the postural reflexes in 1908, Magnus and his team had experimented and reasoned their way from the top of the spinal cord upwards through the brainstem and midbrain. As he presented their results, 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:

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[38] Magnus (1926a)p536
[39] Sherrington (1948)p326

…the principal results of the study are that the centers for the body posture and the labyrinth reflexes are arranged in three great functional groups in the brain stem.

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…*[40]

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 the nerve centres for a variety of other functions. Here, for example, are found the centres for the twelve cranial nerves which control the visual, auditory and gustatory systems. Detailed functions controlled from this area include the activities of extraocular muscles, as well as the workings of the eyelids, lips, forehead and general facial muscles.

This lower part of the brain 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' work threw further light on the central question to which Sherrington had devoted *The integrative action of the nervous system.* It had long been known 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. The big question was how the neuromuscular system managed to ensure that this assembly of segments was able to act in a coordinated way.

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, was a striking example of the need for body-wide neuromuscular coordination. The working model developed by Magnus went a long way to describing what was happening. This is how he 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.* [41]

In *Body Posture* he summarises his conclusions:

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[40] Magnus (1924)p632
[41] Magnus (1925)p340

> *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…*[42]

Posture is thus no simple matter of adopting a rigid pose and keeping it. The whole neurological apparatus of the brainstem, from the top of the spinal cord up to the midbrain, is engaged in the nervous activity of controlling posture – and of course much else. Magnus had not touched upon the linkages between the postural nuclei and those involved with the other senses: the muscular tensing following a sudden noise, the wincing and tightening caused by an unexpectedly bitter taste; the response to a pleasant or unpleasant tactile stimulus, to take a few obvious examples.

The precise role of the cerebellum is still a topic of considerable research interest though the consensus is that is essential to fine motor control. Magnus work helped provide the basis for this modern understanding by resolving the debate on whether it was the centre for the labyrinth reflexes. He stated firmly:

> *…the centers for the labyrinth reflexes lie outside the cerebellum, and that one must finally break with the concept, still widely accepted, according to which the cerebellum is the central apparatus for the labyrinths.*[43]

At the completion of his research programme, Magnus was modest about his achievement. He saw his conclusion as an interim one, a 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.*[44]

He described what he saw as the follow-up task in the following words:

> *For the majority of reflexes it is not yet known what anatomically known structures (nuclei), localized physiologically in specific regions are involved, in which anatomically known pathways the afferent and efferent excitation runs in the central nervous system, and by which neurones these pathways are formed. For many reflexes it is still not known whether the pathways run on one or both sides, whether and where they cross, etc. There is, therefore, much work to be done before the structure of the central apparatus for body posture will be known in all details…*[45]

His concluding words in the second Cameron Prize lecture in 1926 presented what he saw as the challenge facing his student audience:

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[42] Magnus (1924)p653
[43] Magnus (1924)p627
[44] Magnus (1924)p676
[45] Ibid.655

> *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.*[46]

Magnus 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. His 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.*[47]

It could have come straight from Magnus himself.

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[46] Magnus (1926b)p588
[47] Brodal (1998) p353

SECTION 4: THE SIGNIFICANCE OF THE POSTURAL REFLEXES

Magnus' experimental work was focused principally on the reflex systems of decerebrate animals but relating his research results to wider questions of human behaviour was always of major interest to him. 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.

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 posture should be a reflex activity rather than being under the direct control of the cerebral cortex. 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.

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 still much to be explored in the rich legacy of their work.

Outside conscious control

One of Magnus' most arresting findings is that the neural control centres for the postural reflexes are located in the brainstem and function in the complete absence of the cerebral cortex. This might appear fairly 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 that such efforts to achieve conscious control over the postural reflexes were likely to achieve precisely the opposite result to that intended, 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 actions that the body performs in response to signals from the cerebral cortex are technically referred to as phasic, they go through a regular cycle of changes or phases. The brain sends a signal to the relevant muscles, they perform an action, and then return to their resting state. It is the last of these, the restoration of the body to its proper resting state that particularly involves the postural reflexes.

