

Portland State University

**PDXScholar**

---

Mathematics and Statistics Faculty  
Publications and Presentations

Fariborz Maseeh Department of Mathematics  
and Statistics

---

1-2015

# Body Sensations: Neurobiology, Learning to Feel, and Sensory Teamwork

Gin McCollum

Portland State University, [gin.mccollum@pdx.edu](mailto:gin.mccollum@pdx.edu)

Follow this and additional works at: [https://pdxscholar.library.pdx.edu/mth\\_fac](https://pdxscholar.library.pdx.edu/mth_fac)



Part of the [Neuroscience and Neurobiology Commons](#)

**Let us know how access to this document benefits you.**

---

## Citation Details

McCollum, Gin, "Body Sensations: Neurobiology, Learning to Feel, and Sensory Teamwork" (2015).  
*Mathematics and Statistics Faculty Publications and Presentations*. 190.  
[https://pdxscholar.library.pdx.edu/mth\\_fac/190](https://pdxscholar.library.pdx.edu/mth_fac/190)

This Article is brought to you for free and open access. It has been accepted for inclusion in Mathematics and Statistics Faculty Publications and Presentations by an authorized administrator of PDXScholar. Please contact us if we can make this document more accessible: [pdxscholar@pdx.edu](mailto:pdxscholar@pdx.edu).

## Body Sensations: Neurobiology, Learning to Feel, and Sensory Teamwork

Gin McCollum

Most of us must learn to feel, as an artist learns to see in order to draw. All of the physiological processes of feeling and seeing can happen with no awareness at all, when the mind is wandering elsewhere. Essential to the learning process is awareness, **prajna**. With no awareness, we have unconscious sensations, not conscious perceptions.

The light striking the retina of the eye is the first step in seeing. A great deal more happens in the visual part of the cerebral cortex, at the back of the head, and along the pathways to it. The conscious experience of seeing is typically correlated with neural activity in the visual part of the cerebral cortex. Probably the whole brain is re-organized in the process of becoming an artist.

Similarly, body-feeling or somatosensation starts in receptors in the skin, muscles, tendons, ligaments, and joints. Pathways through the spinal cord to the brain communicate sensations. At the same time, the neural activity is combined, as light sensations are combined into lines and shapes before we see a scene. The process of learning to feel brings awareness, **prajna**, to these combinations of body sensations and to the whole experience of feeling.

We each learn individually how an asana feels. For example, in **tadasana**, I feel the pressure on the soles of my feet, the muscle feel of straightening the hips and lifting the chest, and the skin stretch in the arms and hands. What do you feel? To stand upright, we also use vision, aligning ourselves to the trees or walls around us. The receptors of the inner ear communicate further gravitational information along pathways to the eyes, neck, and spinal cord.

Practicing the various asanas provides a framework for learning to feel, as drawing provides a framework for learning to see. An asana is typically experienced as a whole, rather than as a scattering of sensations. That whole experience is formed as the body sensations are combined in spinal pathways, the brainstem, and the brain. We will start with the receptors in the skin, familiar as touch, because their separate qualities tend to be easier to perceive.

### *Touch and the Various Receptors in the Skin*

The menagerie of touch receptors in the skin remind me of the tiny curlicues found in embroidery and filigree, but placed separately. And they are much tinier. For example, the ball of each thumb contains about 500 touch receptors. Furthermore, there are different kinds of receptors for different sensations, such as light touch, deep pressure, motion of a hair, pain, and temperature. Of the many types of touch or receptors or sensation, body position and movement is sensed particularly with deep pressure, skin stretch, and light touch.

