Developing Habitual Patterns

Learning becomes the greatest and, indeed, the unique feature distinguishing man from the rest of the living universe.

-Moshe Feldenkrais

A newborn comes into the world and is immediately overwhelmed by new sensations. The chill of the air, the warmth of his mother's touch, and the roughness of a blanket against his skin. This world is vastly different than his mother's womb. Now there is constant stimulation and seemingly no limit to the space around him.

Not yet able to crawl or walk, the infant explores with his eyes and ears. He recognizes faces and voices, and soon begins to interact by babbling and mimicking facial expressions. Around four months, his brain has developed some ability to gauge where objects are in space. With his newfound depth perception, he begins to reach and grab for anything in his field of vision that seems interesting.

The infant's desire to move toward objects that he can now see, combined with an innate desire to be upright in gravity, motivates him to lift his head off the ground. The muscles in the back of his neck contract, and around five or six months the muscles in his lower back begin to contract as well. Now he can move! Gaining control of the extensor muscles of his neck and back allow the infant to crawl, sit and stand.

At this young age, the little boy is already developing learned movement habits; the motor learning process is constantly at work in his nervous system. It begins with experimentation. Each time he tries to climb the stairs he makes conscious, deliberate choices about how to move his arms and legs, and when something works, he repeats it. Soon he has developed a pattern that works every time: he puts his left hand up on the second step, then his right knee on the first step, then his right hand on the second step, and finally his left foot on the first step. He presses his left foot downward, pushing himself up toward the next step, and then starts the pattern again. With each repetition, the movement pattern becomes more deeply learned. Soon the boy can climb the stairs quickly and easily, with little conscious effort. While the movement pattern that he created and taught himself has become so automatic that it seems to be innate, we know that this is anything but the case.

At birth, the size of the boy's brain was around twelve ounces, only a quarter of what it will weigh when he is fully grown. In contrast, most mammals are born with brains that are already ninety percent of their adult weight. Within weeks or for some, just a few hours after birth, these animals know how to walk and communicate with their species, and they rely largely on “hardwired” reflexes and instincts for their entire lives. As a general rule, the smaller an animal's brain is at birth compared to its adult brain weight, the greater capacity it has to learn and make conscious choices. Chimpanzees' brains are roughly half their adult size at birth, and bottlenose dolphins are a bit smarter, born with forty-two percent of their adult brain weight. Elephants are born with just thirty-five percent of their adult brain weight, giving them an incredible capacity to learn. Like humans, elephants go through a learning period of about ten years before they are considered to be fully mature.

Motor learning is a fundamental part of our problem of chronic pain. Our learned motor patterns, when they are unnatural and maladaptive, are the primary cause of chronic musculoskeletal pain and physical degeneration. But before we dive into the details of how we develop learned motor patterns, let's talk about what compels us to move in the first place.

How We Sense

Movement begins as sensation. We sense that there is dust in our nostrils and reflexively sneeze. We feel hunger and decide to get up and make a sandwich. Even voluntary movement unrelated to what we feel in our bodies, such as the decision to get out of bed and get ready for work, is dependent upon sensation to determine the way that we move; we must be able to sense our body position and detect where objects in our environment are in relation to us. There is a constant feedback loop between the sensory and motor nerves. First we sense what we feel in our body, where we are in space and what is happening in our environment, and then we react accordingly.

Some sensory nerves have specialized receptors called nociceptors, which receive information that gets processed into the sensation of pain. There are many other types of nerve endings which receive different sensory information, like that relating to what we see, hear, smell, taste and touch in our external environment, as well as what we sense in our internal environment about our body position, relationship to gravity, and temperature. Some sensory nerves send information to the brain, where it is processed and translated into something meaningful to which we then respond. Other sensory nerves synapse in the spinal cord or brain stem, triggering automatic reflexes like sneezes and postural corrections. Three sensory systems in particular—the visual, vestibular and proprioceptive—play very important roles in determining our movement and posture.

In the eye alone there are over one hundred million photoreceptors, known as rods, cones and ganglion cells, which take in light information. These photoreceptors make up the retina, a layer of tissue which lines the inner surface of the eye. The retina processes light information and sends it via the optic nerve to the brain. Various parts of the brain then use this information to create our perceptions of depth, movement, shape and color, as well as to control our daily sleep and waking cycle.

