Integrative reading

Among the most important functions of the nervous system is that of obtaining information about the physical and chemical conditions of the internal and external environment of the body, and of changes that occur. This information becomes crucial for maintaining homeostasis, counteracting heterostasis, and adapting to environmental conditions. In all sensory systems that are common characteristics, both in their anatomy as well as in the basic functions of their components.

Let's begin defining a **sensory system** as a group of organs, paths, and neural processing centers specialized in collecting information from the environment, both external and internal, whose integration enables triggering the final steps related to motor programming and implementation itself. In fact, input from the sensory systems are crucial in motor adjustments once the movement has been discharged from the cerebral cortex. This refers to a set of structures that have been shaped throughout evolutionary history to collect relevant information that we need for further development of adaptive behaviors.

We can find the following components within the sensory systems:

- Receptors: histological anatomic structures specialized in the reception and transduction of a particular sensory stimulus.
- Parareceptors: histological anatomic structures related to the receptor that protect, collaborate and amplify the gathering of information.
- Afferent pathways: made up of a group of sensory neurons that transport information towards higher centers.
- Integration centers: anatomical centers within the central and peripheral nervous systems that serve as a relay and commute information (spinal cord, dorsal root ganglion, thalamus).
- Cortical projection areas: specific sections of the cerebral cortex where sensory information first arrives for its later analysis (17, 42, 3, 1, 5, 7).

The receptors are the first element that makes up the sensory system. **Receptors** are either non-neural cells or nerve endings that are adapted and specialized for the initial collection of information, both from external and internal environments.

Receptors are classified as:

- **Interceptors**
    - Visceroreceptor: inform about the status of our organs that are not directly linked to posture and movement (among which we can consider those systems that provide vascular, cardiac, respiratory, or digestive information, and even from endocrine and immune systems, without overlooking the nociceptors).

    - Proprioceptors: we include not only those that provide information about tendons, muscles and joints, but also those receptors that provide information about the vestibular apparatus. And above all, fascias (that is, the different systems specialized in posture and movement control).

- **Exteroceptors:**
    - Vision
    - Hearing
    - Touch
    - Taste
    - Smell

Below we will describe some functions that are inherent to the sensory systems:

- All sensory systems have an afferent neuron, an integration or commutation center, as well as a primary projection area and an efferent pathway to modulate motor activity.
- An afferent neuron is that which transmits information from the receptor to the integration centers in our PNS. There are some of these sensory neurons that carry special interest, like the IA and IB and IIA for example, which provide proprioceptive information to the central nervous system and which, for the quality of information they transmit, without overlooking the work of the receptor itself, are largely responsible for the ability to recognize our positions and finally regulate the control of our movement.

Regarding those elements that make up the sensory physiology, they are:

- Adequate stimulus.
- Sensory unit and receptive field.
- Transduction and analog-digital conversion.
- Post-discharge.

- Adaptation, and Neural message parameter.

Of the mechanoreceptive receptors, we will focus primarily on the proprioceptors. When we talk about **proprioceptors**, we can identify various types with different functions and with afferent neurons that communicate to the CNS and transmit information with different codes to be interpreted. Drawing from here, controls that are more relevant to the motor act can be generated. There are different receptors depending on the structure in which they are located. Among these types of receptors we find:

- Muscular: Muscle spindles.
- Tendinous: Golgi tendon organs.
- Joint: Ruffini receptors.
- Ligaments: Golgi receptors.
- Capsular ligament insertion: Vatter and Paccini receptors.
- Cutaneous: Meissner's, Golgi-Mazzoni and Paccini corpuscle.
- In fascias: III and IV, and Golgi receptors.
- Vestibular: utricular and saccular maculae, and ampulla of the canals.

Let's return to the idea that these dimensions are trainable. Processing this information at high quality and in the least amount of time possible makes all the difference in performance. In this context, it should be clarified that:

- The **proprioceptive sense** is what offers the most clear chances of training since it is possible to configure clear and convergent dimensions of approach.
- The **tactile and haptic sense** can improve over the course of a lifetime, and what happens with subjects that lose their vision is a clear example of this adaptation.
- The **vestibular sense** presents a methodological challenge, with equal chances for improvement as the other mechanoreceptive dimensions.

Training objectives:

- Improving equilibrium.
- Posture improvement
- Prevention and correction
- Falls prevention
- Improving gait.
- Detection of alterations

Proprioceptive training is not the same as equilibrium training. **Equilibrium**, ultimately, puts all sensory systems into play, but when canceling out the visual sense, proprioceptive involvement is boosted. Keeping balanced not only puts proprioception into play, but also the whole set of mechanoreceptors integrated with the rest of the interceptors and exteroceptors.

A system with less prominence, but no less importance, is that of the **tactile sense**. The objectives of this training are to improve final motor adjustments in countless activities in daily life and in sport motions, encouraging proper applications of force in activities of taking and gripping, and improving the recognition of shapes and textures of the effects of adjusting object manipulation tasks.

We understand that tactile training methodology does not differ much from the tactile sense, simply because it is impossible to train the tactile sense without movement and parallel proprioceptive stimulation. The integration of the tactile and proprioceptive senses results in what is called the **haptic sense.** Let's remember that this implies the integration of touch and proprioception and that, therefore, the majority of human actions demand this sense. We are constantly using the haptic sense, like for example, when we touch our faces countless times a day.