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.*[48]

Magnus' conception of human muscular activity thus involves a dynamic interplay between the voluntary changes induced by motor instructions from the 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.*[49]

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 everyday life, however, human activities are rarely as clearly demarcated as this implies. They shade from one into the other, sometimes bringing large swathes of muscles into vigorous activity, sometimes involving no more than minor movements of body parts or simply a local change in muscular tone. The cycles of voluntary muscular activation and return to the resting state are thus 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' findings echo and amplify what Sherrington had said in *The integrative action of the nervous system* 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.* [50] [51]

The postural reflexes thus play a continuing background role, maintaining an active restorative tendency in the musculature to return to its natural balanced state. The neuromusculature needs such a reference, or default, state to which it tends 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

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[48] Magnus (1925)p349
[49] Magnus (1926b)p588
[50] Sherrington (1948)p232
[51] It is noteworthy that Sherrington refers to *habitual* attitudes, conflating habit and reflex. Whether this was deliberate on Sherrington's part it is impossible to know but it is a topic to which this paper will later return.

postural reflexes are working properly, and this is a crucial condition, they override these residual muscular tensions and restore the muscles to their natural, or innate, state of harmonious equilibrium.

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.*[52]

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.*[53]

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.*[54]

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.*[55]

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[52] Magnus (1925)p346
[53] Magnus (1924)p653
[54] Magnus (1926b)p588
[55] Ibid.588

To take the example of the common feeling of disorientation that occurs after a fall or as the after-effect of illness, alcohol or drugs. After such an event, the postural reflexes play an obvious and essential part in restoring the balance and sense of location in the environment. Magnus is pointing out that even in the much less dramatic circumstances of daily life, the postural reflexes are continually bringing the body and its senses back into their proper relationship with their surroundings. It is a theme he developed further in his posthumously published discussion of what he called *the physiological a priori.*

The physiological a priori

No one knows how Magnus would have carried forward his work on the postural reflexes. But tantalising hints of how he might have developed some of his 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 its delivery 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.*[56]

One of the illustrative 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 that might be taken are how the state of our ears and hearing-apparatus condition the impulses sent along the cochlear nerve to the brain and so affect what we hear; or how our sense of taste and smell are distorted when we have a cold or flu.

He emphasises that there is no avoiding these effects:

> *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.*[57]

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*

[56] Magnus (1930)p97
[57] Ibid.99

> *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.*[58]

It is evident in the case of the "lower" animals, those with a less developed cerebral cortex, that the degree of innate or *a priori* conditioning of their sensory observations leaves them little room for behavioural manoeuvre; a lizard is a prisoner of its *a priori* and largely reflex lizardness. Higher up the cerebral scale, among the domestic animals, for example, the scope for 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."*[59] 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 observational results of their work, or the conclusions they draw from them, 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. The term "stiff-necked" has been used to describe those who cannot change their ways despite changing circumstances.

Luckily, the normal insistence by scientists on the reproducibility of results by different researchers goes a considerable way to eliminate the dangers of scientific findings being distorted by the *a priori* biases or perceptual deficiencies of individual scientists, from whatever cause these may arise. But the persistence and virulence of disagreement among scientists over the interpretation of the same ostensibly objective data or the ability of individuals to hold ferociously to their views despite what their peers feel is compelling contrary evidence, nevertheless suggests that Magnus had a valid point.

Overriding the postural reflexes

The importance of the postural reflexes to the proper overall functioning of vertebrate animals and humans in particular suggest they should not be easily displaced or

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[58] Ibid.103
[59] Sherrington (1948)pxiv

distorted but this is not the case. When Sherrington was discussing their role in providing *a nervous background of active equilibrium* he remarked 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.*[60]

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 and other reflexes. The volitional urges of cats, dogs and the other animals with which Magnus worked have a greater capacity to overrule their postural reflexes; they can be trained to do perform "non-natural" actions. 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 still less rigidly demarcated.

As Sherrington observed:

> *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.*[61]

Sherrington's example of handwriting, a far from innate ability, is an amalgam of reflex, volitional and habitual acts. When we are learning how to write, we have to focus on how the individual letters are formed; the actions are volitional though supported and abetted by a myriad of reflex and habitual responses as the rest of our musculature responds to the novel actions in the writing hand and arm. As the actions involved in forming the letters became habitual, we can allow the movements of our wrist and fingers to happen without paying them explicit attention. The physical act of writing then becomes almost unconscious, with the by-now habitual sequences of muscular activity involved in letter-formation being evoked in response to the cortical impulses to write particular words.

