SCIENCE AND ALEXANDER

TOWARDS A COMMON UNDERSTANDING

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[DROP CAP] What can science bring to the Alexander Technique? Certainly F.M. Alexander did not need established scientific disciplines to create his profound and insightful body of work; it has survived him and continues to grow. Nonetheless, I believe that science has much to offer the Alexander Technique: documentation of its effectiveness; precise physiological descriptions and explanations; and clarification of its relationship to other disciplines. In this article I relate science to the Technique and describe potential benefits that science can offer.

I believe that public awareness of the Alexander Technique is limited by its continued isolation from established scientific disciplines. The Technique has not developed a widespread recognition as a discipline nor an understanding of its benefits, medical or otherwise. It is certainly not a treatment[,] nor should it solely concern itself with medical conditions, but the number of people it could help is staggering. Take low back pain alone: 30 million Americans have low back pain on which 50 billion dollars is spent annually. Say 80 % of these conditions are use-related and 10 % of these people have the resources to learn and substantially benefit from the Technique. This equates to over two million people in the United States alone. The enormity of this number indicates the lack of general awareness of the efficacy of the Technique.

I think the Technique suffers from the lack of precise descriptions in physiological terms of what it does and why its methodology is effective. Aside from direct experience, I have not seen effective means to communicate what the Technique is[,] nor TO convey its importance to the uninitiated. Most important, of course, is that the Technique works. However, taken together, a lack of physiological descriptors of what happens, a lack of understanding why it works, and an inability to effectively communicate what the Technique is and why it is important constitute a problem, or at least a challenge to establishing widespread credibility. For this exact reason, some physical therapy programs misunderstand and directly dismiss the Technique as invalid. In addition, without an agreed upon physiological understanding, the Alexander community is susceptible to internal fragmentation and disagreement. I believe that current scientific knowledge is sufficient to provide a solid physiological framework for understanding the Technique, which can help address these issues.

In the introduction to the *Use of the Self* John Dewey stated that Alexander's process of observation and discovery resembled the scientific method.1 There is a fundamental difference, however: science is a community process. The establishment of a new scientific finding requires acceptance from a skeptical and sometimes adversarial community through a several-stage process. A new finding is first submitted to a journal and examined anonymously for validity and importance by other scientists with relevant experimental expertise. If published it is available for general discussion and debate and, in particular, open to dispute, replication or extension by other studies. A finding only becomes established if it is generally accepted, not just because it is published. Science does not just seek agreement of its members, but with physical reality; clearly documented findings that contradict established theories are encouraged through increased funding and publicity. Thus, the true state of a field (knowledge and terminology) evolves slowly and represents agreement across many independent laboratories.

Although Alexander used careful observation and experimentation, he developed an entity unique in scope, vocabulary and procedure in relative isolation, independent of a critical community of peers. In fact, Alexander was resistant to independent scientific inquiry into his work. Dewey wrote to Frank Pierce Jones that a scientific investigation was something that Alexander "was never able to undertake because of early obstinate prejudices."2. Thus, the development of the Alexander Technique was not a scientific process. Science is conservative, not privy to introspection, and, despite its checks and balances, can get stuck in established paradigms. It would be difficult for something so novel and introspective to develop within the confines of science. The independent development of the Technique speaks to Alexander's ingenuity and spirit.

Some of the Technique's credibility has been generated through endorsements by established individuals (e.g. Dewey, Huxley, Tinbergen). In his books Alexander listed “medical men” who approved his Technique. Endorsements, however effective with the public, do not establish acceptance within scientific or medical communities. To illustrate this take Nikolaas Tinbergen[,] who won the Nobel Prize in Medicine for the study of animal behaviour. In his

Nobel Oration Tinbergen used the Alexander Technique as a primary example to illustrate that behavioural approaches have medical relevance. Alexander Teachers often quote his speech to demonstrate scientific backing of the Technique. In fact, the response of the scientific community to this speech was quite the opposite. A close colleague of Tinbergen's stated the he and many others were not persuaded by this speech and thought that Tinbergen's mention of the Alexander Technique was a mistake. Thus, even the opinion of the recipient of the most prestigious prize in science didn't sway other scientists. For better or worse, science must be influenced through its own methodology.

