The special importance of the head-neck junction

Gerald Foley 19 January 2015

The head-neck junction is one of the major influences on the posture and overall working of the body. A moment's self-exploration, pushing the head forward, pulling it back, tightening the neck, or letting the head flop forward will reveal a range of effects on the shoulders and chest, the disposition of the hips, the distribution of weight between and upon the feet, and the sense of balance.

Malfunctioning in this area has widespread effects on the rest of the body. This is not surprising when the head-neck junction is recognised as the link between the body's control and command centre in the head and the rest of the body. Think of what it would be like in an articulated vehicle if the link between the cab and the trailer were not working properly, or trying to fly an aeroplane without effective communication between the cockpit and control surfaces in the wings and tail.

This paper sets out to examine the head-neck junction and show why there are such strong health and functional reasons for ensuring it is working as it should.[1]

The physiology of the head-neck junction

It is useful to begin by looking at the basic physiology of the head-neck area.

The head

The skull provides the underlying bony structure of the head. The eight cranial bones form the cranial cavity which houses and protects the brain. The two maxillae that project forwards and downwards from the front of the skull, provide the underlying structure of the upper jaws, the lower part of the eye-sockets, the nasal cavity and the hard palate. The mandibles, or lower jawbones, are the only moveable skull bones. They are hinged into the temporal bone of the skull at the temporomandibular joint just below the ear.

The head is supported on the top cervical vertebra, the atlas. Two curved downward projections from the occipital bone of the skull are known as the occipital condyles and form a rocker joint with the atlas vertebra. The next vertebra, the axis, has an upward projection, called the dens, which fits into the atlas. When the head turns, this ensures the top two vertebrae move together.

The support point for the head is surprisingly high in the head. The atlas vertebra is located approximately mid-way between the auditory meatuses, the openings into the ears. Evolution has placed the centre of gravity of the skull slightly in front of the occipital condyles so that it is subject to a constant tendency to tip forward. In order to counteract that, a small degree of tension is required in the muscles in the back of the neck; if it is not there, the head flops forward.

The upper part of the brain, the cerebrum, is housed in the upper area of the cranial cavity. This is where the brain's cognitive functions take place. The cerebrum is divided into the two cerebral hemispheres with their much discussed differences between the contributions of the right and left. Towards the back of the cerebrum are found the visual centres. Below the cerebral hemispheres are the brainstem, thalamus and other areas of the brain which receive and respond to the various sensor systems around the body, including the

[1] A particularly useful document is Berthoz et al (1992) which contains the collected papers from an international conference entitled *The Head-Neck Sensory Motor System* held in France in 1989 at which over one hundred papers were presented.

muscle spindles, the pressure sensors in the joints and those in the skin and the soles of the feet, and the tiny individual muscles separately supporting each of the body's hairs.

The head also provides a platform for the sensors that monitor the external world, often referred to as the distance receptors or exteroceptors. In humans the most important of these are the eyes but other animals may rely more on the nose and ears. The head also houses the labyrinths, the body's balance and head-movement monitors.

The average weight of the head is around four kilograms (8½ lbs). Lifting and carrying two bags of sugar or four bricks is a useful exercise in that it gives a tangible idea of the task involved in supporting and adjusting the skull on top of the cervical spine. When everything is working properly, it is a task the neuromuscular system handles with such untiring and delicate precision that we never notice it.

The neck

The neck is reputedly the most complex musculo-skeletal system in the body.[2] Its bony structure 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 neck has thirty-seven separate joints and is in a state of constant movement. It is said it moves over six hundred times an hour, whether the person is awake or asleep.[3]

The cervical spine is supported by an elaborate arrangement of muscles. 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 as a whole. In the layer of muscles outside the scalenus are found the larger muscles which attach into the head and provide it with its various rotatory, flexion and extension movements; these muscles include the sternocleidomastoids, the trapezius, and the levatores scapulae. The whole structural arrangement depends on each supporting muscle having precisely the right amount of tone, or tension, at all times to play its own particular part in the adjustment of the head-neck relationship from moment to moment.

