

Comment by FJV

This paper is written as a student paper in a biology course at Bryn Mawr College. It tells the story on proprioception in a broad scope. It is never intended to be scientifically sound but a good read and it touches upon the relevant subjects. A web reader posted a comment to it which I have left as it is.

Proprioception: how and why?

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There are five common senses that are discussed and learned from an early age: sight, hearing, taste, touch, and smell. The I-function, the conscious part of the brain, is very aware of these senses. It voluntarily checks information obtained by these senses in order to experience the environment, and also when a strong enough stimuli has signaled attention to these specific receptors. There are other equally important sensory systems set up that are essential for normal body functioning, but these are not so easily recognized by the I-function because the nervous system keeps the input unconscious.

One overlooked sense, known as proprioception, is as important, if not more important as the other senses, for normal functioning. Proprioception is "the process by which the body can vary muscle contraction in immediate response to incoming information regarding external forces," by utilizing stretch receptors in the muscles to keep track of the joint position in the body [\(1\)](#).

Proprioception and kinesthesia, the sensation of joint motion and acceleration, are the sensory feedback mechanisms for motor control and posture. These mechanisms along with

the vestibular system, a fluid filled network within the inner ear that can feel the pull of gravity and helps the body keep oriented and balanced, are unconsciously utilized by the brain to provide a constant influx of sensory information [\(2\)](#). The brain can then send out immediate and unconscious adjustments to the muscles and joints in order to achieve movement and balance. Why has the nervous system developed the sense of proprioception, and why is it an unconscious aspect of the sensory system?

Proprioception, also often referred to as the sixth sense, was developed by the nervous system as a means to keep track of and control the different parts of the body. An example that enables one to best understand this sensory system is one showing what happens if this sensory system is no longer there. Ian Waterman lost his sixth sense along with the ability to feel light touch when a virus killed the necessary nerves. The man still had all the nerves to control muscle movement but had no feedback from the outside world about where his limbs were except that obtained by sight. A normal person is able to move a finger, knowing where and what the finger is doing, with little effort. The

normal person could just volunteer the finger to move back and forth and proprioception would make this an easy task. Without proprioception, the brain cannot feel what the finger is doing, and the process must be carried out in more conscious and calculated steps. The person must use vision to compensate for the lost feedback on the progress of the finger. Then the I-function must voluntarily and consciously tell the finger what to do while watching the feedback (3).

The eyes have to also be trained to judge weights and lengths of objects. As Waterman attempts to lift objects there is no feedback on how hard to flex the muscles except from what clues vision gives. Studies of Waterman support that through feedback from proprioception the brain is able to calculate angles of movement and command the limb to move exact distances. If vision is taken away, the lights are cut out, then Waterman will fall in a heap on the floor, with no ability to make successful voluntary movements. The examples of Waterman illustrate the type of information obtained because of proprioception and the great importance of this information. Without this sense humans would be forced to spend a great amount of their conscious energy moving around or would not be mobile at all (3).

The proprioception sensory system is carried out utilizing proprioceptors in the muscles that monitor length, tension, pressure, and noxious stimuli. The muscle spindles, the most complex and studied of the proprioceptors, informs other neurons of the length of the muscle and the velocity of the stretch. The

density of muscle spindles within a muscle increases for muscles involved in fine movements, as opposed to those involved in larger course movements. The brain needs input from many of these spindles in order to register changes in angle and position that the muscle has accomplished. There is also more spindles found in the arms and legs, muscles that must maintain posture against gravity (1).

Another proprioceptor, the golgi tendon organ, is found where the tendons meet the muscle. They send detailed information about the tension occurring in specific parts of the muscle. There are also proprioceptors sending information to the nervous system from joints and ligaments. Depending on the amount, where in the body, and from what proprioceptors the different input is coming from, determines if the information will be made conscious or processed unconsciously. All the input coming into the nervous system is processed, and then depending on the state of the muscle, there are commands sent back to the muscle (1).

After thinking of Waterman's plight to accomplish many basic movements without the help of proprioception, the realization of the importance of this sense becomes apparent. I can possibly imagine the species successfully evolving without eyesight, especially if the sense of hearing evolved more keenly. However, it is much harder to imagine the human species evolving without the ability to easily move. Waterman's situation also makes the reasoning become clearer as to why the nervous system evolved keeping the I-

function separate from most proprioceptor feedback. Proprioception is extremely important and encompasses so many areas of the body. The sensory information being processed is a constant and a monumental amount. If the I-function, which can only focus on a few aspects at once, had to be responsible for all of the input coming in from all the different muscles there would be difficulties. The confusion would be overwhelming and the I-function would be useless in making decisions at the speed necessary, because it would need to think first. Thinking takes time, where the unconscious nervous system responds immediately through processes wired to specifically deal with the type and amount of input coming in. Systems like proprioception and other unconscious, yet crucially essential, systems allow the I-function to develop without having to be bothered with all functioning of the body. These unconscious systems allow a lot to get done at once. The I-function may spend time learning new skills and developing ideas without being inhibited by the large amount of stimulus needed for a successfully functioning of the body.