In this perspective, there is no conflict between the voluntary, the habitual and the reflex muscular control systems. They work in harmony, with control of the activity swapping automatically between the cortex and the brainstem. The problem is that the practical reality is much more messy and it is useful to turn here to Berta Bobath. 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*

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[60] Sherrington (1948)p232
[61] Sherrington (1948)p387

> *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.*[62]

Her practical experience taught her, however, that the human cortex has a much greater capacity to interfere with and distort the functioning of the postural reflex system than is suggested by Magnus' experiments on decerebrate animals. In other words, the separation between the reflex and the voluntary is not as clearly defined as his experiments suggest. Discussing his finding that normal standing takes place in decerebrate animals as long as the thalamus is present, Bobath 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.*[63]

Although Bobath did not question Magnus' basic findings on the workings of the postural reflexes she clearly recognised the limitations of his analysis. He himself was also fully aware that there is a high degree of interaction between the cortical and subcortical and that the cortex could interfere with the workings of the postural reflexes but the details were outside the frame of reference of his research. By removing the cortex he was able to study the isolated functioning of the postural reflexes but the details of how they behaved in combination with the cortex remained unexplored.

Bobath's work in which she was dealing 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 for Magnus. Her relevance to the present discussion is that her work provides an intermediate case between Magnus' decerebrate laboratory subjects and the intact human being in which the cerebrum and the subcortical postural control centres are properly in contact.

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 reflexes and by the patient's volitional efforts when using their patterns for function.*[64]

In other words, people in whom the normal relationship between the volitional brain and the brainstem is not functioning properly, instead of being able to allow the postural reflexes to function as they should, tend to make deliberate compensatory

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[62] Bobath (1985)p2
[63] Ibid.6
[64] Ibid.2

efforts. In the case of cerebral palsy sufferers in whom normal postural activity has never been possible, the volitional brain is deprived of the operating template provided by the postural reflexes.

The conditions being considered in the present 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, illustrated by Sherrington learning to write or the cerebral palsy victims' *volitional efforts* to perform the tasks of their daily existence, is that in addition to their capacity to mobilise the postural reflexes, humans have a capacity to co-opt or bypass them.

When this is allied to the high degree of plasticity in their neurological system, the way is open for humans to devise a wider range of ways of using themselves than any other vertebrate. This 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 also why performing dogs and bears make poor dancers compared to even a moderately well-coordinated human. The downside of the ability to override their postural reflexes is that it also brings a variety of deleterious consequences which humans are all too prone to inflict on themselves.

Habit takes over

Volitional activity, if repeated sufficiently often, becomes habitual, that is it occurs automatically, independently of any conscious thought. This is what makes it possible for athletes to perform their often prodigious feats. The ability to return a fast tennis service is certainly not innate but the player who delays until the approaching ball has been consciously apprehended before deciding how to return it will be hopelessly late in responding. The only way to learn how to do it is by long practice until the necessary muscle response can be carried out without consciously focusing upon it. This learned response is then triggered by the appropriate stimulus and so closely resembles a reflex that it is often referred to as being one even by scientists.

It is not just the spectacular skills of the athlete or the complex processes of writing which can become so thoroughly learned as to slip below the level of conscious thought. To a much greater extent the same applies to the ordinary activities of daily life, the way people sit, walk, hold themselves when they are reading, talking, driving, brushing their teeth, talking on the phone or using a computer. The activities of everyday life are mainly unconscious, a combination of reflex and habitual, supporting and guided by a small volitional element.

The problem is that many of these learned modes of behaviour involve a permanent suppression of the postural reflexes. People who use computers for eight hours a day, to take a common example, often develop permanently distorted ways of holding and using themselves and, in time, they become completely unaware of the extent to which the restorative action of the postural reflexes has been suppressed.

Athletes and dancers often develop ways of using themselves in daily life which are seriously at variance with the workings of their innate postural reflexes; the splayed feet of classical ballet dancers or the lumbering gait of many weightlifters and rugby forwards come to mind. Although no brain lesions are involved, these postural habits represent a disruption of proper communication between the cerebrum and the lower

brain in which these unconscious 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". Habit has taken over. 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 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 5: THE HEAD-NECK RELATIONSHIP

The physical and neurological structures and mechanisms involved in the interaction between the head and the neck are often grouped under the collective title of the head-neck relationship.