Deep pressure is typically felt at the base of a pose, where the body rests against the ground. Such foundations include the soles of the feet in **tadasana** and the skin under the sit-bones in **dandasana**, along with the skin under the thighs and calves. Deep pressure is also felt in the forearms in **sirsasana**. In addition to the deep pressure at the base of the pose, deep pressure may be felt where two body parts press against each other. For example, in **marichiyasana III**, the back of the upper arm presses against the outer knee, with both experiencing deep pressure. In **bakasana**, the inner knees press into the upper arms. The inner knees also press into the upper arms in **bhujapidasana**, where they are draped over the arms, and the deep pressure between the limbs serves as a guide for staying in position and avoiding slipping.

Skin stretch may be more individual. I feel skin stretch in my upper arms in **urdhva hastasana** in **tadasana**. In **utthita hasta padangusthasana I**, I feel skin stretch at the back

of my lifted thigh. In ***utthita trikonasana***, I feel skin stretch over the upper hip. Basically, skin stretch is felt where the asana asks us to elongate more than we usually do. As with deep pressure, skin stretch is often a good guide to the integrity of the pose. For example, in ***utthita parsvakonasana***, am I really stretching well, all the way from the back foot along my side to the finger-tips of my up arm? Skin stretch can answer that question.

Light touch is often felt during movement. For example, your t-shirt may brush lightly against your skin as you move into a pose. Similarly, your hair may lightly brush your skin. The hair itself has its own receptors, spiraling around the hair follicle, giving hair a wonderful sensitivity to touch. A breeze may stir your hair or lightly touch your skin. These light-touch receptors contribute almost all the time to the sensation of motion, as do the deep pressure and skin stretch receptors. T-shirt motion often forms part of the mix when performing simple trunk twists, such as are used to get into any number of asanas, for instance ***parsva upavista konasana***. I notice light touch especially when I am practicing at home in loose, fleece pants, doing standing poses or inversions.

Becoming aware of the separate sensations is one way to deepen the experiences of an asana and of movement. However, body feelings are typically mixed. Awareness typically focuses on the feeling of a coherent body position or movement, not of a scattering of separate touch sensations.

The sensations most characteristic of the touch receptors of the skin are known because it has been convenient to do experiments in which special probes, such as fine hairs, are used to stimulate receptors separately. In addition, it has been possible to follow the way neural activity from receptors in the skin is combined as it follows pathways to the brain. Sensations on the finger-tips and face are finely separable in awareness, whereas those on the back are only coarsely so. When sensations from a large area have been combined, especially from places that are more obscure, the brain sometimes assigns awareness to a different part of the area than the part that was stimulated. For example, stomach discomfort may be felt in the shoulders. Similarly, rotator cuff inflammation is often felt halfway down the upper arm. Such examples are called "referred pain".

It has been more difficult to experimentally separate out the sensations from muscle, tendon, ligament, and joint receptors. This difficulty arises partly from the way the nervous system mixes the various sensations as they follow pathways to the brain. Awareness is thought to happen *in* the brain, but can be *of* anything the nervous system contacts. In those pathways and in the brain, sensations become part of the team that shape a movement, such as walking or bringing a cup to your lips.

### *Muscle, Tendon, Ligament, and Joint Receptors*

In my current stage in ***virabhadrasana III***, I move slowly into the pose, keeping my body well balanced over the standing foot. In holding the pose, I take pleasure in the feeling of activating the muscles of the upper back and of the lifted leg, especially the back of the thigh. The balance issues make me aware of the small shifts in activity among the hip muscles of the standing leg. All of these muscle sensations use the muscle spindles, which wrap around muscle fibers somewhat the way hair follicle receptors wrap around hair follicles. About the hip, sensation is primarily by means of muscle receptors. However, more generally, position and movement are sensed by a combination of tendon, ligament, joint, and muscle receptors.

Muscle spindles include a special system that allow them to be particularly adaptable, as we change position or, perhaps, over time as our body changes with practice. A muscle spindle sits in the muscle tissue and feels it lengthen. Within the muscle spindle are separate little muscle fibers that keep the muscle spindle taut when the muscle contracts. The sensitivity of the muscle spindle and the little muscle fibers within the spindle cooperate to produce sensations appropriate to the movement. That cooperation gives the muscle spindle system extra adaptability, as we practice and learn to feel.