The criticism that scientists can lack practical knowledge of what they study does not invalidate their results nor the power of science's approach. I can assure you that people who study posture and movement do not necessarily demonstrate good posture themselves. It is extremely unfortunate that science does not cultivate practical first-hand understanding; it slows its progress and limits its practical application. However, that scientists can lack practical experience means merely that you as teachers have much to teach them, not that their findings are wrong.

I think science can provide two major contributions to the Alexander Technique in the near and more distant future. First, studies have the potential to demonstrate the benefits of and provide evidence for the effectiveness of the Technique. Second, science can provide a physiological framework that includes precise language, physiological descriptions and explanations of its methodology that can help to define the Technique and establish its relationship to other disciplines.

DIRECT STUDIES OF THE ALEXANDER TECHNIQUE

To date there have been a number of scientific investigations into the Alexander Technique, some with sound methodology. However, taken together these studies do not form a conclusive body of work. Real scientific and medical support cannot be built from isolated experimental instances, but requires a thorough deliberate body of evidence that convincingly argues efficacy and importance. Synthesis between different studies as well as with the existing physiological literature is essential to create a case. The work of Frank Pierce Jones forms the most cohesive series of studies that argue for the Technique. In my opinion, his work did not make a lasting impact on science because of prior limitations in both technology and the state of scientific understanding[,] in addition to the difficulty in measuring the Technique and Jones' short life as a scientist. He has provided an admirable start.

The Alexander community can facilitate research by identifying measurable quantities that change as the result of lessons. This would also help to define and clarify the Technique. Measurements need not be sophisticated nor technologically based; they can include quantities such as someone's height or their self-report of pain. Measurements must have two qualities: repeatability and validity. To be repeatable measurements must agree between observations from a single person and from one person to the next; to be valid measurements must reflect the quality that is desired to be measured.

Measurements can be made at different levels of specificity[,] ranging from outcomes, which measure the severity of a relevant medical condition or the level of performance on a task[,]3 to more direct measurements of specific physiological parameters like the activity of a single muscle. Measuring an outcome over the course of lessons is straightforward; a condition's severity or subject's ability can give an implicit measurement of improvement and a clear demonstration of importance. Unfortunately, it is hard to avoid biases from the experimenter or the methodology which can limit the credibility and influence of outcome studies. Regardless, it is important to perform carefully controlled outcome studies on the Alexander Technique.

More direct measurements of use have a greater potential to explain the Technique than outcome studies but are difficult to perform, and it is hard to demonstrate the relevance of any specific measurement. Kinetic, physiological, or psychological qualities can all be used. However, use is extremely elusive; it may be easy to perceive differences through your hands but it is difficult to appreciate the sophistication of these perceptions. I cannot overstate the difficulties involved in making well-controlled measurements of use. First, it is difficult to find ways to measure use that are not influenced by arbitrary qualities. For instance, the activity of neck muscles is related to the exact position and acceleration of the head as well as the degree of neck stiffening: looking up with a free neck can produce more muscular activity than looking straight ahead and stiffening. Thus, the activity of neck muscles alone is not a valid measurement of neck freedom. Second, it is difficult to measure the condition of the whole. Although use is an integrated phenomenon reflecting the overall coordination of many body parts, most measurements are specific to a given part and reveal little about the whole. It will be challenging to find a single, or even several, measurable quantities that reflect the integrated whole. Austin and Ausubel provide an elegant example: they measured lung capacity by recording maximal air flow and pressure, which depend on overall thoracic mobility and not just the activity of a particular muscle or muscle group (not surprisingly, lung capacity increased during lessons).4 Finally, measured quantities must not be arbitrary in light of current scientific understanding. It would be largely ineffectual to argue that a forward and up head motion is optimal and not just an arbitrary way of moving. To demonstrate relevance, a quantity must accompany something unequivocally important, for example, increased lung capacity, efficient movement or reduced stiffness.

A promising direction in future research will be to measure axial (spinal) coordination: the freedom of the atlanto-occipital joint, the integrity and coherence in the coordination of the spine and the concomitant reduction in axial stiffness. These qualities do not emerge solely from the Alexander Technique but are present in outstanding athletes and dancers and I believe demonstrably underlie efficient movement and coordination in general.