The proper functioning of this relationship underpins the working of the eyes, ears, and nose; the organs of balance; and the flow of proprioceptive information into the brain and transmission from it of reflex and volitional instructions to the rest of the body. It is also central to the question of posture and its control.

Physiology of the neck

Before discussing the head-neck relationship it is useful to start with the basic physiology of the neck. It is reputedly the most complex musculo-skeletal system in the body.[65]

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. The scalenus (ladder) muscles run from the two upper ribs and connect the transverse processes of the cervical vertebrae, assuring their relationship with each other and stabilising the cervical spine. Outside the scalenus muscles are found the larger muscles which provide the neck and head with their various flexion, extension and rotatory movements; among others, these muscles include the sternocleidomastoids, the trapezius, and the levator scapulae.

The cervical spine itself comprises thirty-seven separate joints whose function is to provide for the movements of the head in relation to the body. It 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.[66] 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 average head weighs around four kilograms (8½ lbs). Lifting and carrying four bricks or two bags of sugar in a plastic bag is a useful exercise in that it gives a tangible idea of the task that the neck handles with such untiring and delicate precision.

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 in the muscle system controlling the movements of the head and neck:

> *… 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.*[67]

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

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[65] Bland and Boushet (1992)p135
[66] Ibid.135
[67] Jull et al (2008)p24

> *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.*[68]

The authors, in the above quotation, are referring to the control of head movements in a lizard in which the neuroanatomy is similar to that of a human being but the control systems are mainly reflex and much simpler than those of a human. The text nevertheless provides a clear picture of the complexity of the neuromuscular mechanisms involved in controlling and managing the movements of the head.

The relevant common feature between humans and lizards, in the present context, is that the neuromuscular structures of the neck can be employed in a variety of ways to achieve the same end-result. The actual freedom enjoyed by the lizard in how it performs its tasks is, however, heavily constrained by its mainly reflex nature, which means that its responses to stimuli are for the most part stereotypical. Human beings, in comparison, enjoy a much wider range of choice, including that of misusing their head-neck systems in ways which are quite impossible for lizards.

The coordinating role of the neck

The neck is the conduit for the two-way streams of nervous impulses which flow between the brain, acting as the body's analysis and command centre, and the working neuromuscular systems of the rest of the body. But the neck is a great deal more than a passive conduit for 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 important human 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 resume their normal position in the eye-sockets. This twisting of the neck, in turn, mobilises further righting reflexes in the shoulders, hips legs and feet to bring the rest of the body into adjustment with the changed position of the head. A simple movement of the eyes and head thus mobilises the postural reflexes to adjust the disposition of muscular tone from the head down to the soles of the feet.

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[68] Wang et al (1992)p91

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. This demands 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.[69] 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.*[70]

In normal conditions the neck does its job almost entirely reflexly and, in the absence of injury or physical decline, the head-neck-body relationship remains unproblematic. Humans, as opposed to other vertebrates, are however extremely ingenious in devising subtle and not so subtle ways of interfering with the proper functioning of the head-neck relationship. One of the less well-known but extremely potent forms of this interference is by preventing the sub-occipital muscles from properly fulfilling their special role in the physical monitoring of the head-neck relationship.

The special role of the sub-occipital muscles

The sub-occipital muscles are located at the top of the cervical column, just below the occipital bone. They occur in pairs and can be divided into those posterior to the cervical column and those anterior to it. The posterior group consists of the following: the *rectus capitis posterior minor* and the *obliquus capitis superior* which connect the nuchal line of the skull to the atlas vertebra; the *rectus capitis posterior major* which connects the nuchal line of the skull to the axis vertebra; and the *obliquus capitis inferior* which connects the atlas and the axis vertebrae. These are all posterior to the cervical column.

Forward of the occipital condyles, and therefore, in some senses, acting antagonistically to the posterior group, are found the small anterior sub-occipital muscles. Among these, the *rectus capitis anterior* and the *rectus capitis lateralis* insert into the base of the occipital bone forward of the foramen magnum and connect into the atlas vertebra. The *longus colli* runs from the front of the atlas vertebra, connecting all the cervical vertebrae with the top three thoracic vertebrae. The *longus capitis* connects the occipital bone, anterior to the foramen magnum, with the third to the sixth vertebrae.