Most of the twisting and other movements that people often attribute to the neck occurs in the head-neck junction. The neck contributes a certain amount of flexibility but its main role is to provide support and stability for the head.

One of the features of the capacity for movement in the head-neck relationship is that there is a high degree of redundancy in the system, in the sense that many of the adjustments it makes can be achieved in a variety of different ways. Here is a description of what is involved:

> *… 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.*[4]

This redundancy makes the precise analysis of the functioning of the head-neck relationship difficult. The following describes what is involved in controlling the head movements in a lizard, a simple creature with a tiny brain and a limited repertoire of movements upon which it can draw. Even so:

> *There are some difficult problems in understanding the control of head movements. The head-neck system is multijointed and the posture and*

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[2] Bland and Boushet (1992)p135
[3] Ibid.135
[4] Jull et al (2008)p24

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.[5]

Although the lizard does what it does with considerable precision – snaring a fly with its extended tongue, for example – the actual freedom it enjoys on precisely how these things are done is heavily constrained by its mainly reflex nature, which means that its responses to stimuli are for the most part stereotypical and largely predictable. Human beings, in comparison, enjoy a much wider range of choice, including that of misusing their highly complex head-neck systems in ways which are quite impossible for lizards.

A platform for the external sensors

In addition to housing the brain, the head acts as a platform for the teleceptors, the sensory instruments through which the external world is perceived. In humans, the most important teleceptors are the eyes with the ears and nose playing a secondary role.

Consider the functioning of the eyes. When the neuromuscular system is working as it should, 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 what are called the head righting reflexes that mobilise the appropriate neck muscles to twist the head round in the direction of the object so that the eyes resume their normal central position in the eye-sockets. This twisting in the head-neck area, in turn, mobilises further reflex movements in the shoulders, hips, legs and feet to bring the rest of the body into adjustment with the changed position of the head.

As a result of a simple movement of the eyes, there is a chain of muscular reactions from the head down to the soles of the feet. If the head-neck relationship is not working properly, the sequence of movements that should flow from shifting the gaze are distorted from their inception. Instead of flowing seamlessly into each other, they are disjoined, more awkward and effortful than they need to be. Stiffness in the head-neck junction has a similar effect on the rest of the body to wearing a neck-brace.

The proper functioning of the ears also requires a surprisingly complex series of muscular actions in the head-neck area. 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 something from a table, for example – it is also essential to know its location relative to the rest of the body.[6] Thus the

[5] Wang et al (1992)p91
[6] Taylor (1992)p488

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.*[7]

When the head-neck junction is working properly, the various muscle groups involved collaborate almost entirely reflexly to provide the sensitively self-adjusting platform required for the optimum functioning of the exteroceptors with the rest of the body reflexly making its adjustments to the changed position and orientation of the head. Despite the complexity of its functioning, in the absence of injury or physical decline, the working of the head-neck relationship in vertebrate animals, except for humans, remains unproblematic.

The jaw and soft palate muscles

Adding to the complexity of muscular activity in the area of the head-neck junction are the muscles that move the lower jaw. These include the temporalis, the masseter, the buccinator, the medial and lateral pterygoids and others that power the biting, tearing and chewing movements involved in eating. Intermingling with these and sharing their tasks are the muscles involved in yawning, smiling laughing and changing facial expressions. Playing an anti-gravity role, they also hold the lower jaw so that the mouth does not sag open.

Closely adjacent to these various jaw muscles, lies the soft palate with its own range of muscles controlling various aspects of swallowing and breathing. The tongue is itself a muscle covered with mucous membrane A variety of extrinsic muscles contribute to its control and its various functions associated with the ingestion and mastication of food as well those involved in talking, singing and vocalisation. Anxiety or habit can lead to people maintaining their tongue pressed against their lower teeth.

The aim here is not to analyse these various functions in detail but to point to the muscular complexity of this area of the body and the extent to which it interacts with the head-neck area. It is noticeable, for example, how tightening the jaw or the tongue produces a concomitant stiffening of the neck. At the neurological level, there is a high degree of interlinking, with nerve fibres from the cranial nerves and the top of the spinal cord providing the necessary interconnections so that muscles do not act in complete isolation as though we were made up of mechanically separate parts rather than the joined-up entities we are.