GENERAL PHYSIOLOGICAL BACKGROUND

*"The majesty of a scientist can be measured by the number of years their *** work suppresses new ideas."*

Victor Gurfinkel

It has taken almost one hundred years since Sherrington championed the existence and importance of reflexes for science to accept that reflexes play only a limited role in our coordination. Movement and balance are extremely complex tasks. Previous hypotheses that our movement was based on reflexes did not appreciate the complexity of these tasks nor of our coordination. Although they do exist, it is now clear that reflexes are far too simple to form the basis for our coordination. Similarly, explanations of the Alexander Technique should appreciate the complexity and adeptness of our coordination.

Because an animal's coordination was too complex and variable for controlled study, Sherrington (and Magnus) removed much of an animal's brain (including the entire cerebral cortex) before subjecting it to study. Not surprisingly, the coordination of such decerebrate animals was very simple and repeatable, and hence subject to experimental investigation. They believed that these simple movements in less-than-whole animals reflected the fundamental building blocks of complex coordination and not the pathological by-products of surgery. The term reflex was first defined to capture the directness and simplicity in coordination they observed. Sherrington defined a reflex very specifically: a direct anatomical connection between a sensory receptor and muscle. Thus, in a reflex, the strength of a muscle contraction simply mirrors the activity in sensory receptors.5 Complex coordination was thought to emerge through chains of reflexes that appropriately trigger one-another. Although reflexes do indeed exist (for example, a knee-jerk is a reflex), we now know that the premise of Sherrington and Magnus is wrong; reflexes are not the building blocks of our coordination.6 Many experiments have shown that our automatic reactions can differ tremendously depending on our intentions and expectations and the exact context. For this precise reason they are not reflexes. The "postural reflex" that keeps us upright does not exist.7

Moving about the world is too complicated for reflexes to underlie our coordination. Not only are there numerous interdependencies among the movement of body parts (for an arm alone, the equations relating the forces at each joint to the motion of the arm are several pages long), but to be successful our coordination must take into account knowledge about each specific situation. For example, balancing on a slippery floor vs. a sticky floor require different modes of coordination. The coordination of movement and balance is so challenging that it still eludes the entire field of robotics; robots can be programmed to carry out particular tasks but do not perform well in novel situations. Because we balance and move throughout the world so adeptly (our use may be terrible but we don't often fall), we are unaware of the difficulties we face and the sophistication of what we do.

Various explanations have been put forth to explain the Alexander Technique that are not consistent with either experimental findings or physical laws. Wrong explanations can be detrimental, especially if they influence one's ideas. One example of an erroneous explanation is that a gravity induced forward tilt of the head triggers a reflex that generates appropriate tone in spinal musculature. This cannot be true: to stabilise the spine, the selection of appropriate muscles, their individual forces and the relative timing of their contractions depends on the situation. Consider, for example, a gymnast performing a flip. The force that gravity applies to the head and the forces generated from spinning are complex and continuously changing. The forward tilt of the head with respect to the spine simply doesn't provide the information necessary to determine the tone required for the movement. Additionally, if you stand leaning backwards and look upwards, gravity will pull your head backwards with respect to the spine, not forwards, yet an appropriate tone of back and neck muscles is still necessary. Thus, not only is this explanation too simplistic to explain our capabilities, it is dangerous because it could instill an idea to limit head movement.

Explanations of the Alexander Technique must make sense from an evolutionary perspective. Our physiological mechanisms have evolved precisely because they are effective and adaptive, not arbitrary. They are extremely precise; even slight neurological changes, say due to stroke, have devastating functional consequences. A theory of the Technique should explain why the mechanisms that underlie use are both adaptive and also maladaptive, often deteriorating with age. A current theory in stress research illustrates how maladaptive responses can be understood from an evolutionary perspective. On the surface, symptoms of stress seem useless: people get high blood pressure, ulcers, immune system suppression, reproductive dysfunction and in extreme cases, stunted growth. Why would these responses have evolved? How could they possibly be adaptive? Consider the following perspective. Say you are in a field being chased by a lion. Your first priority is to immediately mobilise as much energy to your muscles as possible to facilitate your escape. To do this your body speeds up your heart rate and shuts down metabolically costly processes that are not particularly useful in the short term such as digestion, your immune system, reproduction, and growth (these processes are especially not useful if caught by the lion). In this situation the stress responses make sense because they facilitate your escape.8

Although evading a predator was common during the course of evolution, as a result of civilization the overall character of situations that cause distress has changed. Modern stressors typically are not physical and are often anticipated and prolonged (like the possibility of losing a job). Turning on the stress responses in this case is maladaptive. The long-term suppression of metabolic processes such as digestion is harmful and leads to the aforementioned diseases. Thus, stress is a perfectly adaptive response to impending physical disaster and is only maladaptive because we invoke it inappropriately. Similarly, explanations for the Alexander Technique should explain why our mechanisms of coordination and response are adaptive, and where and why they are not.

