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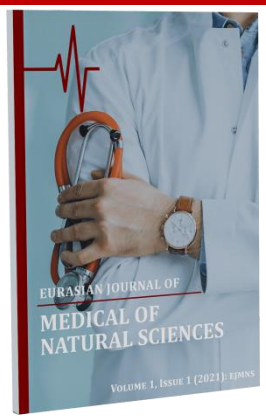

CENTRAL SYSTEM

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ABSTRACT

This comprehensive article delves into the multifaceted world of the central nervous system (CNS), encompassing the brain and spinal cord. It explores the intricate anatomy and functions of the CNS, shedding light on sensory processing, motor control, cognitive functions, and autonomic processes. The article also delves into neural communication, the protective mechanisms safeguarding the CNS, and the dynamic nature of neuroplasticity. Disorders affecting the CNS, diagnostic techniques, therapeutic interventions, and the future of CNS research are thoroughly examined. By providing a holistic overview, this article serves as an insightful resource for understanding the pivotal role of the CNS in orchestrating the complexities of the mind and body.

Introduction. Give a brief description of the system, including its name, acronym, and the program's or system's intended use. The Federal Student Aid (FSA) office within the U.S. Department of Education (Department) is responsible for managing the Central Processing System (CPS). Title IV of the Higher Education Act of 1965, as amended (Title IV) permits FSA to process individual electronic or paper Free Application for Federal Student Aid (FAFSA) applications. CPS is used to do this processing. The general support system (GSS) of the Next Generation Data Center (NGDC) hosts CPS. When individuals submit applications for aid, CPS determines their eligibility for financial aid and notifies them (because on the internet or by U.S. mail) of their eligibility as well as the kinds of aid that are available to them (loans and grants)

The results of the eligibility calculation are sent to institutions of higher education (IHEs) by the CPS using the Student Aid Internet Gateway (SAIG) system of the Federal Student Aid (FSA). IHEs then utilize the data from the ISIR to come up with award packages the fact that

could include loans, grants, and school-based scholarships. Prior to enrollment, applicants receive award packages to assist them in making attendance decisions.

The clinical use of electrical stimulation of the central nervous system (CNS) to treat a wide range of conditions, including epilepsy and Parkinson's disease (PD), as well as for sensory restoration and many other purposes, has advanced greatly over the past few decades. On the other hand, little is understood about how microstimulation influences cells. The majority of current research focuses on how electrical stimulation impact neurons. The response of other CNS cells, including oligodendrocytes, astrocytes, microglia, and vascular endothelial cells, to stimulation hasn't attracted as much research attention. We are starting to gain a better understanding of these cell types' diverse and essential roles in brain function in both health and disease are becoming better appreciated. . This review will first summarize common stimulation modalities from the perspective of device design and stimulation parameters and how these different parameters have an impact on the physiological response in order to shed light on the significance of how electrical stimulation, as distinct from device implantation, impacts non-neuronal cell types. Afterwards, an overview of what is known now regarding the responses of various cell types to various stimulation modalities will be provided, making use of data from clinical trials, clinically relevant animal models, and in vitro systems.

Clinically relevant approaches to electrical stimulation of the central nervous system.

Hundreds of thousands of patients with neurological disorders now enjoy an improved standard of life thanks to clinically available electrical neuromodulation technologies. Deep brain stimulation (DBS) has proven to be the most effective method for treating movement disorders (Lozano et al., 2019). The choice of stimulation parameters and electrode configuration is crucial for achieving the intended therapeutic effects. whereas electrode materials and stimulation paradigms have a significant impact on stimulation efficacy and safety, electrode device placement, size, and material composition find out the specificity of neuronal recruitment. The following sections provide descriptions of the electrode construction, material composition, and stimulation parameters for common clinical applications of electrical stimulation, and these are summarized in Table 1. Since electrical stimulation is a rapidly developing field, this list does not represent an exhaustive list of paradigms; rather, it demonstrates some of the more effective and broadly applicable clinical modalities in electrical stimulation of the central nervous system.

Invasive neurostimulation devices utilizing pulsatile current stimulation.

First, we will briefly review some of the more well-known neurostimulation processes that need to be surgically implanted into the central nervous system. Most of these modalities use alternating current stimulation, and biphasic pulsatile stimulation with pulse widths of hundreds of microseconds is frequently employ. The cortex, subcortical ganglia, and spinal cord are among the target regions. Depending on the therapeutic target, electrode configurations can be either macroelectrodes or microelectrodes. The most literature has been produced on DBS and ICMS of these modalities, and these will be the subjects of this review's subsequent sections. For the sake of completeness and to give a broader overview, other emerging modalities are mentioned here.

Responsive neurostimulation.