The role of the vagus nerve can be mentioned as a particular example of such linkages. The vagus is the tenth cranial nerve, and innervates muscles in the throat and neck but as its name implies it wanders much farther down through the body. In its course, it also innervates the smooth muscle in the oesophagus, the stomach, and the large and small intestines illustrating the degree of neurological interlinking involved. Who has not felt the familiar stiffening of the neck and lurching of the intestines on looking at the time and realising how late we are going to be?

Excessive tension in the head-neck area

The complexity of the muscular and nervous system involved in the head- neck area offers ample opportunity for things to go wrong. Like all animals, humans are subject to the

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[7] Mittelstaedt and Mittelstaedt (1992)p369

vagaries of injury, illness, and ageing, all of which can affect the working of the head-neck junction but humans have the additional possibility of cultivating habits of excessive tension in head-neck area.

When the large muscles in and around this area, such as the trapezius, levator scapulae and sternocleidomastoid, are habitually over-contracted, they pull the head back and down so that the cervical column is compressed, and the relative movement of the head and neck in the sub-occipital area is restricted or may not take place at all. The framework of muscles around the neck instead of providing a flexible and supportive framework acts like a constraining neck brace.

This means the head is no longer able to its part as a major quasi-independent element in the dynamic balance of the body but is locked into being part of the upper torso. Rather than having the weight of the head as a deployable element in the management of posture, the neuromuscular system must manage without its counterbalancing assistance, relying solely on a necessarily cruder and less effective manipulation of the remainder of the body. This means that other muscles are compelled to take on roles which they have not evolved to fill, tending to make body-movements more clumsy. The frequently lumbering gait of the heavier members of a rugby team, whose survival in the scrum necessitates a heavily over-developed musculature in the head-neck area, illustrates the point.

This takes us into a discussion of the role of red and white fibres in the body's skeletal muscle system. The details are complex but the general picture is clear.[8] Most muscles are composed of a mixture of both red and white fibres but those used in the basic work of maintaining sitting and standing postures as well as the requirements of gentle to moderate rhythmic activity are predominantly composed of red fibres that are essentially non-fatiguable – their capacity is continually renewed by breathing and the circulation of the blood. When, however, there is a need for a more vigorous or a very quick response, the nervous system brings the predominantly white fibre muscles into play. When the body is being used properly, the choice between red and white muscle fibres, their "order of recruitment" is made automatically by the nervous system – as is the choice between muscles.

If the neck is stiff and the head-neck junction is not moving freely, the normal muscle recruitment processes no longer work properly. This, for example, can lead to undue dependence on the easily fatiguable and predominantly white-fibre thoracic muscles as supports for the back rather than the predominantly red-fibre postural muscles such as the multifidus that are more adapted to the task. People with highly developed muscle systems in their upper thoracic area may therefore find it difficult to sit up straight in a chair for more than a few minutes and despite cultivating their muscular "fitness" in the gym may suffer chronic back pain. This is because they are unduly relying on their fatiguable white fibre rather than their red fibre muscles for the maintenance of their sitting posture.

Continued excessive tension in the head-neck area can also lead to the "tension headaches" from which so many people suffer. People with such headaches often feel a need for forceful stretching and twisting of the neck, often accompanied by clenched fists and movements of the arms. These attempts to relieve the aching and feelings of stiffness are often accompanied by clicking and cracking sounds in the neck and shoulder areas as over-tense tendons shift their positions relative to each other and their various neighbouring bony structures. Other people, after a stressful day at a computer may feel some hard stretching and a vigorous run or session in the gym is what they need. This is from the *British Journal of Sports Medicine:*

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[8] A more detailed discussion of this topic is available here: http://www.geraldfoley.co.uk/MUSCLES%20April%202012.pdf

> *...stretching somehow increases tolerance to pain – that is it has an analgesic effect. It does not seem prudent to decrease one's tolerance to pain, possibly create some damage at the cytoskeletal level and then exercise this damaged anaesthetised muscle.*[9]

It should also be noted that exercise tends to strengthen muscles that are already tense to a greater degree than those that are relaxed. Vigorous running and gym visits as a means of relieving tension in the head-neck area, despite any relief that people may feel, in the longer term are likely to reinforce their excessive head-neck tension and the problems that flow from it.