Our vestibular system, responsible for maintaining our sense of balance, gets information about the movement of the head entirely from its internal environment—the movement of its own hair cells. Within the inner ear is a structure called the vestibular labyrinth, which is made up of the semicircular canals and the otolith organs. When we turn our head, fluid in the semicircular canals moves hair cells located within the canals, and vestibular receptors connected to the hair cells relay information to the brain about how fast and in what direction we're turning. When we move forward or backward, hair cells in the otolith organs are moved, giving vestibular receptors information about our acceleration and deceleration. We process vestibular sensation mainly at a subconscious level, automatically adjusting our head and body position to remain balanced. We are typically unaware of our vestibular system unless it is not functioning normally, such as in the condition of vertigo, or when it is forced to deal with conflicting sources of visual and vestibular information, such as occurs with motion sickness.

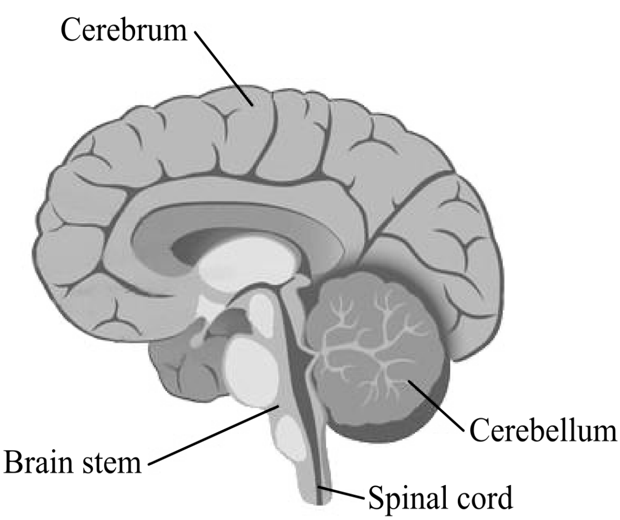
Working in tandem with the visual and vestibular systems is the proprioceptive system. Proprioceptors are sensory receptors located in muscles and joints which detect changes in muscle length and in the angle and movement of our joints. Muscle spindles, which sense changes in muscle length, and Golgi tendon organs, which sense the amount of contraction in a muscle, are two examples of proprioceptors. Having an accurate sense of proprioception is critical to maintaining healthy posture, relaxed muscles, and natural, efficient movement patterns. Our brain seamlessly blends information from our visual and vestibular systems with information from our proprioceptive system to give us a sense of balance, body position, and how we are moving through space.

Along with proprioception, the sensations of pain, touch and temperature are known as the somatic senses. Like proprioceptors and nociceptors, nerve endings which sense touch and temperature are spread throughout the body. Mechanoreceptors, which can sense bending and stretching by stimuli as small as .006 mm high and .04 mm wide, detect touch and pressure in the skin, heart, blood vessels, bladder, digestive organs and teeth. Specialized mechanoreceptors work with the brain to perceive variations in types of touch and pressure, allowing us to feel the differences between pressing, pricking, stroking, vibrating, tickling, and scratching. Our thermoreceptors are incredibly sensitive as well, able to detect a change in temperature on the skin of just .01 degree Celcius. When pressure is strong enough or temperature is hot or cold enough to potentially cause damage, our nociceptors are stimulated, and we feel pain.

How We Move

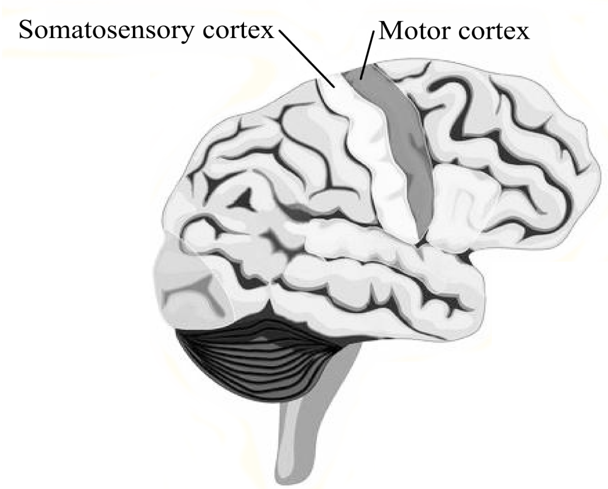
All parts of the nervous system, from the brain to the spinal cord to the peripheral nerves, are involved in motor control. Let's start at the top.