Responsive neurostimulation (RNS) is a brain-responsive neurostimulation system approved by the FDA to manage drug resistant seizures, which make up about 30–40% of the total number of patients with epilepsy. Nair et al. (2020) published a 9-year prospective study on the efficacy and safety of RNS for focal epilepsy and reported the median reduction in seizure frequency to be 75%. Stimulation was well-tolerated, and adverse events were similar to other neurostimulation devices. RNS is a closed-loop brain responsive neurostimulator. Unlike DBS, the RNS system includes a cranially implanted neurostimulator. Stimulator units can power both depth leads (1.27 mm diameter, 2 mm length, 0.08 cm2 surface area, Pt/Ir) and cortical strip leads (3.175 mm diameter, 0.08 cm2 surface area, Pt/Ir) depending on the epileptogenic loci being targeted (Jobst et al., 2017). Each lead typically contains four electrode contacts. Via these contacts, the electrocorticographic (ECoG) signal is continually monitored and the device is programmed by the physician to deliver stimulation in response to defined patient specific ECoG patterns which are determined by the physician to be predictive of a seizure. Stimulation parameters can also be adjusted by the physician to achieve the best seizure suppression. This closed-loop stimulation paradigm could have potential benefits compared to continuous stimulation, and it will be interesting to see how this technology develops.

Spinal cord stimulation

Chronic pain can be managed with the invasive procedure known as spinal cord stimulation (SCS). The SCS pulse generator is pushed under the skin, and leads are inserted into the spinal cord to deliver electrical stimulation. nevertheless up to 30% of SCS patients experience no persistent pain. The electrode material used in RNS and DBS is also used in spinal cord stimulation. A paddle-shaped lead with evenly placed oval or circular electrode contacts in multiple rows—usually three or more—that come into close contact with the spinal cord after implantation is a typical lead construction. The contact sizes of these leads are measured in millimeters.

Microstimulation devices. Intracortical microstimulation

A partial restoration of tactile and visual perception is made possible by intracortical microstimulation (ICMS), which uses arrays of closely spaced microelectrodes implanted in the cortex to deliver tiny amounts of current. It is helpful for people with sensorimotor dysfunction to cultivate dexterous prosthesis control. Microelectrodes with geometric surface areas of less than 5,000 μm2 are commonly used in ICMS. Due to the high spatial selectivity provided by the small electrode size, a greater range of stimulation parameters could be a possible, potentially evoking a wider range of perceived sensation in the patient. In keeping with a recent review by Zheng et al. (2021a), the surface coating material for stimulating microelectrodes is usually a sputtered iridium oxide film, though other materials are also being tested.

Non-invasive neurostimulation devices utilizing direct current stimulation

While there are many different paradigms being investigated for non-invasive neuromodulation of the central nervous system, we will concentrate on transcranial direct current stimulation (tDCS) in this review because it is the most extensively researched. As opposed to implanted devices, tDCS uses electrodes that are orders of magnitude larger and uses direct current stimulation. The role of the intervening non-neuronal tissue is a vital consideration to take seriously when it comes to non-invasive neurostimulation.

Transcranial direct-current stimulation

Transcranial direct-current stimulation (tDCS) is a non-invasive electrical stimulation technique that employs electrodes applied to the scalp to deliver direct current at amplitudes between 0.5 and 4 mA. Despite studies have demonstrated its efficacy in treating pain (O'Connell et al., 2018) and depression (Bennabi and Haffen, 2018), the FDA has not yet approved it as a treatment. Scalp electrodes are utilized to deliver direct current, which alters excitability but does not produce action potentials. It has been demonstrated that motor cortex excitability can be increased by anodal (positive) current and decreased by cathodal (negative) current. The safety of brain stimulation is determined by several critical parameters, such as electrode size and shape, stimulation duration, current densities, and electrode shapes. Most studies reported a current density between 0.029 and 0.08 mA/cm2, electrode size between 25 and 35 cm2 with a stimulation current of 1–3 mA for a duration of 20–30 min. Additionally, most studies utilized conductive rubber or metal electrodes that are embedded in a sodium chloride-soaked sponge (typically between 15 and 140 mM NaCl). A comprehensive overview of the various tDCS stimulation protocols can be found elsewhere.

Though many electrical neurostimulation techniques have shown clinical success, there are still issues that need more studies. These difficulties can be divided into three categories: (1) material stability; (2) charge injection limit; and (3) tissue health and function. Zheng et al. (2021a), Merrill et al. (2005), and Cogan (2008) provide a detailed review of these issues. The roles that non-neuronal cells play in the effects of electrical stimulation have received less focus than neurons in this investigation. By comprehending how non-neuronal cells responded to electrical stimulation, important insights into the CNS's overall biological response to electrical stimulation are expected to be gained, which will help develop more reliable and efficient neural stimulation interfaces.

