
Charlene Clyde, Freelance Artist
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Muscle Memory: Where does it come from and how does it work?

Understanding proprioception and kinaesthesia in dance

Charmaine Tay, October 2020

Dancers have a highly sophisticated working memory - they are able to watch a sequence of movements and recreate the movement patterns with exceptional accuracy[5], integrating all the necessary information while performing lengths of physical tasks with varying sequences. Dancers have been described as kinaesthetic thinkers[3] while professional dancers have been found to position match with outstanding accuracy[12]. *But how do they do this?* By training their sense of proprioception and kinaesthesia.

So, what is proprioception and kinaesthesia, and why are they so important in dance? Proprioception is responsible for maintenance of balance control as well as alignment, agility and aesthetic competency[1], while kinaesthesia is responsible for "memorising" movement patterns[6]. Think about the time you rehearsed a routine over and over, that by the time you performed on stage, you manage to execute all the steps and transitions perfectly without much thought. *How does this work?*

Mechanoreceptors

Your body has specialised mechanoreceptors that fire with mechanical stimuli (movement) found in your muscles, tendons, ligaments, joints and even in your skin. These are known as your muscle spindle, golgi tendon organ, ruffini endings, pacinian corpuscles and free nerve endings. They detect intra and extra personal sensations of static positions and movement. Peripheral input from these sensory nerve endings enter the spinal cord at the dorsal horn. These signals then mediate spinal reflexes to carry them towards the subcortical and cortical parts of the brain. The cortex is responsible for conscious recognition of joint position sense (proprioception) and movement sequences (kinaesthesia). Once the cortex of the brain has acknowledged the mechanical stimuli, it sends appropriate efferent signals via motor neurons to maintain equilibrium.

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In this article, we will be focusing more on muscle spindles to understand the basic principle behind proprioception and understand its similarity and differences with kinaesthesia.

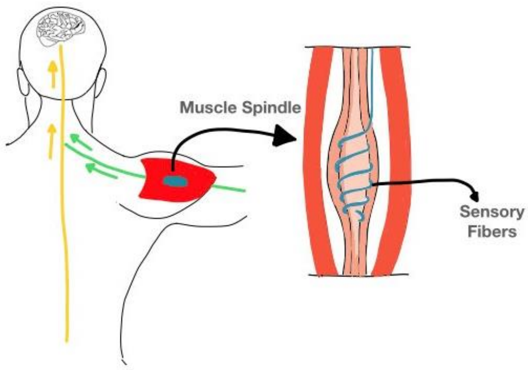

Diagram 1. Mechanoreceptors

How does proprioception work?

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With your eyes closed, would you be able to stand up and walk across an empty room? Would you know if you your right foot is in front of your left and vice versa, or if you are sitting down or standing up? How does your body know where it is in space without having to look at it? This is known as your sense of proprioception. It is defined as the ability of knowing where your body is exactly in space, sensing position and posture. This sense originates from a bunch of little sensors (mechanoreceptors a.k.a. sensory receptors) that are located throughout our entire body and almost in all our muscles. That information is then projected along efferent nerves, through our central nervous system (CNS) (located in our spinal cord) and reaches our brain, processing a motor output[10].

Let's imagine this is a muscle in your arm. When you flex and extend your elbows, your muscles contracts and stretches accordingly. The mechanoreceptor located at the belly of the muscle called the muscle spindle, is a spring-like structure that is sensitive to stretch[9].

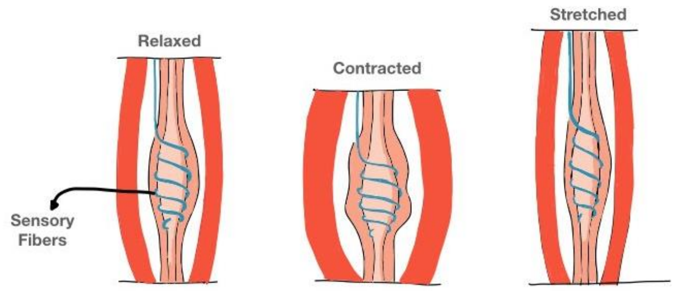

Diagram 2. Muscle movement

When our muscle stretches, it fires signals to our brain to remember how contracted or stretched every muscle is in each position. This complex both changes in length and the rate of change in length (speed). In other words, it takes into account the amount of stretch as well as the time taken to stretch that particular muscle. In this way, the brain is able to monitor the length of the muscle at any given time and gives us proprioceptive feedback to help us sense our joint position sense of where our body is in space[2]. Whether your elbow is stretched to 180° or bent at 90°, or anywhere in between, your brain is able to sense joint position by determining the length of the muscle spindles, even without visual feedback.

While the muscle spindle gives feedback on length, another mechanoreceptor, the golgi tendon organ (GTO) located within tendons (at each ends of muscles) detects degrees of tension generated by a muscle. Increased force generated by skeletal muscles triggers increased GTO activity[7]. Our body then takes all the information from these sensory receptors, organizes itself and determines the most appropriate response to accomplish a task! The next time your dance teacher comes and correct your posture or alignment and asks you to "feel the position" instead of checking the mirror during the correction, you know why!

Kinaesthesia

Kinaesthesia, on the other hand, is more behavioural and relates to movement rather than positions[2]. Let's imagine you are learning how to do a new dance move. While attempting the new dance move in class, sometimes you get it, sometimes you don't. But every single time you attempt that new dance move, your body is able to detect exactly how it is moving and overtime, it learns that you are able to execute the movement well when you move in a certain way or direction. With repetition, your body starts to detect what movement needs to be done and undergoes the same movement more often, so that you are able to teach yourself how you should move to complete that particular task at hand successfully. This is why your

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movements and transitions become flawless with practice! (And probably why your instructor's "one last time" isn't really the last time at rehearsals!)

Given that kinaesthesia is behavioural, we need to take time to go through proper technique with our students especially when teaching higher level moves to prevent bad movement habits from forming, while developing good ones.

Proprioception and kinaesthesia are not the same although there may be a crossover in their overall function[13]. They are both important to our balance and neuromuscular control telling our body where it's at space and how it can respond to certain stimuli.

Retraining proprioception post-injury

In our previous article here, we discussed about how an injury can impair the sense of proprioception[8]. Look out for our upcoming video on *SCAPEdance Science as our experts guide us through some ways they have been helping dancers rehabilitate their sense of proprioception!

End.

Currently a dance science and anatomy lecturer at the dance department, as well as a body conditioning, advance ballet and jazz at the musical theatre department of LASALLE College of The Arts. Charmaine also coaches competition group and elite programme at City Ballet Academy for local and international dance competitions. Charmaine is currently serving on the Dance Educator Committee of the International Association of Dance Medicine and Science

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