PHYSIOLOGICAL FRAMEWORK FOR THE TECHNIQUE

As science's understanding of our coordination has grown, its ability to explain the Alexander Technique has increased. There are many findings from a variety of fields that are relevant.

Because the brain processes information slowly in comparison to the demands of the world and has a limited ability to consciously process events, it relies upon many automatic mechanisms to speed our reactions and free our attention from the details of our coordination. Automation is truly important: people with damage to brain regions that automate movement have to constantly be aware of every aspect of their coordination. Not only are they limited in their capability to move, but they can't do much else (like carry on a conversation while walking) because they must pay attention to so many details such as where to place their feet and the texture of the floor. By the end of the day these people are extremely fatigued.

The brain's automatic systems must be sophisticated enough to produce the complexity and diversity required of our coordination. As described above, not only is the task of balance complex but its requirements differ significantly among situations. Many processes are involved in the automation of our coordination. In the following sections I describe three of these: knowledge (internal representation), expectations (*set*), and attention, and relate them to the Alexander Technique.

Knowledge (Internal Representation)

The brain utilises physical knowledge of the world to coordinate movement. Many experiments have demonstrated that different movements are not learned separately. The brain does not store a long list of motor programs and simply call the appropriate one at the appropriate time, but instead makes generalisations to form knowledge, which it then applies to many different motor programs. This knowledge includes a characterization of how our bodies move: the size and weight of its parts, the locations and allowed motion of joints, how sensory information relates to movement, and so on. This integrative framework is called the brain's internal representation (or internal model) of the body and allows us to make novel movements at will because at some level we understand our body’s layout and the physics of its movement. For example, a person can write on a small piece of paper or on a large chalkboard. These two tasks use different joints and muscles yet they share a common motor program; your handwriting is similar whether you use your fingers or arm (not just the appearance of the letters, but even the relative accelerations of the pencil and chalk are similar). Thus, the brain has a single representation of the desired movement trajectory and uses the internal representation of the hand or the arm, respectively, to coordinate the movement, rather than learning and storing completely separate programs for each task.

In addition to its use in controlling movement, the brain's internal representation of the body is used to interpret sensory information and generate our perceptions. Our perceptions are not a direct awareness of sensory receptors, but are themselves the result of a complex synthesis that extracts higher-level meaning from raw receptor activity. A movement can potentially trigger different types of sensory receptors located all over the body, yet we have a single perception of the sensation and its relevance. While the distribution of pressure under the soles of the feet is used to maintain balance, determining the meaning of a particular distribution of pressure requires knowing the foot's location with respect to the body (whether it is in front or back of the body or, turned out or in, etc.). Depending on position, a particular distribution of pressure has a different interpretation and a different implication for balance. For instance, if your feet are pointed straight ahead, increased pressure on the ball of your left foot means that you are swaying forward. On the other hand, if your left foot is rotated externally, the same pressure means that you are swaying to the left. This example seems simple because consciously it is obvious which direction we are swaying; it is our internal model of the body that allows this perception to be obvious.

Expectations (*Set*)

Expectations are automatically used to select and shape our coordination. When you step off a curb or sit down in a chair, your brain generates an expectation of their height which it uses to control the movement. Expectations of this form are called "*Set*" and are used in formulating and triggering preset action plans, in light of a specific situation. Our conscious awareness automatically informs our *set* and shapes our movement. Expectations need not be conscious, though, as the brain also subconsciously generates and uses expectations. Experiments have shown that our *set* influences our actions in general, even on cognitive tasks, and not just our movement.

