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Time Lag Analysis for Readiness Potential by a Firing Pattern Controller Model of a Motor Nerve System Considered Innervation and Jitter

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Abstract : Human makes preparation called readiness potential unconsciously (RP) before awareness of their own decision. For example, when recognizing a button and pressing the button, the RP peaks are observed 200 ms before the initiation of the movement. It has been known that the preparatory movements are acquired before actual movements, but it has not been still well understood how humans can obtain the RP during their growth. On the proposition of why the brain must respond earlier, we assume that humans have to adopt the dangerous environment to survive and then obtain the behavior to cover the various time lags distributed in the body. Without RP, humans cannot take action quickly to avoid dangerous situations. In taking action, the brain makes decisions, and signals are transmitted through the Spinal Cord to the muscles to the body moves according to the laws of physics. Our research focuses on the time lag of the neuron signal transmitting from a brain to muscle via a spinal cord. This time lag is one of the essential factors for readiness potential. We propose a firing pattern controller model of a motor nerve system considered innervation and jitter, which produces time lag. In our simulation, we adopt innervation and jitter in our proposed muscle-skeleton model, because these two factors can create infinitesimal time lag. Q10 Hodgkin Huxley model to calculate action potentials is also adopted because the refractory period produces a more significant time lag for continuous firing. Keeping constant power of muscle requires cooperation firing of motor neurons because a refractory period stifles the continuous firing of a neuron. One more factor in producing time lag is slow or fast-twitch. The Expanded Hill Type model is adopted to calculate power and time lag. We will simulate our model of muscle skeleton model by controlling the firing pattern and discuss the relationship between the time lag of physics and neurons. For our discussion, we analyze the time lag with our simulation for knee bending. The law of inertia caused the most influential time lag. The next most crucial time lag was the time to generate the action potential induced by innervation and jitter. In our simulation, the time lag at the beginning of the knee movement is 202ms to 203.5ms. It means that readiness potential should be prepared more than 200ms before decision making.

Keywords : firing patterns, innervation, jitter, motor nerve system, readiness potential
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