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[69] Taylor (1992)p488
[70] Mittelstaedt and Mittelstaedt (1992)p369

In anatomy books, the *"*actions*"* of the posterior and anterior sub-occipital muscles are conventionally 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*"* it, 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.[71]

It is obviously true that the sub-occipital and small anterior vertebral muscles are involved in such relative 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 primary 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 which generate nervous impulses in response to the contraction and extension of the muscle fibres in which they are found. 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.*[72]

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 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.*[73]

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[71] See, for example, Stone and Stone (pp 62, 68, 69)
[72] McComas (1996) p48
[73] Jull et al (2008)p60

According to these figures, the sub-occipital muscles are up to one hundred and twenty times more sensitive to stretching than the nearby trapezius which is so evidently involved in the flexure and extension of the head. Thus, although the sub-occipitals 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 optimally located for the task of monitoring the changing positions of the head and neck in relation to each other. Their major function is thus far more likely to be proprioceptive than as contributors to the task of moving the head. 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.*[74]

The implication is that these muscles rather than merely making a minor contribution as prime movers of the head are providing the nervous system with feedback relevant to the control of the postural reflexes. This fits with their spindle-rich character and the complexity of their configuration in the critical juncture of the head and the neck. Although Magnus makes no comment on these muscles, this explanation would fit easily and compatibly into his analysis.

Disrupting normal head-neck functioning

Given the complexity and delicacy of the neck and the mechanisms by which it relates to the head, there is amply opportunity for things to go wrong. In the case of cats, dogs and lizards, the deterioration in their gait and general patterns of muscular use become ever more evident as they grow old or suffer the effects of disease or injury.

Humans as well as being subject to ageing and the vagaries of illness and accident have the additional possibility of damaging themselves through the way they exploit their freedom to misuse themselves.

Excessive tension in the head-neck shoulder area

One of the most insidious ways in which people misuse themselves is by the inadvertent cultivation of excessive tension in the head-neck-shoulder area. When the large muscles in this part of the body, area such as the trapezius, levator scapulae and sternocleidomastoid, are excessively contracted, pulling the head back and down so that the cervical column is compressed, the relative movement of the head and neck in the sub-occipital area is restricted or may not take place at all. As a result, there is little or no variation in the length of the sub-occipital muscles and they can 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 in their turn 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 the

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[74] Williams (1995) p813

head, its control of the body's movements is bound to be impaired to a greater or less extent; in short, the postural reflexes will not be working properly.

Such damage to the natural working of the postural reflexes is far more common than is usually realised. 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. The fitness regimes to which people devote themselves with such dedication can leave many people with tight and bulging muscles but malfunctioning postural reflexes. Others misguidedly conflate determination and concentration with the highly damaging combination of a stiff neck and tightened jaws. It was a cause of considerable amusement to Alexander, a staunch agnostic, that the bible viewed being stiff-necked with such disfavour.

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.

Another important example is ordinary 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 later the adult are subjected. Marching with the chest puffed out, slouching, shuffling, sticking the head forward, teetering on high heels, any number of 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.

Apart from the effects of the obvious tightening of the neck muscles discussed above, it is worth noting that other aspects of modern life carry risks for the proper functioning of the muscles of the head-neck area. Consider the delicacy with which the neck muscles are used to locate the direction from which a sound is coming. The process relies on fine-tuning the direction of the head so that the sound enters each ear at precisely the same moment. This is clearly rendered more difficult if the muscles in this area are in a chronic state of excess tension. It would be interesting to know the extent, if any, to which plugging ear-phones into each ear, thus rendering auditory direction-finding redundant, leads to deterioration or coarsening of the fine motor control systems of the neck.

Working life is fraught with health risks for the majority of people. The large numbers of people in low-paid insecure jobs, often in poor working conditions, are open to a variety of ways of misusing themselves and frequently do so. But the privileges of wealth do not exempt the highly paid from risks of damage in the head-neck area. 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 people have acquired in their habitual way of using themselves than they are to restore the proper functioning of their neuromuscular systems. 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.