The use of expectations in the form of *set* is fundamental to our coordination, especially in motor tasks when there is limited time to react. For instance, standing on a slippery surface, a regular floor, or a thin ledge each require key differences in coordination. Knowledge of which surface you are standing on changes your *set* which automatically implements the appropriate balance strategy. As another example, consider that you are standing on a bus holding onto a handle. If the bus suddenly swerves, muscles in your arm will quickly and automatically contract to stabilize you. This is not a reflex because, in the exact same situation, if you expect that the handle is not securely fastened you change your *set* and your arm muscles are automatically not used. Expectations are important in our coordination; people with disorders that impair their ability to use *set* have significant balance problems.

Learning

Because our internal representation and expectations are learned, they can incorporate inaccuracies that influence our movement and perceptions. It is important that internal representations adapt as they must accommodate changes in our bodies due to growth. Learning is also important because we generate internal representations of external objects in order to manipulate them. Dancing in that new pair of platform shoes may be difficult at first but soon becomes easier as you understand how their height and weight affect your leg movement. Although adaptation is important, exposure to a limited variety of movements can cause us to learn errors in our internal representation. Slouching over a desk every day could perhaps alter the perceived location and range of one's atlanto-occipital joint. Problems can especially result when this “faulty” knowledge is then used to control movement in other situations such as the coordination of the neck in general. Such errors in internal representation could cascade; errors in the internal representation of the hip joint could produce poor control of movements, like squatting or walking down stairs, which could lead to excessive stabilisation and muscular co-contraction.

Although expectations are important in controlling movement, they can be limiting by precluding the use of current information. For example, when picking up a box with the mistaken expectation that it’s heavy, our brains plan more co-contraction and[,] without sufficient attention, use it when lifting the box. Studies have shown that although our preconceived expectations can speed the performance of tasks, they can also limit our ability to choose an appropriate solution.

Attention

Attention can affect many aspects of movement by bringing the high-level mechanisms of conscious monitoring and control to an action. Even well-learned tasks can be modified in the moment through conscious attention. Consider, for instance, a baseball player who tailors a highly practiced swing according to each particular pitch. The less we attend to something the more it is performed automatically, with limited conscious control. As in the above example of lifting a box, performing a task without awareness necessarily invokes programs based on past experience rather than interacting in the present. Even slightly limiting awareness by neglecting a body part and fixing it can place mechanical demands on the rest of the body and impair overall coordination.

Many experiments have examined attention and how it can be expanded, selectively controlled, and focused. Attention is thought to have evolved as a mechanism to allocate limited high level brain resources to important aspects of a situation. Separate brain systems exist for different types of attention: one for monitoring events and another for focally engaging conscious processing.

The monitoring attentional system selects which senses are monitored and the extent that attention is narrowed or widened (e.g. to include just centralised vision or the whole peripheral visual field). This system can also selectively highlight information based on the properties we choose allowing us to easily pick out red marks on a page or listen for a name in a crowded room.

The focal attentional system directs conscious processing of high priority events. This system engages when something "catches your eye"[,] like when a brick flies directly at you. The focal system is used to orient to external events but also can be directed inward, for instance to selectively examine the sensation from part of the body or to visualise memories. Focal awareness engages automatically in response to stimuli in accordance with their perceived relevance and urgency. The focal system need not always be activated. It can be disengaged at will (as during meditation). This disengagement corresponds to the sensation of being "empty headed" and can facilitate the perception of subtle thoughts or events.

The two aforementioned attentional systems differ in the amount of information that each can process simultaneously. The focal attentional system is limited in this capacity; selectively focusing on one task degrades the performance of others. Determining the square root of 482 while debating about the definition of the Alexander Technique is difficult. Although we can focally attend to only few events concurrently, we can monitor many events without interference. It is easy to look for check marks on a page while listening to music.

Relationship to the Technique

The above concepts provide a beneficial scientific framework for the Alexander Technique. Like the stress responses, the automatic mechanisms behind our coordination are purposeful and important, but due to lifestyle changes, they can be maladaptive. Our priorities have changed: focal events are extremely important in modern life; we spend our time in static postures without awareness. By not monitoring what we are doing we relinquish control to our automatic subsystems which affects both what they do and what they learn. This degrades our coordination and limits our conscious awareness, control and choice.