All of this highlights the fact that a stiff neck, as opposed to stiffening in other areas of the body, seems to have a peculiar potency in the way it disrupts the normal functioning of the body. This is well recognised and is presumably why being "stiff-necked" has acquired its pejorative connotations in the Bible and elsewhere. To understand why this is so, it is necessary to look at the small sub-occipital muscles and the role they have in the body's balance and postural systems.

The special role of the small sub-occipital muscles

The small sub-occipital muscles are located at the top of the cervical column, just below the occipital bone of the skull. 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 *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 to the axis vertebra; and the *obliquus capitis inferior* which connects the atlas and the axis vertebrae.

Forward of the occipital condyles are found the small anterior sub-occipital muscles. These also occur in pairs. The *rectus capitis anterior* and the *rectus capitis lateralis* insert into the base of the occipital bone forward of the foramen magnum and connect into the atlas vertebra. The *longus colli* runs from the front of the atlas vertebra, connecting all the cervical vertebrae with the top three thoracic vertebrae. The *longus capitis* connects the occipital bone, anterior to the foramen magnum, with the third to the sixth vertebrae.

In anatomy books, the actions of the posterior and anterior sub-occipital muscles are conventionally listed as producing the various nodding and rotatory movements of the head with which they are evidently associated. The rectus capitis anterior, for example, is said to *"flex"* the head, rocking it forward on the occipital condyles, and the rectus capitis posterior minor *"extends"* it, rocking it backward. The obliquus capitis superior *"rotates"* the head by turning the atlas vertebra and the axis vertebra with which it is interlocked by the upward projection of the dens.[10]

It is self-evident that the posterior and anterior sub-occipital muscles are involved in such relative movements of the skull and the top two cervical vertebrae, since they lengthen and shorten as the distances between their points attachment change with the movements of the head. But mechanically they can make little contribution to the forces involved in 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 and as a result, the forces they are able to exert on the large weight of the head are 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

[9] Shrier (2000)p324
[10] See, for example, Stone and Stone (pp 62, 68, 69)

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 are likely to have a role in fine-tuning its movements.

Such a minor role does not seem sufficient to warrant such an intricate muscular arrangement, so the question becomes what is its primary purpose. It is noteworthy, in this context, that the sub-occipital muscles are particularly rich in spindles, the tiny sensors that 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 and the reason for it, 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.*[11]

A more detailed account of the relative distribution of muscle spindles in different muscles gives the following:

> *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.*[12]

According to these figures, the sub-occipital muscles are up to one hundred and twenty times more sensitive to registering their own stretching than the nearby trapezius which is so evidently involved in the flexure and extension of the head. This suggests that the primary role of the sub-occipital muscles is to act as sensitive strain-gauges, monitoring the relative movements of the head and the neck.

Gray's Anatomy remarks:

> *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.*[13]

Richmond et al remark that the sub-occipital joints and muscles may be viewed as a fine-tuning mechanism..

> *...that can be called into play independently of lower cervical joints, to position the skull for the needs of sensory and motor system associated with the skull, such as vision and audition*[14].

Innervation of the sub-occipital muscles is from the cervical plexus at the top of the spinal cord adjacent to the control centres for the spinal nerves in the brainstem, the "central apparatus" identified by Magnus.

Once it is recognised how the efficient regulation of posture as well as the performance of the exteroceptive organs, the eyes and ears, and other areas of the neuromusculature, depend on a properly working head-neck relationship, the elaborate sub-occipital muscle

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[11] McComas (1996) p48
[12] Jull et al (2008)p60
[13] Williams (1995) p813
[14] Richmond et al (1992)p145

arrangement begins to make sense in a functional as well as an evolutionary perspective. It also fits with the otherwise mysterious spindle-rich character of the sub-occipital muscles and the complexity of their configuration in the critical juncture of the head and the neck.

