Module 4. Integrative reading

Does a motor logic exist? Does an athlete reason before programming a movement? If they do, how is this reasoning different from normal reasoning that we do in other types of situations?

We understand that yes, they do reason. It involves probabilistic inductive inferences, where we do not have time to linguistically translate the perceptual information. That is to say, what perception adds is the premise of reasoning with the possibility of being linguistically translated.

If an athlete, in a fast-paced playing situation, had to transform all of the perceptual information into linguistic wording, they would lose—for reasons of time—the opportunity of choosing the correct motor program. We reason regarding the base of perceptual information that we do not have time to translate to linguistic wording, but this reasoning depends on the quality of the motor program that we choose in distinct sport situations.

We can then create a distinction between what we call **physical education through movement** and **physical education for movement.** When we refer to education through movement, we try to get our students or trainers to reason according the motor alternatives to solve situations. On the other hand, education for movement forgoes this reasoning step, by way of simply reproducing what is shown and the only decision made is to start or to not start the movement.

Not every sensation we have is subject to our conscious, we have different representations through the day. Many times, images are impossible to stop, they flow without control; nonetheless, it does not involve thinking. Thinking is deeper and more complex, although it is something which is sustained in images.

Representing simply means generating and sustaining an image, which we do on a regular basis throughout our lives. In movements, we can train them as skills. **Thinking**, on the other hand, includes a major process, it includes creating a strategy, which is able to forgo images.

Many times, movements are so fast that we can neither generate nor sustain them and much less list, classify and assess options in order to finally choose the most convenient based on the context. It would also be incorrect to think during execution because this produces the phenomenon of **paralysis by analysis**: when we try to generate and sustain images or assess options at the same time that we should be controlling rapid and complex movements. The problem is when and how to do it, not imagining or thinking.

It is important to know when we should think in order to make decisions and at the same time we must know about the aspects we have to be able to decide. Those aspects are: **technique, tactics and strategy.**

When we speak about decisions inherent to **technique**, we say they are fundamentally sustained to action by the pre-motor cortex. Technique decisions correspond to area 6: this area determines which muscle groups and fascicles are appropriate for the determined action. This moment is critical so that everything which happens afterwards can be successful in the sport.

When we speak about **tactics**, we refer to putting in motion all of the previously chosen physical process by the pre-frontal cortex, faced with an environment that can be more or less changing, and the rival that we are up against. This is when an athlete should choose the most appropriate tactical intentions that help their team, or themselves, to achieve the objectives put forward by their strategy.

We must understand **strategies** as a plan to achieve an objective. Within this plan we have to address various aspects that influence its development. In order to make the best possible decisions, each member must be aware of every aspect of competition and from there, develop a strategic plan that helps their team or students achieve the objectives put forward at the beginning. This type of planning, in general, is not urgent in nature.

When we speak about **decision making**, emotional states must also be mentioned, which influence this process. The proprioceptive and interoceptive corporal map not only contributes to feelings but also to complex social behavior. Visceral responses mark potential options as advantageous or not.

The brain also has a system that transfers external stimulus to internal visceral changes which account for its relevancy; we can see here the relationship between interoception and the medial ventral cortex. Emotions, in some way, modify the hormonal interoceptive state. They also modify physiological values and these markers, still being unconscious, condition the decision making processes.

We could summarize everything by saying: every individual that interacts with their environment has the ability to feel and through that sensation, creates images, processes them and modifies their behavior.

Distinct regions of the nervous system exist that have different functions related to the decision making process. Among them are:

- VMPFC (ventromedial prefontal cortex).
- MOFC (medial orbitofrontal cortex).
- DLPFC (dorsolateral prefrontal cortex).
- AN (Amygdala nucleus).
- OSB (opto-striated body).

The action of deciding has three clear moments. It involves three sequential steps that not only occur in sport but in general life as well.

Each one of these moments has a nervous structure associated with it:

- **Assessment:** also called multi-behavioral assessment, is implemented by the ventromedial prefontal cortex associated with the striatum.
- **Choice:** is implemented in the lateral prefontral cortex and the parietal areas and involves the options itself.
- **Action:** is the last implementation that advances the movement and its correlates are the least known.

In the process of assessment, decisional markers integrate various dimensions of only one option into a subjective value and then the best option is chosen: it is the **subjective consideration of value**. Here the VMPFC and the striatum are involved.

Choice involves choosing based on a value. It is then sent to the motor cortex to be implemented. The following areas are involved: parietal frontal cortex, lateral parietal cortex, the premotor cortex, supplementary motor area and the motor cortex, which indicates a strategy based on various actors.