In *Man's Supreme Inheritance* Alexander observed that the mind and body are at some level indivisible.9 This is now established: knowledge and expectations automatically affect action. Changing habits to produce more efficient coordination requires addressing its underlying mechanisms which depend on our ideas. This is a fundamental insight of the Technique: it is essential to notice our knowledge and expectations and change them to reflect actuality. This is markedly different from using one's existing ideas to simply perform different movements.

It is well-established that our sensory experience is not absolute; the information we perceive has been highly processed before entering our awareness. Our brain often excludes what we expect from our perceptions, making the unexpected stand out but obscuring our perception of things that happen consistently, like one's patterns of muscular holding. Our perceptions also depend on our knowledge. It is of particular relevance to the Technique that our internal representation is used to interpret sensory information. Learned inaccuracies can cause illusory or "faulty" perceptions; the man who has misrepresented his atlanto-occipital joint in his internal representation will not accurately interpret sensory information and not realise that he is "back and down". Additionally, recent experiments suggest that the brain forms an internal representation of vertical that can be subject to inaccuracies.

In my opinion Alexander used the term "inhibition" to refer to at least two separate but related physiological processes: (1) stopping the triggering of an automatic process and (2) stopping focal attention from automatically engaging to a stimulus. Studies have demonstrated both of these processes. First, experiments have shown that the automatic triggering of reactions based on one's *set* can be stopped just before action, i.e. inhibiting a habitual response. Secondly, attention is known to be under considerable volitional control; we need not focally attend to stimuli that jump out at us. Alexander warned against concentration and the fixing of gaze[,] which are hallmarks of focal attention. Perhaps it is important to not engage the focal attentional system to the exclusion of monitoring ourselves and our environment. Stopping has been described as being an important part of the Technique. Stopping the focal attentional system helps us notice the expectations and preconceptions that shape our actions and reactions.

As the brain structures that produce our coordination become better understood, there will likely be increased insight into the processes themselves. It might be relevant to the Technique that areas in the parietal cortex participate in generating both the spatial awareness of ourselves and extra-personal space and are involved in our internal representation of our body. In addition, there is evidence that hand dystonias result from an altered internal representation of the hand (hand dystonia is an inability to coordinate fingers independently that results from focused attention and repetitive use of the hand; these are officially untreatable but have been overcome through Alexander lessons). Recordings from primary sensory cortex in subjects with hand dystonias have had abnormally undifferentiated internal hand representations with overlapping representations of different fingers 10

Another brain area, the basal ganglia, is involved in *set*: this structure subconsciously generates associations, recognises contexts, and learns and triggers action sequences. The basal ganglia learn automatically through an algorithm called reinforcement learning which operates by recognising and predicting successful outcomes (yes, it is probably involved in the feeling that something is done "right"). Damage to the basal ganglia results in an impaired ability to subconsciously learn and use expectations. This produces some of the movement and balance problems in Parkinson's and Huntington's diseases, and can also cause habit-related behaviour such as addiction and obsessive compulsive disorder. Incidentally, the most common protocol used to study this brain system is called the "go/no-go" task, which has been designed to study the forming of expectations, the pre-planning of actions, and the abandoning of them. This task consists of presenting one or more stimuli to a subject who is instructed to not respond; eventually a cue is presented to indicate the appropriate response, or whether to not respond at all (sound familiar?).

The mechanisms of coordination discussed so far are learned and flexible, not innate. Innate mechanisms are involved in our coordination and include circuits that generate the basic patterns of muscular activity for walking, chewing, breathing, sneesing and so on. There are also innate reactions, some of which involve the neck. These include the Landau reaction, the asymmetric tonic neck reaction and various righting reactions, which are present in the first few months of life. Many of these innate reactions (like the first two above) are only seen early in life, but may last were there is brain damage, such as IN cerebral palsy. It is unclear what the existence of such infantile or damage-induced movement patterns implies about coordination in healthy adults and why they disappear in childhood. Other reactions, like some righting reactions, are thought to play a role in our coordination as adults. Although innate, they are flexible, never absolute or obligatory and, hence, although they are sometimes referred to in this way, not reflexes. When present, they are integrated into the overall scheme of our coordination.