The largest part of the brain is the *cerebrum*, and it is responsible for voluntary action and conscious thought. The *cerebral cortex*, often referred to as simply the cortex, is the outer layer of the cerebrum. Its gray matter is made up mainly of cell bodies, glial cells and capillaries. All areas of the brain located beneath the cortex can be referred to as *subcortical*. One of these subcortical structures is the *cerebellum*, which is responsible for organizing our movement patterns. The *brain stem* extends downward, relaying information between the brain and the spinal cord. The brain stem also controls processes that are most vital to life, including breathing, heart rate, consciousness and body temperature.



Each part of the brain plays a different role in controlling our movement. The cerebrum is responsible for strategy of movement; it is the “big picture” guy. The cerebellum is responsible for tactics; it figures out the sequence of muscle contractions necessary to carry out the movement and how to arrange the movement in time and space. If a person's cerebellum is damaged, they will have difficulty coordinating movement. Finally, the brain stem and spinal cord execute the movement; they automatically adjust our posture to allow for the movement and relay messages which generate the movement.

There are specific areas of the cerebral cortex which process sensory information and control movement, referred to as the *somatosensory cortex* and the *motor cortex*.



Together, the somatosensory and motor cortices create the shape of a headband, spanning the brain across the head from ear to ear. Each cortex is made up of many smaller areas which are responsible for sensing and controlling different parts of the body, and these areas of the brain can adapt to increased or decreased levels of input and use. For example, a person who had his right hand amputated would use his left hand a great deal, and as a result the areas of his brain that control the movement of and process sensory information from his left hand would increase in size.

For the sake of simplicity, let's classify movements into two types: voluntary and reflexive. Voluntary movements are initiated by the cerebrum; they are movements that we deliberately decide to do and must learn how to execute, such as tying our shoelaces or dancing the rumba. In contrast, reflexive movements occur automatically and subconsciously. Reflexive movements are controlled by the spinal cord or brain stem, depending on what part of the body is involved. Sensory neurons carrying information from our extremities synapse with neurons in the spinal cord or brain stem, and certain sensory information will trigger an automatic response known as a *reflex*. As the reflex occurs, the sensory information continues to travel all the way to the brain, allowing for a voluntary response which may override the reflex.

Reflexes serve a critical evolutionary purpose. Since our nerves are carrying both the sensory and motor signals a much shorter distance—just to the spinal cord or brain stem and back to the extremities, instead of all the way to the brain and back—a great deal of time is saved. Reflexes allow us to respond nearly instantaneously to potentially harmful stimuli. The difference of just a second in reaction time can mean the difference between life and death.

Motor Learning

There are two significant changes that occur in our nervous system as we learn a movement: neural pathways become stronger, and the control and memory of the movement shifts to different areas of the brain.

You may have heard the phrase "neurons that fire together, wire together." This short phrase summarizes the synaptic plasticity theory of learning set forth by Canadian psychologist Donald Hebb in his 1949 book *The Organization of Behavior.* Neuroplasticity is the ability of the brain to change and grow based on input and use. The concept of neuroplasticity had been previously proposed by others, most notably American psychologists William James and Karl Lashley, and Polish neuroscientist Jerzy Konorski, but it was largely ignored by the scientific community until Hebb brought the concept to the forefront in his groundbreaking book.