It is also worth considering the wider risks that malfunctioning in the head-neck area bring to the natural functioning of the eyes and ears. The common response when people experience difficulties in seeing or hearing is to "strain" to do so by stiffening the neck. This obviously brings no improvement in vision or hearing but is likely to contribute to an impairment of the restorative actions of the postural reflexes. Nineteenth century ophthalmologists, in fact, commonly associated myopia with distorted posture. A well-known ophthalmologist, John Soelberg Wells noting the tendency of myopes to stoop and stick their head forward affirmed *"...we should, therefore, always direct myopes to read with the head well thrown back.* [75]*"*

Injury in the head-neck area

The critical role of the head-neck relationship in the overall functioning of the body helps account for the fact that damage in the cervical area from whiplash or other injuries can have such widespread and long-lasting health effects notably 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.*[76]

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.[77]

People who have suffered whip-lash injury sometimes find that while they appear to have recovered completely from its direct effects they are still afflicted by headaches and other symptoms. Magnus' findings, especially in relation to the non-fatigability 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

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[75] Soelberg Wells (1864) pp70
[76] Brown (1992)p645
[77] Ibid.645

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.[78] These imbalances of tone evoke compensatory distortions in other muscle areas so that the musculature becomes locked in malposture and its attendant ill-effects. 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.

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.[79] 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.*[80]

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."*[81]

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 and, especially, on the delicate workings of the sub-occipitals. 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.

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[78] Magnus (1926a)p534
[79] Homola (1999)p86
[80] Jull et al (2008)p195
[81] Homola (1999)p239

SECTION 7: SOME PROMINENT SCIENTIFIC SUPPORTERS

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 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 that he retrained himself in medical research, and was appointed a Research Associate at Tufts University in Boston; he subsequently carried out a series of studies on the AT during the 1950s, publishing his results in the scientific literature. David Garlick 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 life, scientific work and involvement with the AT are given below.

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 *Australopithecus 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.

Dart's wife Marjorie gave birth to their son Galen in 1940. The birth was premature and the baby who weighed only a kilogram suffered from severe spasticity and lack of muscular coordination. Dart, a devoted father, came across the Alexander Technique when he was trying to find ways of dealing with child's problems. 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…*[82]

[82] Dart (1996) p33

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.

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. Dart was greatly influenced by the now-discredited "recapitulation theory" of the German anatomist Ernst Haeckel (1834-1919) who also happened to be 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. Dart therefore devised a series of exercise and movement programmes for Galen which were based on the stages phylogenic development Galen had supposedly missed in the womb.

During the 1940s and 1950s Dart wrote three Alexander-influenced papers which were published in South African medical journals and reproduced in a 1996 publication called *Skill and Poise* from which the present quotations have been taken. 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.

In this paper, 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.*[83]

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 that

> *… if the head containing the balancing organs is not the prime mover, if it is incorrectly placed and maintained for equilibrated execution of the movements planned, the movements will be unbalanced and, in brief, caricatures of what these movements should be…The vast majority of people, relying more on one torsional sheet than the other, develop a right-handed twist or asymmetry of movement.*[84]

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[83] Ibid.85
[84] Ibid.p90

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.[85] 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.*[86]

He saw Alexander's work as providing a unique approach to the task of achieving a balance between the reflex and the *"purposive"* in human activity. He goes on to say:

> *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…*[87]

Dart remained a strong public 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.*[88]

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 rest upon his 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.[89] These involved observations by Coghill and his assistants of the developing responsiveness of the neurological system of the *amblystoma* at fifteen minute intervals for the first sixty hours after hatching. It was an extraordinary experimental endeavour and the results evoked widespread scientific interest. Coghill gave a series of lectures on his findings

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[85] Ibid.p85
[86] Ibid.p91
[87] Ibid.p91
[88] Ibid.55
[89] Herrick (1949)p34

at London University in 1928 which were published in book form under the title *Anatomy and the problem of behaviour.*[90]

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.*[91]

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.*[92]

Just as it had done with 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 got on well. In spite of his illness, Coghill wrote an Appreciation for the book, *The universal constant in living,* which Alexander was just completing at the time.