Mechanical factors are relevant to the Technique. Whatever the mechanisms of our coordination, they are applied to a very specific structure with its own dynamics: our musculo-skeletal structure. Our core structure is itself unstable; without active muscular stabilization our spine and its connective tissue will collapse under the body's own weight. Unfortunately, it is difficult to measure and describe patterns of muscular activity in the back and neck that keep us from collapsing[,] as this involves hundreds of deep muscles with intricate mechanical relationships. Because many back muscles are deep, recording their activity requires inserting needle electrodes into them (a separate electrode for each muscle). Needless to say, science has much still to learn about spinal coordination. It is difficult to use theoretical approaches to determine optimal patterns of muscular activity due to the large number of muscles involved. Muscles do not act in isolation; the contraction of any one muscle affects the requirements of many others. Regardless, the mechanical underpinnings of the Technique make good physical sense: releasing neck and back musculature to lengthen and widen the torso, bringing the head into alignment with the spine and freeing it about its upper-most joints, freeing the limb musculature from the torso. Especially, I think that the resultant reduced stiffness and the springiness of the spine are arguably very important. Hopefully, through both theoretical and experimental approaches it will be possible to demonstrate (other than through first-hand experience) the efficiency of the coherent and integrated pattern of coordination that can be learned through the Technique.

The question remains: Why are the head and neck so important? The head and neck have unique and important functions, are physically vulnerable, and are mechanically influential. There are several possibilities: (1) The most striking feature of the head and neck is that together they form the platform for the visual and vestibular (inner ear) systems which are important for balance. (2) Vision requires head stability. Because even slight motion blurs vision, there are multiple circuits in the brain, some involving the neck, that help to stabilise head and eye position. (3) The neck plays an important sensory role in balance. Some neck muscles have high numbers of stretch receptors in order to determine the position between the head (i.e. the visual and vestibular systems) and the rest of the body. The absence of this information can severely impair balance and result in vertigo. (4) The neck plays a protective role. The neck is a vulnerable part of the body because it contains the spinal cord, is very mobile, and relatively unprotected. Consider shaking someone who is asleep; without stabilisation, their head flops all around. To prevent injury it is important to stabilise the head and neck. (5) From a mechanical perspective the head and neck are influential because of their mobility and their position on top of the core of our skeletal structure.

The control of the neck is complex and currently not well understood. It is easy to jump to conclusions about the relevance of this or that particular neck reaction to the Technique, however, in my opinion this is somewhat reckless. Consider the righting reactions described by Magnus in decerebrate animals and the innate neck reactions of infants.11 Without doubt, if residuals of these reactions do actually exist in healthy adults, they are not stereotyped or isolated but integrated into a much larger context. For instance, neck influences can be modified by tricking someone's perception of their neck position. In this case, their reactions agree with their illusory perception and not the actual position of their neck. Thus, simple hardwired circuits do not control the neck. Certainty the head and neck are important, but it is not yet clear how scientific understanding of their control relates to the Technique.

CONCLUSIONS

Because Alexander developed the Technique in relative isolation, he was able to create something unique and special that likely could not have evolved from within conventional academic disciplines. However, the Technique's continued isolation is detrimental. Scientific studies have the potential to quantify changes that result from lessons and to demonstrate the effectiveness of the technique, thereby enhancing its credibility. I think science's greater contribution will be to bring physiological description and understanding to the Technique. There are a number of findings from other fields that are relevant; the above exposition is only a sampling of what is pertinent. Although science doesn't hold all answers, the numerous connections that exist between science and the Alexander Technique should be made explicit.

An effective means to integrate a scientific perspective into the Technique would be through the teacher training programs. This could be done without compromising the identity or uniqueness of the Technique. I don't see this as a particularly difficult task as there is not an overwhelming amount of information to relate, and the framework for this knowledge has already been created with clear examples through the Technique itself.

Science could ensure that the Alexander Technique is identified by the physiological or behavioural phenomenon of use itself and not by the set of procedures that are used. It is difficult to communicate the function and value of a field that is defined by its procedures, especially to the uninitiated or the skeptical. In addition, procedural definitions make a field subject to internal conflicts, for instance, in the definition of the field itself or between teaching styles. Defining the Technique based on the phenomenon of use does not in any way mean diluting it, but only that the process of the study of use, conscious control, and how to teach it is paramount, rather than a fixed set of procedures for doing so. I believe without doubt that F.M. Alexander was interested in the underlying process of use, and not a fixed set of procedures.