In the book, Hebb explains that "synaptic connectivity changes as a function of repetitive firing." In other words, when we repeat an action like swinging a golf club over and over, the neurons involved in controlling that action develop increasingly stronger connections. Not only do existing synapses begin to fire more efficiently, but new synapses are formed as well. As a result, our golf swing becomes more automatic, reliable and forceful the more often we practice. We develop what is known as *muscle memory.*

Despite what the term implies, muscles have no memory of their own—they are controlled by the nervous system. Initially, both voluntary and reflexive movements occur and then cease completely; once we decide to stop moving or the stimulus triggering the reflex is removed, our muscles stop contracting and our body comes to rest. However, when we perform a voluntary movement many times, or if a reflex is stimulated repeatedly, our nervous system notices. And our nervous system likes to be as efficient as possible, because making fast decisions helps us survive. When our nervous system notices that we keep repeating the same movement or posture, it begins to make that movement or posture automatic. As the motor pattern becomes more deeply learned, our brain starts keeping the muscles involved in that pattern partially contracted all the time, and the control of the pattern shifts to different areas of the brain. This process allows the parts of brain responsible for making voluntary decisions to focus on new things which require conscious attention.

In order to demonstrate how lower levels of the brain take over control of practiced movements, researchers from Texas and Iowa did brain scans of people while they learned how to execute a simple finger movement. During the first two weeks of daily practice, the prefrontal cortex—the area of the cerebral cortex that plans complex behavior, makes decisions and focuses attention—was highly interactive with other brain regions. After four weeks of practice, the prefrontal cortex was less active and its connections with other brain regions were weakened. The need for conscious attention was diminished as the subjects mastered their new skill.

Over the four-week test period, activity in the motor cortex and a part of the brain called the *basal ganglia* steadily increased. The basal ganglia is a subcortical cluster of neurons which plays a role in learning, memory, voluntary motor control, and habit formation. The strengthened connections between the basal ganglia and the motor cortex, as well as those between areas within the motor cortex, correlated with an enhancement of movement planning and sequence control and decreasing involvement from the prefrontal cortex.

As movements become learned, not only does control of the movements shift to different areas of the brain, but storage of the motor memories moves as well. For the past four decades, scientists have been debating where specifically in the brain our “muscle memories” are stored. Numerous studies have demonstrated that the cerebellum plays a crucial role in the motor learning process, allowing us to recruit new muscles and control the timing of muscle contractions. Finally in 2006, researchers made an important discovery. By examining eye movements of mice, scientists found that short-term memories created in the cerebellar cortex become long-term memories when they are transferred to the cerebellar nucleus.

The process of motor learning is gradual. The more times we repeat a movement, the more deeply it is learned and the more automatic and less conscious it becomes. The motor learning process is also subject to many factors such as how frequently a movement is practiced and whether or not conflicting movement patterns have been learned before or are being learned concurrently.

Thanks to research on the efficacy of visualization techniques, we know that we can practice our motor skills and strengthen our muscle memory without actually moving. When we simply imagine ourselves performing a certain task, our brain functions in much the same way as if we are physically carrying out the action. Brain scans show that we go through the same planning and preparation phases, then stop before activating the primary motor cortex.

As a side note, visualization techniques offer great opportunities for athletes and performers, allowing them to practice with no sensory distractions, physical limitations or risk of injury. In fact, an experiment carried out by Russian coaches leading up to the 1980 Olympics showed that not only does visualization work, but it can be more effective than physical training. The coaches separated their athletes into four groups: the first did 100% physical training, the second did 75% physical training and 25% visualization, the third did 50% physical training and 50% visualization, and the fourth did 25% physical training and 75%

visualization. Remarkably, the group of athletes that showed the greatest improvement in performance was the fourth group.

Learned movement patterns can remain with us for long periods of time even if they are not actively practiced. While synaptic connections will weaken, some vestiges of the neural pathways remain, and the memory of how to execute a movement can be stored. One study found that people retained typing skills after two consecutive twenty-five year periods of not typing at all. Other research has shown that the ability to juggle, drive and solve mazes can be quickly remembered and reinstated after many years of not being practiced. As the saying goes, it's just like riding a bike.

Despite the potential permanence of our learned motor skills, we do have the ability to learn new movement patterns well enough that they can override old ones. A wonderful example of this learning ability is golfer Tiger Woods, who has deconstructed and reconstructed his swing not once, not twice, but three times in less than two decades. Ever the perfectionist, Woods seems to take great pleasure in harnessing his analytical and kinesthetic skills in pursuit of the perfect swing.