Each system has evaluative exclusivity. Thus, each system codes the same value for the same action in a different way.

Action is in charge of the motor centers located within the medula, which sends efferent signals to create a movement. At the same time, other nervous system structures will influence the motor action, regulating it, comparing the executed action with the desired action, facilitating coordination.

Decision making is explained by the three following systems:

- **Pavlovian systems:** this system considers the study of simple approximations between stimulus and response.

- **Habitual systems:** these include the relationships between stimulus and responses that do not quickly adapt to change, risk or the depreciation of reward.
- **Goal oriented systems:** The relationship between stimulus and response that quickly adapt to risk and depreciation of awards.

Faced with the three possibilities we ask ourselves: Is there another possibility which is better than the latest model? Could the different dynamic systems add different aspects? The **decision making mechanism** is the means which through an individual applies their cognitive abilities to the necessities that each motor task requires; overall, the performance block where thought abilities are located.

In order to achieve this objective, practical situations should be practiced, where motor logic becomes progressively more evident. This in turn, will increase the chances of overcoming similar situations in life.

Decision making training refers to submitting the subject to situations which constantly involve different brain areas throughout the decision; it advances context where the subject makes decisions the whole time, in other words, making decisions which are implicit to the situation. Overall, this involves a greater utilization of the prefrontal area.

Sport in itself is a completely uncertain context where athletes choose from one second to the next their actions, where they will go, who they will defend, where they will look. It would be disadvantageous to not have this principle present while making decisions about processes to achieve performance during sport.

Within this course, Sanchez Bañuelos has been cited multiple times related to decision making training. It is important at this time to stress variable and decision classifications set forth by this author, who analyzes four variables in order to study the process of decision making in sport:

- Quantity.
- Time.
- Uncertainty
- Risk.

The author also mentions both a hierarchy and sequential organization of decision making which determines its level of complexity. Understanding sport logic, we divide them in the following way:

- **Low organization:** Typically used in team sports, with a changing environment and diverse task goals.

- **High organization:** Composed of a sequence of set actions and with a link provided to decision making, used in gymnastic and dance routines.

Related to quantity, we reiterate:

- **Number of decisions** The number of decisions made by an athlete depends on factors such as the diversity of the goals, the time to decide and the complexity of the task.
- **Number of alternative responses:** According to the nature of each sport, situations exists where the quantity of alternative responses is very limited or even zero, and others where each game situation has multiple solutions. Thus, a larger number of decisions can be made (Bañuelos S. , 1990).

Related to certainty:

- **Random:**
  - Random: are those variables where the predictability of events is minimal and, thus, decision making is more complex and is not exempt from emotions.
  - Competition: Random variables can be adversely complicated by an intelligent opponent, which involves higher demand and stress during the process.

- **Non-random:** These are activities where there is a very high level of predictability and, thus, the difficulty of the decision making process is low and other factors determine success.

Related to risk:

As was mentioned in previous units, emotions can reduce decision making processes. Risk presented by an activity can trigger emotions which go against our objectives, for example, fear.

In order to avoid fear we propose:

- Good methodological progression.
- Give set patterns.
- Work sensations and perceptions.

Related to time:

The time to make decisions is a constant variable in team sports, where the context demands a greater quantity of decisions to counteract situations that the actions of our opponents negatively affect our aim.

The time to make decisions depends on other things:

- The objective.
- The environment and its modifications.
- The subject's physical capacity. (Suárez, Rodríguez, Ramos, Trujillo, & Silva, 2013).

One of the central themes of this course is what we call, motor programming.

One of the most important authors in this area is Nikolai Bernstein, who understood movement as the lens to see and understand the human mind and his greatest challenge was whether movements are repeated or not.

The traditional position (Pavlovian) understood that yes, different movements can be identical. Nonetheless, Nikolai Bernstein opposed this concept stating that movements are not repeated when the subject's functional level of organization is increased. The functional complexity of humans does not allow for the possibility of movements to be repeated. The theory states that human beings do not repeat movements but on the other hand, basic, low complexity unicellular organisms do. The higher the complexity, the less possibility to repeat, thus each human movement is different. The statement that movements can be repeated connected perfectly with the political ideology of Russia at the time.

This is where we get the concept **motor programming** from, which consists of pre-establishing a sequence of actions before they occur. Overall, it establishes beforehand a sequence of muscular activations in a precise order. In neural terms, it loads a pattern of specific connections between the nervous and muscular system, whose deployment, organized in time, is the said movement.

