Journal of Cardiovascular Disease Research

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 09, 2023

NEUROLOGICAL LEARNING FROM FEEDBACK TO FEED-FORWARD A PERSPECTIVE

Dr. Geetha Shavali, MBBS, DTRD, MD
Associate Professor, Department of Physiology,
Osmania Medical College.

All biological systems work on the principles of oscillatory dynamics and optimization. There is always a range in which the system works. For instance, the heart beats at a range of 70-80 times per minute, the lungs inflate and deflate at a rate of 14-18 times per minute. Every joint moves few degrees on either side of a particular axis optimally. The eyeballs also move in an oscillatory range covering the surrounding field of vision. In the same manner the neurological learning also occurs in an optimal limit by increasing or decreasing the quantity of the neurotransmitter in the various synapses, thus strengthening or weakening the pathways. There is a lot of synaptic pruning occurring in the neural development to define the definite sensory and motor pathways. Majority of the neural control is attained in the childhood itself by motor learning behaviors. In adults, most of the motor activity becomes intrinsic and stereotyped.

Every motor activity performed by an organism in its lifetime is an example of neurological learning which is being performed at its best in all spatial and temporal constraints. Each activity learnt is evolving from feedback to a feed-forward circuitry. A toddler, as he tries to get up and take a step, falls down. He tries to get up again and do the same activity measuring the errors of his target. He does the same activity umpty number of times, gaining progressive correction until he achieves perfection by assessing the exact error. This learning happens in a negative feedback mechanism correcting the error step-by-step. Once he achieves this, the neurological network memorises the exact approximation to perform that act. With increase in the frequency of doing this act, the synaptic pathway gets strengthened. Let us take another example of mimicking a song which we love to listen to. First, we start humming, trying to match the varied frequencies and amplitudes but we fail to match the pitch, interval or the timing of each word. We try to correct and do it again decreasing the error this time. We repeat the words and music a number of times to match the original timbre and frequencies. That is, we are trying to improve it in a feedback manner, word-by-word, rhythum-by-rhythum and once we master it, the neurological learning goes into a feed-forward circuitry and we become very confident of singing the song with perfect frequencies. Even before we utter the words of the song from the mouth, all the extrinsic and intrinsic motor muscles are set into action for uttering those words.

Feed-forwardness is responsible for the expertise and refinement of any skill. It is the basis of all the reinforced learning. It is the basis for perfection in revision. The neurons responsible for any motor activity start firing slowly when the action is performed for the first time. Then on repetition, the firing speedens up, synaptic strengthening occurs. Initially there is a physiological pattern established in the brain due to the feedback learning. This changes to an anatomical pathway with synaptic pruning and plasticity exhibiting feed-forwardness.

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Initially, every act is learnt in a negative feedback mechanism, attains perfection by internalizing or strengthening the anatomical pathway and the act is then performed in a feed-forward manner. This is how every motor activity is becoming an involuntary reflex activity being controlled at the spinal cord level. When any newer activity or newer movement is to be performed or when the biological system encounters any harm or danger, then only the higher centres get involved. Most of the physical activities in our lives are repetitive synchronous acts from childhood to old age which the system has learnt in a feedback mechanism and attained perfection to perform in a feed-forward manner. Being feed-forward is advantageous to the system to perform the same acts but within optimal limits. For instance, if one is asked to race a distance of one kilometre, the heart rate increases by 5-10 beats even before the initiation of the race, preparing the system to perform the act aptly. But if the same heart rate increases by 20-30 beats per minute it may be harmful to the biological system. In the same manner whenever a particular motor activity is being performed the neurons in the established anatomical pathway also should fire synchronously only in an optimal range so that the motor or the effector part of the body does not overshoot or undershoot and the activity is performed precisely. Though in feedforward circuitry still the neurological performance occurs on optimization principles attaining the maximum benefit from minimal input.

KEYWORDS

Neurological learning; feedback circuitry; feed-forward circuitry; optimization principles; synaptic pruning; synaptic plasticity.