The I-function is most likely very aware of senses such as sight, hearing, and smell, because it can focus on the details that it wishes to consciously concentrate on. A lot of stimulus can be discounted by the I-function very quickly, if not ignored before it reaches that far, so that the I-function can concentrate. This is a necessary property of the I-function because we are multi-task beings that are constantly surrounded by stimuli. The I-function must have the ability to make decisions and be able to identify the stimuli in the environment relevant to our well being. The information coming

in from the proprioceptors cannot be ignored, just as the neurons that are signaled to pump the heart cannot ignore the stimulus, because the majority of the information coming in is necessary for normal movement.

While proprioception is necessary for learning a type of movement or skill involving muscle, concentration from the I-function is essential as well. Once the skill, such as the appropriate movements of driving or the movements a baby must accomplish to walk, have been conquered and learned the I-function is not as functional during these tasks. The proprioception and motor systems can take over, utilizing a feedback system to accomplish a job that the unconscious brain already has learned. The I-function can go on to do other things, because it would mainly just hinder smooth muscle processes with too much thought and analysis. That is why humans do so many learned things best if not thought about. For example, the harder a driver focuses on what her muscles are doing as she drives, the choppy her movements will be, and the worse the driving will be.

The phantom limb also indirectly supports reasoning for the evolution of proprioception. A person with a phantom limb still feels pain or some sort of sensation even though they were born without the limb or it was amputated. The evidence that people having no limb at birth still can experience a phantom limb supports Ronald Melzack's idea of there existing a "neuromatrix" (4). The brain has a particular matrix, or map of the body, genetically installed in the brain that both responds to stimuli from proprioception and continuously sends impulses to different parts of the body to

check on the condition and location of the body parts. The matrix can be altered due to experience such as storing memory or changing synaptic connections, but the overall organization is set from birth. Studies show that the matrix can record the experience of pain and generate experiences of sensation on its own (4).

When the matrix sends out signals to the missing limb and receives no response from proprioception the matrix registers a problem in the limb instead of no limb. When the brain recognizes something wrong it reports a painful sensation to clarify that there is a problem in the area of the limb to the rest of the brain, and the person experiences a painful limb even though they know it is not there (4).

There is a matrix in the brain monitoring all of the sensory information and constantly checking to see where the limbs are. This matrix is able to adjust; recording data and generating certain sensation long after the stimulus has stopped. Therefore, it may also have the ability to record patterns of action by the muscles, while the I-function consciously works the muscles through new unfamiliar patterns of movement. The patterns recorded or learned, like those of pain, could be triggered by the I-function to signal for a pattern of movement. Then a learned pattern of movement could be set forth, initiating smooth muscle movements, such as a free throw during a basket ball game,

without the I-function monitoring or interfering.

If this is a way that the brain records and utilizes sensory input to conquer and utilize movement pattern, then proprioception is a primary building block in the human's ability to learn, repeat, and become comfortable with so many movements throughout life. Therefore, it is essential that the I-function not be bothered by the sense of proprioception, unless learning a new movement, because these movement patterns would be useless if the I-function had to deal with the incoming proprioception anyway. With proprioception as an unconscious sense and the matrix giving unconscious feedback to muscles, utilizing my already learned movement patterns, I can concentrate on what I am saying in my paper without having to also consciously tell my fingers to hit certain keys at certain times.

With the sense of proprioception our lives are made less complicated, and we are given the ability to learn and utilize many movement patterns freeing the I-function to focus awareness on new tasks and thoughts. The I-function seems to be one of the most complicated aspects of the brain. Was the I-function one of the last aspects to evolve in the human brain thus far? If so was it because the necessities for survival were accomplished by the species, proprioception allows movement and eating is instinctual to the brain? Why did evolution cause the human to develop the I-function?

References

- 1) Proprioception, A simplified overview of anatomical structures and neurophysiological actions involved in joint stability.
- 2) [Mixed up in Space](#), An article concerning how the vestibular and proprioceptor systems react in space.
- 3) [Why can't this man feel whether or not he is standing up?](#), The story of one man's loss of proprioception
- 4) Phantom Limbs, Discussions about what and why there are phantom limbs

Continuing conversation

04/28/2005, from a Reader on the Web

Thank you for posting the paper by Shannon Lee entitled "Proprioception - how and why". The paper described exactly what I had gone through during the last year. As a result of a lumbar disc herniation L4-L5 I experienced a loss of proprioception in my lower left leg. It was difficult to communicate this problem to my surgeon. I now understand that they don't operate on sensory nerve damage alone (not that I was asking them to perform another surgery). I had taken a course in neurobiology in graduate school. However, realizing that I may be influenced by additional research on the subject, I simply described my symptoms to the surgeon. After a lumbar laminectomy last May I was able to walk without a limp. The symptoms returned by mid July; only this time they became progressively worse until I could only drag my lower leg along. On November first I had a spinal fusion. The first time I took a step I knew where my foot was again. I could relate to the individual in the article. It was mentally exhausting to concentrate on every step. Without looking at my foot I would trip or even attempt to walk on the top of my foot without feeling pain. By the time of surgery I had lost the ability to walk with a heel to toe movement. I could not place my toes on the floor to push off like you would at the start of a race. This was frustrating because before the back injury I ran several miles a day, was a member of a racquetball league, and enjoyed a very active lifestyle. I am thankful that my surgeon was willing to operate based on the results of a discogram. I also had a lot of back pain. Today I still am unable to move one of my toes laterally. That is quite an improvement over dragging my entire lower leg. Recovery has been slower than I expected. It is like I had to teach myself to walk.