Standing poses such as **virabhadrasana III** and **trikonasana** challenge us to gain awareness of the muscle sensations associated with hip movements. Most people come to yoga with an ability to stand upright or align themselves visually with the walls or both at once. However, sensitivity to hip movement and position is less common. Therefore, in learning **trikonasana**, we are taught to visually align our feet to the walls and our trunks over the line between our feet. Vision tutors body feeling. Gradually, with the help of vision, we learn the sensations in our hips associated with rotating the front leg, with rotating the trunk over the front leg, and with turning the trunk up so that the up arm can reach straight up. These hip sensations are likely to be individual, because of the complexity of the hip musculature, shape and proportion differences between people, and differences in flexibility, which change with time and practice.

### *Awareness of the Whole Motion*

For movement, it is more important where you are reaching your arm or leg -- in which direction and how far -- rather than at what angle you are holding your knee or elbow. For example, coming down out of **ardha chandrasana**, the up foot reaches for the floor at a suitable distance behind the standing foot. You can't see, but everyday practice has given you the body-feeling to place that foot. Everyday movements include reaching a foot toward a step or a hand toward a pencil, so that unfolding an arm or leg to the right combination of hip-knee-ankle or shoulder-elbow-wrist angles is well-practiced.

One of the early tasks in asana practice is to jump or step the feet four to four and a half feet apart. At first, we peer at our feet, visually estimating the distance between. With practice, body-feeling can take over in sensing a wide, wider, or very wide stance. A person could probably become quite accurate at jumping the feet to a particular distance with the eyes closed. However, it's natural to continue using a cooperation between vision and body-feeling. Teamwork among senses is the norm in movement, where the cooperation can be between vision and body-feeling, or other senses, or among the various body-feeling receptors.

This sensory cooperation forms an active system that you mold with your movements, including your yoga practice, as you learn to feel. Learning to see involves eye movements and the brain. Learning to feel involves spinal pathways, the brain, learning new movements, and change of muscle and connective tissue as we practice.

### *Maintaining Sensory Teamwork*

With age, some people lose the teamwork among their senses (an aspect of sensorimotor integration, important for people of all ages). By using awareness, we build up the teamwork among our senses. By ignoring one sense or over-emphasizing another, a person can lose that teamwork. Most commonly, elders over-emphasize vision. Vision is easily available to awareness and seems precise. That's why we use it in learning asanas such as **trikonasana**. However, depending on vision alone limits balance resilience. As in finance, diversification is a good idea for sensing where your body is in space and for avoiding a fall.

In an experiment by a Japanese team, elderly people stood on blocks of foam rubber and learned to distinguish different hardnesses of foam rubber with their feet.\* That brought their attention to body feeling. The researchers found that the elders who became more aware of the feeling in their feet improved their balance abilities.

Attention to one's own body senses has to be an individual practice; it is not a treatment that someone else can perform on you. I would like to see more knowledge and methods become available to those inclined to take personal responsibility for their own resilience in balance, mobility, and general health. In Iyengar yoga, there is a helpful emphasis on precision in asanas and on **svadhyaya**, which includes the awareness of body-feeling.

Body-feeling is an essential part of our balance and mobility system that tends to fade over time, when ignored. However, awareness can keep it strong and vivid.

Gin McCollum is a theoretical neurobiologist ([http://works.bepress.com/gin\\_mccollum](http://works.bepress.com/gin_mccollum)), who has been practicing yoga, mostly Iyengar, for about 24 years.

\* Shu Morioka, Makoto Hiyamizu, Tahahiko Fukumoto, Yasunori Kataoka, Fumio Yagi (2009)  
Effects of Plantar Hardness Discrimination Training on Standing Postural Balance in the Elderly:  
A Randomized Controlled Trial. *Clinical Rehabilitation* 23: 483-491