A common problem

Excessive stiffening of the neck muscles and disruption of the head-neck relationship is more common than usually recognised. Most of the time, people do not realise the extent to which habitual tensions in this area insinuate themselves into their everyday postures and ways of using their bodies. Neither do they recognise the problems it can cause at physical and even a psychological level.

People who spend most of their working lives in front of computers, like the scribes and scholars of earlier times, often sit with their heads thrust forward and chests pulled inwards, a postural configuration that makes it impossible for the head-neck relationship to work properly. They do not realise that the hours in front of the computer are unwittingly being used to practise this posture so that it becomes habitual and they carry it into the rest of their daily activities.

There are many other ways of disrupting the head-neck relationship. "Trying to concentrate", which can begin at a very early age, is one. This is because of the widespread belief that the narrowing of mental focus required in demanding mental or physical work is facilitated by stiffening the neck and tightening the jaws, often accompanied by excessive holding the breath. It is a matter of simple experiment on oneself to demonstrate that the neck-stiffness and breath-holding do not make for clearer thinking or an increased ability to deal with delicate or demanding tasks. Once again, these responses, developed while trying to concentrate, can become habitual, working their way into people's behaviour in daily life.

The ability to walk is an innate capacity in humans, manifesting itself in normal children around the end of their first year. It should be unproblematic but from a surprisingly early age this essentially reflex activity can be distorted in a wide variety of ways depending on the influences to which the developing child and later the adult are subjected. Most of these distortions involved tightening in the head-neck area. They can be seen in the various ways of walking adopted by people as they get older.

The simple balanced walk of a young child gives way to slouching, shuffling, marching with the chest puffed out, "power-walking" with clenched fists, teetering on high heels or whatever other habits people acquire. Such acquired distortions in the natural gait are often so distinctive that people can be recognised by their particular way of walking. Later in life, many pay the price in the hip and knee replacements they need to keep themselves mobile.

Grace and balance in action are not necessarily a guarantee that the body is being used wisely or well. Take the case of classical ballet dancers who must subject themselves to intensive training regimes to reach the levels of performance demanded of them. This same training can cause many of these talented people to distort their normal postural patterns such as the habitual walk with turned-out toes which some ballet dancers develop, nick-named the "ballerina's waddle". The strength and agility, as well as a stoical imperviousness to pain, that characterise dancers and gymnasts enable them to ignore the damage being caused by distortions to their the head-neck relationship. The price for the rigidly held head is often the back problems, spinal operations and early retirement that so many performers have to pay.

People in the large variety of low-paid jobs under poor working conditions are open to a variety of ways of misusing themselves and frequently acquire habits of doing so. In the ordinary working population, back-problems are among the highest causes of work absenteeism. But at the other end of the earnings scale, highly-paid professionals are far from exempt from the risks of damage to the head-neck area and its wider effects. 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” with all the risks of distorting the head-neck relationship that this brings.

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 head-neck relationship with all its wider implications. Nineteenth century ophthalmologists, in fact, commonly associated myopia with distorted posture. John Soelberg Wells (1824-1879) Professor of Ophthalmology at Kings College Hospital, London noting the tendency of myopic people to stoop and stick their head forward, advocated that *“…we should, therefore, always direct myopes to read with the head well thrown back.”*[15]

The American ophthalmic surgeon, E.E. Gibbons, writing at the turn of the 19th century described a contraption in which small children’s heads were strapped to a vertical rod sticking up from the back of their high chair to prevent them looking at things too closely on the table in front of them. [16] Anyone following the advice of these eminent ophthalmologists would certainly interfere with the head-neck relationships of the patients in question trapping them into myopia-related postural distortions and perhaps wondering which was causing which.

A variety of other deleterious effects potentially arising from a mal-functioning head-neck junction can easily be envisaged. One of the most obvious and far-reaching in its impacts is interference with the breathing. Again, some simple self-examination will demonstrate what happens to the breathing when the head-neck junction is deliberately stiffened. Once the regular pattern of tidal breathing is disrupted, a mild form of hyperventilation or over-breathing commonly occurs.