In order to obtain data necessary for the processing of applications for federal student aid, CPS communicates with a number of FSA systems. CPS acquires its FAFSA data from the studentaid.gov website, which is part of the DCC platform. The Postsecondary Training Participants System (PEPS) provides CPS with a daily file that contains data on all IHEs taking part in Title IV programs. To find high school codes, CPS obtains data from the National Center for Education Statistics (NCES). NSLDS provides data to CPS so that it can assess each student's eligibility for Title IV financial aid. Through the SAIG network, the Grant Recipient File is sent from COD to CPS. The email data record file, which includes details about the applicants who will receive emails related to the FAFSA, and the demographic data exchange are sent by CPS to COD (DDE) file (which contains processing information for all transactions processed since the last file was transmitted) via the SAIG network. Every day, CPS receives a file of records from the Person Authentication Service (PAS) that include names, birth dates, and social security numbers of current and potential students as well as parent identifying information. These records are then forwarded to the U.S. Social Security Administration (SSA) for Social Security number (SSN) matching. The validity of the parent and student SSNs is ascertained by this match. The results of a school's verification and documentation of a student's identity and high school graduation status, known as the Identity Verification Results Files, are sent from CPS to the Enterprise Data Warehouse & Analytics (EDWA). Federal student financial aid programs are described in detail by EDWA. All That is done through the SAIG, with the exception of the

FAFSA application, which is sent straight from studentaid.gov to CPS. To support application processing and eligibility verification, additional data are provided by other Federal agencies in addition to the FAFSA information submitted by applicants and other information provided by IHEs. The U.S. Department of Justice (DOJ) in deciding whether an applicant is on drug abuse hold; the U.S. Department of Homeland Security (DHS) for verification of applicants' eligible non-citizen status; the U.S. Department of Veterans Affairs (VA) to confirm applicants' veteran status; and the U.S. Department of Defense (DOD) to identify applicants with parents/guardians who died during service in Iraq or Afghanistan after 2001 are some examples of record match information from these agencies. In order to verify the SSNs reported, CPS also receives the SSA Death Master File, a list of all deceased people that the SSA has on file on the FAFSA and confirm eligibility. Information from these agencies is transmitted and received through the SAIG electronic file transfer system, with the exception of DHS, which uses a web-based secure file transfer protocol (SFTP).

Decoding the Central Nervous System: Orchestrating the Symphony of Mind and Body

The central nervous system (CNS) stands as the command center of the human body, orchestrating intricate processes that govern both voluntary and involuntary actions. Comprising the brain and spinal cord, the CNS plays a paramount role in cognition, sensory perception, motor control, and overall homeostasis. This article explores the anatomy, functions, and complexities of the central nervous system, shedding light on its pivotal role in maintaining the delicate balance that sustains life.

Anatomy of the Central Nervous System:

a. Brain: The brain, a marvel of complexity, is the epicenter of consciousness, thoughts, and emotions. Divided into regions such as the cerebrum, cerebellum, and brainstem, it processes sensory information, regulates motor functions, and controls higher cognitive functions.

b. Spinal Cord: Extending from the brain, the spinal cord serves as a neural highway transmitting signals between the brain and peripheral nerves. It plays a crucial role in reflex actions and serves as a conduit for both sensory and motor information.

Functions of the Central Nervous System:

a. Sensory Processing: The CNS receives and interprets sensory information from the environment, allowing individuals to perceive and interact with their surroundings.

b. Motor Control: Initiating and coordinating voluntary movements, the CNS ensures the precise execution of actions, from the simplest gestures to intricate tasks.

c. Cognitive Functions: Memory, learning, problem-solving, and emotional regulation are orchestrated by the CNS, reflecting its role in higher cognitive processes.

d. Autonomic Functions: The CNS controls involuntary processes, including heartbeat, respiration, and digestion, maintaining internal balance.

Neural Communication:

Neural communication within the CNS relies on a complex network of neurons. Electrical impulses travel along nerve fibers, and chemical signals, in the form of neurotransmitters, facilitate communication between neurons.

Protection and Support: The CNS is safeguarded by protective structures. The skull shields the brain, while the spinal cord is encased in the vertebral column. Additionally, cerebrospinal fluid provides cushioning and support.

Disorders of the Central Nervous System:

Disruptions in CNS function can lead to various disorders, including neurodegenerative diseases (e.g., Alzheimer's, Parkinson's), neuropsychiatric disorders (e.g., depression, schizophrenia), and traumatic injuries affecting the brain or spinal cord.

Diagnostic Techniques:

Advancements in medical imaging, such as magnetic resonance imaging (MRI) and computed tomography (CT), enable detailed visualization of the CNS, aiding in the diagnosis of structural abnormalities and pathological conditions.

Neuroplasticity: The CNS exhibits remarkable adaptability, known as neuroplasticity. It can reorganize and form new neural connections in response to learning, experience, and injury, underscoring its dynamic nature.

Therapeutic Interventions: Treatment modalities for CNS disorders encompass a range of approaches, including medications, physical therapy, surgical interventions, and emerging fields like neurostimulation and gene therapy.

The Future of CNS Research:

Ongoing research endeavors explore the intricacies of the CNS, aiming to unlock the mysteries of consciousness, enhance therapeutic interventions, and develop innovative approaches for neurodegenerative conditions.

Conclusion: The Nexus of Mind and Body: The central nervous system, a nexus of neural complexity, serves as the linchpin connecting mind and body. This article provides a glimpse into its anatomy, functions, and the profound impact it has on every facet of human experience. As research continues to unveil the mysteries of the CNS, a deeper understanding of its intricacies promises new horizons in neuroscience and improved treatments for neurological disorders.

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