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

> *…three well established biological principles: the integration of the whole organism in the performance of particular functions; proprioceptive sensitivity as a factor in determining posture; and the primary importance of posture in determining muscular action. These principles I have established through forty years in anatomical study of Amblystoma in embryonic and larval stages, and they appear to hold good for other vertebrates as well.*[93]

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*

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[90] Coghill (1929)
[91] Ibid.89
[92] Barlow (1978)p257
[93] Alexander (1946)p xix

> *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.*[94]

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.*[95]

It should be noted that in his use of the phrase *"habitual use of improper reflex mechanisms"* Coghill has departed from Sherrington's definition of reflex and is using it in the sense of an acquired or learned pattern of action. What he is saying here is that acquired habits of muscular use which are in conflict with the total pattern are the cause of fatigue, nervous strain and other ills.

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 (1905-1975) was born in Wisconsin. He received a degree and then a Masters in Stanford University and began studying for a PhD in classics at 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

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[94] Ibid.xxiii
[95] Ibid.xxxiv

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 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.*[96]

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 from pupils.[97] He remained in correspondence Alexander, as well as having lessons when the opportunity occurred, up the time of Alexander's death in 1955.

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, his personal experience was that sceptics tended to explain away the positive results from lessons by invoking by factors such as improved motivation.

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[96] Jones (1976)p105
[97] Ibid.108

Negative results, on the other hand might be because the pupil had simply failed to learn the Technique. He rightly felt that statistical 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 believed it would be scientifically more convincing if he could identify the immediate physiological effects of the AT under the practical conditions of an AT lesson. He therefore 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 endeavouring to establish *"the physiological correlates of the kinaesthetic effects that can be produced in a single lesson."*[98]

Jones published some twenty four 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 the totality of his findings and was reprinted in a posthumous collection of his work published in 1998.[99]

His only book was entitled *Freedom to change* but the final chapter remained unfinished at his death. The book, however, contains a summary of his views on the working of the AT which goes 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.*[100]

Jones died of brain cancer in 1975 at the age of seventy.

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 the behaviour of animals in the wild. 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

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[98] Ibid.148
[99] Jones (1998)p249
[100] Ibid.148

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.*[101]

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…*[102]

Tinbergen 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 the same year. 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:

> *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.*[103]

He went on to say:

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[101] Kruuk (2003)p146
[102] Ibid.146
[103] Tinbergen (1973)

> *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 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 understandable 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.*[104]

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 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.*[105]

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*

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[104] Ibid.125
[105] Ibid.126

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."[106]

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 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.*[107]

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

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 increasingly led him into sports medicine. He saw the need to educate doctors and health professionals in the rapidly expanding field 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 involved himself publicly in promoting the AT and became a well-known public speaker on it. He produced a series of twenty short articles dealing with neurological and physiological aspects of the Technique for the specialist AT publication, *Direction Journal,*[108] 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

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[106] Kruuk (2003)p283
[107] Walker (2009)p138
[108] http://www.directionjournal.com/about/

marathon-running depend mainly on red fibres in comparison with the explosive requirements of sprinting or weight-lifting which depend primarily on white fibres.[109]

In one of his 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.*[110]

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.

[109] This is discussed in greater detail in my paper *Muscles and their red and white fibres* at http://www.geraldfoley.co.uk/MUSCLES%20April%202012.pdf

[110] Garlick (D1-1)p7

SECTION 6: A NEUROPHYSIOLOGICAL OVERVIEW

Alexander was pleased when a public figure like Dewey referred to the AT as scientific or a well-known scientist like Tinbergen supported it. He firmly believed that the AT belonged to the medical mainstream and was highly indignant at any suggestion that it might be considered as belonging to the medical fringes. Dewey's introduction to *Constructive conscious control of the individual* made a special point of distinguishing the AT from the popular "cure-alls", fads and quackery of the day.

During Alexander's lifetime, and since then, however, a scientific framework within which the AT can be discussed and analysed satisfactorily has been lacking. 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, Garlick and others inside and outside the AT profession nevertheless provide a variety of insights into various aspects of the working of the AT. This section attempts to assemble these insights into a preliminary neurophysiological overview of what is happening when AT lessons are being given.

What did Alexander discover?

Alexander's achievements were empirical rather than theoretical. His Technique emerged from his successful efforts to develop a way of dealing with his own voice problem and then applying what he had learned to others who came to him for advice. He later found his approach had beneficial effects that extended far beyond the voice.