We can learn a important lesson by observing what Woods went through the first time he changed his swing. Shortly after winning the 1997 Masters Tournament by a record twelve strokes, Woods approached his then-coach Butch Harmon about the possibility of improving his swing. Harmon agreed that it was possible, but cautioned Woods that it would be difficult to play competitively while making the changes. Woods refused to listen, insisting that he was capable of implementing the new swing while continuing to compete. He went on to have one of his worst seasons ever, entering a famous slump during the second half of 1997 and winning only one tournament in 1998.

Harmon knew what he was talking about. Weakening the grip, adjusting the takeaway, raising the left arm on the backswing, changing the clubhead angle, and coordinating the timing of the arms and hips were too many changes to make all at once. Harmon also understood that trying to learn how to swing a club in this new way would be virtually impossible while under the pressure of competition; this was why so many other golfers had failed in their attempts to change their swing.

When under stress, our nervous system will automatically choose to act in whatever way is fastest. The movement pattern that is most deeply learned requires the least amount of conscious thought, and therefore the nervous system will be able to carry it out most efficiently. This is why Woods ran into trouble during the 1998 season. He was trying to use his new swing, but it was still tentative and unreliable; not yet well-learned enough to be ready for the pressure of competition. Undoubtedly, the stress was causing him to automatically revert to his old swing, possibly creating some sort of hybrid of the two swings, as well as a great deal of frustration.

Harmon finally convinced Woods to take a year off from playing competitively so that he could learn his new swing from the ground up, one element at a time. Away from the pressure of competition, Woods was able to practice the new swing slowly and consciously—the only way that muscle memory can truly be changed. With repeated practice of a new movement pattern in a non-stressful environment where the old pattern will not be triggered, a new pattern can eventually become stronger and more efficient than the old one. Finally, we can get to the point where the new pattern automatically kicks in when we are under pressure.

It was at this point, just before the Byron Nelson Championship in May of 1999, that Woods famously called Harmon and said, "I got it."

Over the next two seasons, Woods won seventeen PGA Tour events, including the 2000 U.S. Open Championship which he won by a record-setting fifteen strokes. This win was the first in a streak of four straight consecutive wins in the four major golf tournaments. From August 1999 to September 2004, Woods was ranked the number one golfer in the world. The time and effort it took to change his swing had been well worth it, and Woods repeated the process again in 2004 and 2010.

Losing Control, Sensation and Awareness

The process of acquiring muscle memory is not limited to athletes, nor is it limited to the learning of complex movement patterns like swinging a golf club. The same learning process is going on within your nervous system, all the time, every day of your entire life, even if you sit at a desk all day and go home and watch TV at night. Some people consciously choose to work with their muscle memory, actively training and retraining their motor patterns in pursuit of a goal. But most of us are unaware that that we are engaged in a constant process of subconsciously reinforcing old movement patterns and learning new ones.

The automatic motor learning process is innate in all of us, and it serves an important evolutionary purpose. Take the example of an infant learning how to walk. He must first focus all his conscious attention on figuring out how to shift his weight to his left side in order to lift his right foot up and take a step. Each time he takes a step, the neural pathways controlling his movements become stronger. Gradually, the control of his walking movements shifts away from his prefrontal cortex, and the infant is able to focus his conscious attention on other tasks while walking around effortlessly. You can imagine how critical muscle memory was to our survival hundreds of thousands of years ago. Back then, only the fit survived, and the ability to move quickly and automatically under stress often meant the difference between life and death.

For most of us today, our survival is not so dependent on being able to move quickly. However, the process of learning and automating movement patterns is hardwired into our nervous system, so it occurs whether we want it to or not. And for the most part, acquiring muscle memory is an incredible ability which we would not want to live without. The key to avoiding problems is that we need to become aware of when we are learning habits which might damage our body or lead to chronic pain.

Our brain wants to help us be as efficient as possible, so it will remember any movement or posture which we choose to repeat—even if the movement or posture is unnatural and could potentially cause pain and damage over time. To illustrate this point I'll use an example to which many of us can relate: that of sitting and working at a computer.

Let's pretend that you have just started a new job, and it is your first ever desk job. All of a sudden you'll be spending most of your waking hours sitting at a desk, working at a computer. Let's also pretend that you are a bit nearsighted. Each time you sit down to work at the computer, you reach your head and neck forward a little bit in order to see the screen better. Then you lift up your hands, bringing your arms forward and rotating them inward so that you can type on the keyboard.