One of the physiological effects of even slight habitual over-breathing is that it increases the amount of carbon dioxide expelled with each breath which reduces the amount of carbon dioxide in the blood and makes it more alkaline. This is brings about a condition known as alkalosis or hypercapnia. One of the effects of alkalosis is that it triggers the classic “fight or flight” symptoms,[17] leading to increased anxiety and in severe cases hand trembling, numbness or tingling in the face or extremities, dizziness and other symptoms.

Rudolph Magnus and the physiological a priori

Rudolph Magnus’ enduring scientific reputation rests on his massive study of animal posture. No one knows where he would have next concentrated his research energies 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’ long-term interest in the philosopher Emmanuel Kant.

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

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[15] Wells (1864)
[16] Gibbons (1904) p468
[17] Lum (1981) 3 This paper has a comprehensive discussion of hyperventilation and its consequences

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.[18]

One of the examples he takes is colour-blindness. He points out that if a person is colour-blind, their perceptions of the outside world, and their responses to events in it, will, of necessity, be different from those of a normal-sighted person. Other examples that might be taken are the way the state of our ears and hearing-apparatus what we hear; or how our sense of taste and smell are distorted when we have a cold or flu. At a more general level, he points out that there is no avoiding the limitations imposed on our perception of the world by the mode of functioning of our sensory systems.

He says:

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.[19]

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

We possess numerous mechanisms acting unconsciously and partly sub-cortically which prepare the work beforehand for our psyche, and the results of which are a priori present before sensory observation and its psychological appreciation start. Since all study, analysis, and understanding of the events in the outer world are conducted through the medium of the senses, a scientific worker surely ought to know what are the fundamental mechanisms of his body and of his nervous system which determine the results of his work.[20]

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. But we do have a huge variety of means of augmenting and expanding the sensory equipment with which we are born. Using the instruments we have developed, we are able to probe from the far reaches of the universe to the inner workings of the cells of the body, transcending the limits of our physiological *a priori.*

But Magnus was making a more subtle, important and contentious point about science and the way we acquire scientific knowledge. While most scientists would be prepared to admit that their day to day perception of the world is indeed affected by their state of health and well-being, few would concede that the observational results of their work, or the conclusions they draw from it, are influenced in any way by the state of functioning of their postural reflexes. Yet this is precisely what Magnus said: our perception of the external world comes to us through the filter of our senses. If we have impaired the

[18] Magnus (1930)97
[19] Ibid.99
[20] Ibid.103

workings of our postural reflexes to an extent that they are not performing their sensory recalibration task effectively, our perceptions will indeed be distorted.

In response to this, scientists would argue that their normal insistence on the reproducibility of results by different researchers goes a considerable way to eliminate the dangers of results being distorted by the *a priori* biases or perceptual deficiencies of individual scientists, from whatever cause these may arise. But the persistence and virulence of disagreement among scientists over the interpretation of the same ostensibly objective data or their ability to hold ferociously to their own views despite what their peers feel is compelling contrary evidence nevertheless suggests that Magnus may have had a valid point. It would indeed be interesting to see how tightly the various parties in such disputes tend to hold their necks when dealing with those who disagree with them.

It is an attractive thought that a nicely balanced and mobile head-neck junction is as necessary for carrying out good science as it is for playing the cello or the flute.

Conclusion

The aim of this paper has been to draw attention to the importance of the proper functioning of the human head-neck junction. Many people do not realise the extent to which their everyday activities are hampered by problems in this area.

Detailed guidance on ways of getting rid of habits that interfere with the proper functioning of the head-neck junction is outside the scope of the present paper but it does provide some guidance on what should not be done when people become aware of pain and stiffness in their neck and shoulders.

The common response is to try to exercise the problems away. Standard gym procedures or commonly-used exercise programmes such as the various forms of Pilates, step-aerobics, power-yoga and others, unless specifically designed and put into practice to avoid increasing tension in the head-neck junction, run the risk of worsening rather than ameliorating health and body-performance. Exercising malfunctioning joints without a very clear idea of their proper working is not a good idea. The basis of any effective therapeutic intervention is an understanding of the importance the head-neck junction, how it works and the necessity of keeping it as freely mobile as possible.

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