In his later years he was persuaded to set up a training school for teachers of his methods. The first training course was set up in London in 1931 when Alexander was sixty-two. After his death, in 1955, his most prominent followers continued with his work though giving it their own personal slant.

At no stage in his career did Alexander attempt to produce anything resembling a neurophysical theory of his approach. He nevertheless identified the importance of the head-neck relationship at an early stage in his investigation of his own voice problems and soon became aware of its broader significance. In his book, M*an's supreme inheritance* which was published in 1910, he talks of the contorting efforts made by one of his pupils to conceal what he felt was the undue thinness of his neck, and says of the pupil that:

> *In the standing, sitting and walking positions these uses, or rather misuses, of the muscles of the neck soon grew into a very firmly established habit…whilst the muscular co-ordinations of the whole organism were gradually and harmfully interfered with.*[111]

In the early 1920s, having learned of Magnus' research he began to refer to the head-neck relationship as the "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. 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*

[111] Alexander (1910)pp162

> *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.*[112]

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.*[113]

Alexander was obviously mistaken on this point. The central apparatus to which Magnus referred was not a single control centre but a group of neurological centres in the brainstem, from the top of the spinal cord to the midbrain,[114] that controlled the various postural functions he had identified. More importantly, the central apparatus to which Magnus referred controlled the postural reflexes whereas Alexander's "primary control" to which he refers in the above quotation and various other places in his books appears to be a mechanism which can and should be subject to conscious control.[115]

Though this is a valid point, it is of little, if any, 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 independently apparatus or group of neurological structures. Muscular functioning in the everyday behaviour of humans and intact laboratory animals, as Berta Bobath pointed out[116], 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.

Parallels between Magnus and Alexander

Magnus and Alexander never met and it is unlikely Magnus ever heard of the AT. Nevertheless there are some striking affinities between the work of the two men which were no doubt noted by Sherrington when he commended Alexander's approach.

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*:

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[112] Alexander (1995)p148
[113] Alexander (1995)p134
[114] Magnus (1924)p653
[115] I provide an extended discussion of this in a paper entitled *Untangling the primary control* which can be found at http://www.geraldfoley.co.uk/Untangling%20the%20primary%20control.pdf
[116] See p21

> *The mechanism as a whole acts in such a way that the head leads and the body follows.* [117]

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 independently reached the same conclusion as Magnus and 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 the application of Alexander's Technique 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 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 he wrote 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 teaching of how to eliminate interference with the autonomic functioning of the organism.*[118]

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.

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[117] Magnus (1926a)p536
[118] Carrington (1994)p52

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 less of how exactly 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 instruction 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.*[119]

Homeostasis[120] 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 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."*[121]

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

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[119] Sherrington (1946)p89
[120] The word comes from the Greek *homos = same* and *stasis = standing still.*
[121] Rose (p17)

> *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.*[122]

Brodal is pointing out that 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 orders connected with the new and correct use of the different mechanisms.*[123]

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"* or think of 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 ones, and steadily building up those which are correct and reliable.*[124]

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

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[122] Brodal (p548)
[123] Alexander (1910)p131
[124] Ibid.131

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 a 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.[125]

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:

> *… 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.*[126]

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.*[127]

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

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[125] http://www.mouritz.co.uk/6.31.quo.primary.control.html
[126] Alexander (1932) p30
[127] Alexander (1946)p8

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 downwards, 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.*[128]

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 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.[129] 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.*[130]

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

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[128] Ibid.8
[129] http://www.mouritz.co.uk/6.03.quo.direction.html
[130] Alexander (1932) p35

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.*[131]

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 acceptance of the hypothesis that each and every movement can be consciously directed and controlled.*[132]

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.*[133]

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.

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[131] Sherrington (1948)p234
[132] Alexander (1910)p124
[133] Alexander (1946)p85

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.*[134]

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 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 the 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 other 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.*[135]

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 level at which Sherrington worked but his sense of how people actually behaved was 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 of any activity unless they are consciously inhibited. Alexander's achievement was to have devised a practical means of inhibiting habit and allowing it to be replaced by consciously directed activity.

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[134] Ibid.85
[135] Sherrington (1933)p10

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