I'd like you to really feel what it is like to be in this position. Wherever you are, please read the next few paragraphs and then put your book down so that you can try this exercise.

Sit up straight and tall with your feet on the ground right below or in front of your knees, head sitting easily on the top of your spine, eyes looking forward, and arms hanging loosely by your sides. Now, bring your head forward a bit as though you wanted to see a computer screen better, and as you do this, pay attention to what muscles you feel contracting. Did you feel where the contraction is happening? If not, do the movement again. You might have kept your torso stiff and just craned your neck forward using your neck muscles. Or you might have contracted your abdominal muscles, tucking your pelvis under and rounding your back. Most likely, you did some combination of these two actions. Repeat the movement again, feeling your pattern of muscular contraction as you bring your head forward, and feeling the release as you go back to your neutral starting posture.

Now bring your arms up in front of you and rotate your hands inward as if you are going to type on a keyboard, and as you do so, notice what muscles are working. If it's hard to feel this one, relax and start over, and try moving very slowly. You should feel your pectoral muscles as well as your biceps muscles contracting as you come into the typing position.

Each time you sit down to work at your new job, your neck muscles, abdominals, pectorals and biceps all contract to bring you into your typing position. At first, this position is new to you and it will likely feel uncomfortable and tiring; you will instinctively relax back in your chair every few minutes, and subconsciously find reasons to get up and walk around.

But day after day, you come to work and repeat this posture. “Hey,” says your nervous system, “she seems to like sitting this way. Let's help her out and just keep her in this posture all the time!” Really, your nervous system is trying to be helpful. So it sends the message to your neck muscles, abdominals, pectorals and biceps to stay a little bit contracted in this specific pattern all the time. The control of this posture begins to shift away from your prefrontal cortex into lower brain regions where it can be controlled automatically and subconsciously. You become accustomed to the feeling of being in this posture, and it feels more and more comfortable every day. Now you can stop wasting conscious attention on your posture and focus on your work.

When the brain sends the message to a muscle to contract, the message is sent via an upper motor neuron, which synapses on a lower motor neuron in the spinal cord. The lower motor neuron then carries the signal to the muscle fibers to tell them to contract. The brain can only send one type of signal to a muscle, and that is to contract; it cannot send an active message to release. When an action is complete and the message to contract is not being sent anymore, muscles should automatically relax back to their full resting length.

Unfortunately, as you just learned, it is very easy to form muscular habits which involve keeping certain muscles a little bit contracted all the time. This chronic contraction leads to the constant buildup of hydrogen ions which activate your nociceptors, causing pain. Now you can begin to see how our natural learning process of developing muscle memory can so easily lead to discomfort, poor posture and pain.

Loss of voluntary, conscious control of our muscles is only one piece of the puzzle. Loss of sensation and sensory awareness also play a large role in developing habitual motor patterns. As a stimulus is repeated, most of our sensory systems become less responsive. This process is known as *sensory adaptation*.

While we become more sensitive to pain the more our nociceptors are activated, our pain processing system is an exception. In general, activity in sensory systems is highest during and immediately after a new stimulus is presented. Within a short period of time our sensory receptors return to their normal resting state, even if the stimulus is still present.

Imagine going swimming in cool ocean water. When you first dip your toes into the water, it feels quite chilly. If you stand there for a minute, letting the waves lap over your feet, you get used to the temperature and it begins to feel comfortable. Wading in deeper, you experience this phenomenon each time the water comes into contact with a new part of your body. Soon you are fully submerged, your thermoreceptors have returned to their resting state, and the water actually feels warm.

We quickly adapt in a similar way to new sensations of touch, sound, smell and taste. Wearing a new bracelet can be bothersome and distracting until you get used to the sensation of the metal touching your wrist. A repetitive sound like a car alarm is at first annoying, but quickly fades into the background. An unpleasant odor can be overwhelming as you enter a room, but within minutes you barely notice it. A sugary drink seems too sweet until you have taken several sips and become used to the taste.