We distinguish between two dimensions that make up the act of programming. On one side, **invariants or engrams**: this is what we store with respect to movement, as patterns of neuronal connections and motor memory. On the other side, **parameters**: the protagonists of action which do not form a part of motor memory but are required for programming.

Programming a movement is an action, in a way that we are not talking about an anatomical structure, but about a function that requires anatomical correlates. The **act of parameterizing an invariant** consists of: choosing the most appropriate protagonists so that the unfolding of the engram is successful in terms of the best possible adaption to the environment, for survival as much as reproduction. Therefore, it includes a decision to choose, between alternative protagonists, the best ones. The parameterization of an invariant creates, as a result, a series or sequence of muscular activations which, unfolding, create the movement.

Parametrization, in other words, choosing the protagonists, is done by a stable base, which stores movement and is called an engram. Taken from the Greeks, it is the idea of a footprint or line (gramma) that is written onto the brain, it is a structure of stable neuronal connections, a specific circuit of associated and involved neurons in a concrete spatial disposition. They configure the deep architecture of our brains. It is a specific circuit and it creates a network of neuronal connections that generates movement. They are called engrams because of their relationship to each other in order to determine specific responses; in this way they are comparable to gears. It involves the activation of a system of neurons produced by an efferent effect of the excitation of either internal or external nerve endings. In this way, they stimulate the activation of efferent, stable, neuronal structures, which are responsible for movement.

It is important to mention **motor memory**, of which engrams are substrates. Memory is based on the reactivation of engrams, they are traces that separate and identify us. From this perspective, we could also define engrams as the neurophysiological footprint on the brain and as the base of where memories are stored. In short, as a circuit made up of neurons which, when requested, recruits muscle fibers and, in this way, forms a specific motor activation pattern.

Traditionally engrams are recognized as having two basic parts: spatial and temporal structures. The **spatial structure** refers to the where or the topographic relation of the different articular nucleus involved (contingent), while the **temporal structure** alludes to the specific sequences of actions and, above all, there temporal proportion. The spatial structure refers to the where, which distinguishes that movement from the rest, as the temporal refers to the when or the sequential deployment of the movement, also called *phasing* (Jacques, 1988).

Lastly and as a main focus, we will review the concepts of voluntary movement and reflex movement. We remember that the majority of human adults have the strong sensation of having control over their actions, to act in a manner of their choosing. It would be interesting to know what that sensation consists of.

The capacity of voluntary actions is so fundamental to our social existence that limits and prohibitions are carefully justified and regulated. **Voluntary action** could credit different character disorders, created by pathological states such as transiently, by ingesting disturbing substances. Other states and mental processes, especially emotions, along with other deeper and more rooted processes, could change normal inherent functions of voluntary action.

We understand voluntary movement from its contemporary viewpoint, which defines it as the end of a continuum that was begun by a reflex. We can then show the differences between voluntary and reflexive movements.

Reflexive movements include the following characteristics:

- Immediacy.
- Required external stimulus.
- Its shape, occurrence and timing are all determined by stimulus.
- Spinal level.
- Without the possibility to veto.
- Without the possibility of prospective memory.
- Without decisions.

Voluntary movement on the other hand is characterized by:

- Mediacy (free of immediacy).
- An external stimulus is not required.
- It does not depend on stimulus.
- Cortical level.
- The possibility to veto or continue the action.
- The possibility of prospective memory.
- The possibility to decide objectives, actions, programs and to veto or not.

To understand the connection circuits that characterize one from the other we will further clarify the conceptual framework of these differences:

- **Cortical circuits for voluntary movement:** these circuits converge at the MP1. MP1 executes motor commands transferring them the spinal medulla and muscles. MP1 is the final common pathway of the cerebral cortex; the motor neuron of the spinal medulla. It receives inputs from two circuits: one specific to voluntary movement and the other specific to reflex movement, although there are other areas that project to the medulla, which receives input from the same circuits. On a cortical level, there are two clearly alternative itineraries and two cortical circuits, namely:
    - On one side, the **PMC circuit and BG with pre-SMA**, which connects the basal ganglia to the pre-SMA cortex and the premotor cortex with the pre-SMA, lastly, to the MP1, the final common pathway.

- On the other side, the **PMC-parietal circuit,** which also converges at the MP1 and connects the sensory sectors of the parietal cortex to the pre-motor cortex and lastly, to the MP1.

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