Other sensory systems that we consider key when thinking about motor function is the exteroceptive sense of **vision.** Processing speed and image construction are key for motor functions also involved in survival.

Broadly, the process of seeing is comprised of:

1) Light, coming from the sun or from other sources, strikes objects and is reflected by them.
2) Visible light penetrates the eye, crosses through many transparent parts and is refracted, and consequently forms an inverted image of the object on the surface of the retina.
3) The retina transforms signals (action potentials generated at different frequencies) that, through the optic nerve, set out for the integrative centers of the CNS.
4) The information from the retina is processed in complex neuronal groups, primarily located in the thalamus, the brain stem and the cortex; sensation and visual perception emerge from this integration.
5) As a final stage, there is a motor adaptation of the eye as an instrument of external information collection.

Visual processing is, almost in its entirety, highly trainable and can be improved at all developmental stages. The general bibliography, for its part, presents a great variability of exercises, but little systematization.

The types of vision are:

- Peripheral.
- Central: central vision can be responsible for tracking or detecting objects.

As far as **central vision** goes, the most important activities are visual tracking and detection. **Peripheral vision** is defined in relation to central vision and its training is crucial for sports and DLAs. The most viable possibility for peripheral vision is detection and the potential for training the vestibulo-ocular reflex or VOR.

The three main pillars of visual training methodology are:

- Contents: refers to the types of vision that we choose to train and the specific aspects of each.
- Exercises: refers to the large examples of tasks and activities that we can develop and that are transferable to different sports or daily living activities (DLA).
- Variables: refers to the possibilities of systematically increasing the difficulty of exercises, or simplifying them, so that they will be accessible to all.

Our suggestions for your training are:

- Concentrate on the nature of the specific visual processing of the sport you work with: central and peripheral objects, interferences, backgrounds, etcetera.
- Select a typical situation for that sport and take on the task of designing a set of exercises specifically adapted for the visual function.
- Try to systematize a rational progression based on the different variables mentioned earlier and which we will analyze below.

Other highly important systems when talking about motor function is the **auditory system.** It is of vital importance in physical activities as it is key for motor control; for example, in sports with bouncing or hitting actions and in the majority of sports where we find auditory disturbances. Sound is the stimulus that suits the auditory receptor. It is a type of mechanic energy comprised of tiny variations in pressure in the environment, which spread at high speed (340 m/s) in all directions from their point of origin. The auditory sense is comprised of three layers: **External, middle, and inner ear**, each one with specific functions like transport, amplification, and conversion of mechanic energy into a nerve impulse.

The ear also has other non-auditory structures which are the **vestibular system**. The system consists in multiple sensory impulses from vestibular organs, the visual system, and the somatosensory and proprioceptive system. Within the functions of the vestibular system we find:

1) Informing the central nervous system of any angular or linear acceleration or deceleration.
2) Helping visual orientation through control of ocular muscles.
3) Controlling the tone of skeletal muscles in order to maintain proper posture.

We clearly discern at least three possibilities that we will introduce below. All of these options refer to functions as well. The option with the greatest therapeutic power is vestibulo-ocular reflex work. However, the other two offer interesting methodological alternatives and possibilities:

- Accelerations.
- Rotations-turns.
- Vestibulo-ocular reflexes.

Sensory systems have the possibility of being trained. Sensation gives information to the central nervous system to then make the object of knowledge, at which point the phenomenon of **perception** starts to form part of or take on a predominant role. Sensation and perception are both trainable, but the difference is that perception is a creative and constructive phenomenon and proves more trainable than the phenomenon of sensation.

It remains a mystery how our brain combines information (generated through perception), integrates it and constructs a unified object for consciousness. The problem of unifying everything we perceive is that there is no part of the brain in which all information converges to be integrated and, thus, made into an object for consciousness (despite there being hypotheses like Koch and Crick's 40 Hz). Perception is more trainable than sensation. The act of perceiving in and of itself is an act of muscular activation. Let's remember that sensation does not yield errors. It reaches the cerebral cortex just as it was in the primary cortices, i.e., just as it was commuted in the relevant centers. However, the phenomenon of perception can yield errors because the subject's interpretation of the object comes into play, that is, there is an interpretative process involved.

It is crucial to understand that the quality of sensations will depend on the quality of our perceptions and, in turn, the quality of these perceptions will depend on the quality of the posterior ideomotor representation. The act of **ideomotor representation** is an act with huge neural consequences, that can either facilitate movement, or impair it when there is distrust in the use of this tool, or when we fail to correctly represent movement in our mind, that is, without fluidity or with interruptions.

Vision is important for the construction of the image, but the image is much more complete when the person can create information for consciousness that is not just visual, but also kinesthetic. Let's remember that when we represent what perception initially presented—and this through an act of volition that generates and sustains motor imagery for consciousness—not only are we facilitating neural pathways that later adjust, control and regulate the movement, but we are also increasing muscular microactivity expressions with stimulation of the proprioceptors. Today we know that even the intrafusal fibers and the Golgi organ become activated when we accurately imagine a movement even if we are not actually executing it.

It is not all about the CNS, rather the act of imagining also impacts alpha motor neurons, gamma motor neurons, proprioceptors (mainly intrafusal fibers and the Golgi tendon organ).

For your training it is important to keep the specific sessions in order:

- Preliminary.
- Imagining.
- Microactivations.
- Macroactivations.
- Additional tasks.

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