When it comes to learned movement patterns, we're concerned with the adaptation of our vestibular system and our proprioceptive system. Our vestibular system adapts when we are in motion at the same speed for longer than a few moments; so when we are flying in an airplane at 600 miles per hour, we feel like we're sitting still. Likewise, if we tip our head slightly forward or to the side, after a while the tilted position begins to feel normal. This adaptation is a function of both the vestibular and proprioceptive systems.

As I mentioned earlier, proprioceptors are sensory receptors located in our muscles and joints. The proprioceptors in our joints detect changes in the angle, direction and speed of movement in our joints. These proprioceptors adapt quickly; they are very good at sensing changes in our joint position as we move, but they give us very little information about the resting position of our joints. This adaptability is helpful when we are in motion, but allows us to get comfortable in unnatural resting positions—like slouched forward at a computer.

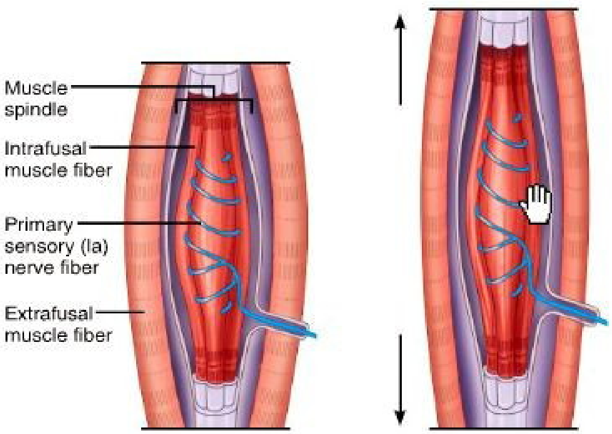
Proprioceptors located within our muscles also allow us to get comfortable in unnatural positions. These proprioceptors, which sense changes in muscle length, are formally called muscle spindles but often referred to as stretch receptors because they can sense when a muscle is being stretched.

Muscle spindles play a critical role in allowing us to maintain upright posture and control of our muscles. In fact, mice without these proprioceptors have abnormal posture and are not able to support their own weight. Humans have evolved to have a particularly high density of muscle spindles in the muscles of our neck, giving us a great deal of control over the support of our head. And as it turns out, muscle spindles are involved in the process of developing damaging motor patterns and chronic pain.

Recall from a few pages ago that a lower motor neuron carries the message from the spinal cord to the muscle telling the muscle fibers to contract. There are two types of lower motor neurons: alpha motor neurons and gamma motor neurons. Alpha motor neurons innervate extrafusal muscle fibers, the type of fibers which make up the bulk of all skeletal muscles, while gamma motor neurons innervate intrafusal muscle fibers.

Muscle spindles, located in the belly of most skeletal muscles, are made up of specialized intrafusal muscle fibers wrapped in a fibrous capsule. When the extrafusal fibers of a muscle are lengthened, the intrafusal fibers of the muscle spindle can't help but lengthen as well.

Axons of sensory neurons are wrapped around the muscle spindle in order to sense its length and the muscle's length. These sensory axons, known as Ia axons, are among those with the thickest myelin sheath of all axons in the body, allowing the messages being sent through them to travel at speeds up to around one hundred meters per second.



(a) Unstretched muscle. (b) Stretched muscle.

When a muscle is stretched, the sensory axons wrapped around the muscle spindle sense the increase in length, and send this information to the alpha motor neuron. The alpha motor neuron then immediately sends the message to the extrafusal muscle fibers to contract in order to protect the muscle from being torn. This nearly instantaneous reaction is called the *myotatic reflex* or stretch reflex.

One might assume that when a muscle contracts that the feedback from the muscle spindle would stop. However, this is not the case, because it would create opportunity for the muscle to get injured. When a muscle is contracted, gamma motor neurons are activated, pulling slightly on the muscle spindle. This makes the muscle spindle send a message that the muscle is a little longer than it actually is. The purpose of this is purely to keep the alpha-gamma feedback loop active so that injury to the muscle does not occur.

Alpha and gamma motor neurons are activated by commands being sent from the brain and by automatic messages from the alpha-gamma loop. The brain sends messages telling the muscles to voluntarily contract, while the alpha-gamma loop automatically maintains the resting level of tension in the muscles. The sensory receptors of Ia axons adapt quickly, so when the extrafusal fibers of a muscle are chronically contracted, our proprioception adjusts so that we feel that the muscle is not as short or tight as it actually is. In other words, the increased level of contraction in our muscles actually begins to feel normal.