Could the Technique evolve in response to science? I would be surprised if any single experimental finding in isolation could provide enough insight to significantly benefit the Technique. Nonetheless, I believe that the overall physiological understanding resulting from many studies could increase the understanding of what the Technique changes and why it is effective, which could deepen insight into and help to communicate the Technique. Whether the Alexander Technique could evolve in response depends on two things: (1) a level of scientific understanding that is sufficient to offer additional insight; and (2) whether it is defined by the study of use rather than by the procedures themselves. *There is no substitute for what works.* The following comma-rich quote from Alexander applies nowhere better than to the future of his Technique: "What is required is not prejudice in either direction, but a calm, clear, open-eyed intelligence, a ready, adaptive outlook, an outlook, believe me, which does not connote indefiniteness of purpose or uncertainty of initiative."12 The future of the Alexander Technique should be approached using its own principles: without preconceptions, with a broad awareness, and with deliberate, conscious choice.

[6807 words including notes] & bio 100 = 6907

ENDNOTES

1. F.M Alexander *The Use of the Self* Methuen, London (1932) pp. xviii-xxi.

2. F.P. Jones *Freedom to Change* Mouritz, :London (1997) pp. 105.

3. For an example of A balance task see the article by R. Dennis "Functional reach improvement in normal older women after Alexander Technique instruction" *Journal of Gerontology* Vol. 54A (1) (1999) M8-M11.).

4. J.H. Austin and P. Ausubel "Enhanced respiratory muscular function in normal adults after lessons in proprioceptive musculoskeletal education without exercises" *Chest* 102(2): (1992) pp. 486-90.

5. In the current scientific literature the term "reflex" is TYPICALLY used to refer only to "spinal" reflexes[,] like the stretch reflex[,] that are very stereotyped and have specific neuronal pathways that traverse only the spinal cord. Occasionally the term reflex is used to refer to automatic reactions that are much more variable and are produced by much higher levels in the brain. In this case terms like "functional reflex" or "trans-cortical reflex" are sometimes used to indicate that these more complicated reactions are not reflexes in the Sherringtonion sense. In this paper I use the term reflex to mean only "spinal reflex". The terms "functional reflex" or "trans-cortical reflex" are equivalent to the automatic *set*-dependent [NOTE ITAL ADDED FOR CONSISTANCY] reactions discussed IN THIS ARTICLE.

6. T.D.M. Roberts "Reflexes Habits and Skills" *Direction* [I DON'T HAVE DATE/ISSUE/PP's].

7. For clarity I have simplified the situation[,] but the essence of the argument holds. Spinal reflexes can actually be modified somewhat according to context. For instance, the strength of a knee jerk reflex is affected by how much weight is placed on the leg. However, reflexes cannot be modified nearly as much as our reactions in general (see the section on *set* [NOTE ITAL ADDED FOR CONSISTANCY] IN THIS ARTICLE). Reflexes are a part of our coordination but they often comprise only a minor part of our reactions. Resistance to passive movement encountered during lessons is not due to reflex activity. The stretch reflex occurs only in response to high velocities of movement (try evoking a knee jerk reflex by slowly pressing on a tendon), occurs shortly after the perturbation (approximately 50 milliseconds) and only lasts for an extremely short duration. It has been clearly shown that reflexes are not sufficient for our balance; animals with their reflexes fully intact but lacking higher brain centers cannot stand.
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8. This example is taken from R. Sapolsky *Why Zebras Don't Get Ulcers* W.H. Freeman & Co. New York (1994).

9. F.M. Alexander *Man's Supreme Inheritance* Chaterson,, London (1946) pp. 7-25,127.

10 F. Lenz and N. Byl. "A primate genesis model of focal dystonia and repetitive strain injury: I. Learning-induced dedifferentiation of the representation of the hand in the primary somatosensory cortex in adult monkeys." *Neurology* 47 (1996) pp.508-520.

11. Consider the righting reactions described by Magnus in decerebrate animals and the innate neck reactions of infants. R. Magnus "Some Results of studies in the physiology of posture" *The Lancet* (1926) pp.531-536; 585-588.

12. F.M. Alexander *Man's Supreme Inheritance* Chaterson,, London (1946) pp. 59.