So as we sit at our computer day after day, our brain learns to keep us in a slouched posture by keeping certain muscles contracted, and our proprioceptive and vestibular systems allow us to get more and more comfortable in this unnatural position. Slouching forward begins to feel normal and even good, and sitting up straight takes effort and feels uncomfortable. We typically remain blissfully unaware of this subconscious adaptation until, one day, it finally causes us pain. The loss of sensory awareness that accompanies learned movement patterns is the final part of our discussion.

The word “awareness” has a New-Agey connotation which may cause people who are grounded in reality to think that it is a fictional concept made up by people tripping on acid. The truth is that awareness is an important and entirely real function of human consciousness. Awareness should be practiced and maintained, as it is critical to our personal safety, ability to have healthy interactions with other people, and of course, preventing ourselves from acquiring damaging motor patterns.

We can improve our awareness by focusing our conscious attention, a concept which is a bit more tangible. We can choose to focus our attention on any portion of the vast amount of sensory information coming into our brain. By focusing our eyes on one object, we are able to observe the tiniest details of the object while ignoring everything else in our visual field. By listening intently, we can hear a conversation happening at the next table in a noisy, crowded restaurant.

Likewise, we can focus our attention on our proprioceptive sensations. Let's use the simple example of tilting your head downward so as to look at the ground. This postural habit is becoming increasingly common among Americans due to constant use of smart phones and computers.

As you are reading these words, your head is likely tilted downward. Bring your eyes up from the page and look straight ahead, so that your head sits straight up and down on top of your spine. Notice how this position feels different than tilting your head downward. Also notice how quickly you return to the tilted downward position. Which position is more comfortable? Can you feel certain muscles that are contracted or released in each position? Can you find a way to relax your neck and shoulders while looking straight ahead?

Now that you have taken the time to notice the difference between what these two positions feel like, you will likely start to notice your head position more often. In fact, once you have noticed or learned something new it can be difficult to not notice it. This tendency of our brain to notice things we have just learned is referred to as the Baader-Meinhof phenomenon. If you haven't heard of it before, you probably will again soon.

You may have had the experience of learning a new word and then suddenly seeing that word everywhere. The Baader-Meinhof phenomenon is also known as the frequency illusion or recency effect, and it is a result of having focused your attention on something new. Once your conscious attention has been brought to this new word, or to an internal sensation such as the position of your head, you have become more aware of this new word or sensation. Each time you read that new word, you will consciously recognize it instead of subconsciously skimming over it. Likewise, now when you hold your head tilted forward, your brain will recognize that proprioceptive sensation rather than ignoring it.

You can think of attention as being focused and active, and awareness as being broad and relaxed. If you begin to pay attention to your proprioceptive sensations, you will become more aware of them; so with practice, you won't need to work so hard at noticing your body position and movement. It's like staying tuned in to a certain radio station so you can always hear it in the background.

As we gradually learn a posture or movement pattern, we get used to the proprioceptive sensations that accompany it, and we begin to notice them less and less. This loss of awareness makes it very easy to fall deeper and deeper into our learned patterns, and also makes it very difficult to change them. In order to improve our body mechanics, we need to have an accurate sense of our starting point. And unfortunately, unnatural and damaging movement patterns feel natural and correct because we have gradually adapted to them.

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We've just covered a great deal of information, and I hope it is becoming clear how all of these processes work together. We are continuously sensing and moving, continuously learning new motor patterns and strengthening existing ones. We are constantly becoming more and less aware of various sensations in our body.

If you'd like to learn how habitual motor patterns lead to pain and degeneration, and how Clinical Somatic Education relieves pain by re-educating the nervous system, we recommend reading *Why We're in Pain* by Sarah St. Pierre, CSE.
To learn more about the book, go to:
http://www.somaticmovementcenter.com/somatics-book-why-were-in-pain/

Are you ready to learn Clinical Somatic Education exercises and start getting out of pain? You can download our Instructional Recordings and start learning today! Go to:
http://www.somaticmovementcenter.com/learn-somatics-exercises-at-home/