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Review Article

Integrative Neuroscience: Linking Neuroanatomophysiology and Neuropsychopharmacology in Understanding Neurodivergence and Neurological Disorders

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Abstract

The integration of neuroanatomophysiology and neuropsychopharmacology links the structural and functional organization of the nervous system with the pharmacological modulation of neural processes, cognition, mood, and behavior, creating an interdisciplinary bridge between neuroscience and clinical practice. Differentiating neurodivergence, understood as natural variations in brain structure and function, from neurological disorders, involving impairments or degenerative processes, is essential for diagnostic accuracy and social inclusivity. Advances in neuroimaging, biomarkers, and targeted pharmacotherapies have enabled earlier detection, better characterization, and personalized interventions. This study aimed to analyze how these fields interact in understanding, diagnosing, and treating neurodivergence and neurological disorders through an integrative bibliographic review. Searches in SciELO, LILACS, BVSMS, and Google Scholar used controlled descriptors and free-text terms, with inclusion of qualitative review articles in Portuguese, English, or Spanish. Data extraction emphasized objectives, methods, and findings, prioritizing methodological rigor to integrate theoretical and applied perspectives for improved clinical outcomes.

Keywords: Neuroanatomophysiology, Neuropsychopharmacology, Neurodivergence, Neurological disorders, Brain structure and function, Neural modulation, Cognitive function.

1. INTRODUCTION

Neuroscience is using advanced high-resolution imaging to explore brain microcircuitry with unprecedented precision. For example, in vivo 7-Tesla MRI in non-human primates has revealed detailed microvascular architecture and mesoscale networks, enhancing understanding of brain connectivity and neurovascular coupling (Wang *et al.*, 2025).

Research on brain energy metabolism has shown how pathological conditions rapidly alter neuronal and astrocytic energetics. Furukawa *et al.* (2025) reported that a single epileptic seizure significantly reduces neuronal ATP and changes astrocyte pyruvate levels, offering new perspectives on energy dynamics during neurological stress.

Recent reviews in Neuroscience have highlighted the role of gut microbiota in modulating neuroinflammation and promoting neuroprotection. Garg *et al.* (2025) proposed microbiota-targeted therapies as promising strategies for preventing and treating age-related neurological disorders.

It is divided into the Central Nervous System (CNS) and the Peripheral Nervous System (PNS). The CNS, comprising the cerebrum, cerebellum, brainstem, and spinal cord, handles complex functions like sensory reception, integration, and motor responses. The PNS connects the body to the CNS and includes somatic and autonomic systems, with the autonomic system further divided into sympathetic and parasympathetic branches (Radanovic, 2015; Radanovic and Márcia, 2016; Afonso *et al.,* 2022).

The nervous system is divided into two main parts: The CNS, which includes the brain and spinal cord, and the PNS, composed of nerves that connect the CNS to the rest of the body. There is also the autonomic nervous system, responsible for controlling involuntary functions such as breathing and heartbeat. This structure allows communication between different parts of the body, regulating motor, sensory, and cognitive functions (Feder, 2009; Nicolelis, 2016; Jennifer *et al.,*2022; Aguilera, 2023; NIH, 2024).

1.1. Functions of the CNS

1. The nervous system is responsible for receiving, processing, and transmitting information throughout the body, ensuring communication between different organs and systems.
2. It regulates voluntary and involuntary actions, controlling muscle movements, reflex responses, and vital functions such as breathing and heart rate.
3. Sensory functions allow the body to detect changes in the internal and external environment, transmitting signals to the brain for interpretation.
4. The integrative function processes incoming information, enabling decision-making, problem-solving, and behavioral responses.
5. Motor functions translate brain signals into physical actions by activating muscles and glands, supporting movement and homeostasis.
6. The autonomic nervous system manages involuntary processes, including digestion, temperature regulation, and endocrine activity.
7. Cognitive functions like memory, learning, and language are also managed by intricate neural networks in the brain.
8. Emotional regulation and social behavior are shaped by interactions between the limbic system and higher cortical areas.
9. Neuroplasticity enables the nervous system to adapt and reorganize itself after injury or in response to new experiences.
10. Overall, the nervous system integrates physiological processes with environmental demands, maintaining health and survival (Pascual-Leone *et al.,* 2015; Bear *et al.,* 2020; Dalgleish *et al.,* 2020; Johnson, 2020; Hall and Guyton, 2021).

1.2. Objective

To analyze how neuroanatomophysiology and neuropsychopharmacology interact in the understanding, diagnosis, and treatment of neurodivergence and neurological disorders.

2.0. METHODS

This study adopted an integrative bibliographic review approach to synthesize all available references on the selected topic. Data were retrieved from the Scientific Electronic Library Online (SciELO), Latin American and Caribbean Literature in Health Sciences (LILACS), the Virtual Health Library of the Brazilian Ministry of Health (BVSMS), and Google Scholar. The search strategy employed a combination of controlled descriptors and free-text terms relevant to the research theme, adapted for each database to maximize retrieval sensitivity and specificity. The selection process involved sequential steps: screening of abstracts, full-text reading of eligible articles, and interpretative synthesis for text composition. Inclusion criteria comprised original qualitative review articles, available in full text, published in Portuguese, English, or Spanish, and aligned with the defined thematic scope and time frame. Exclusion criteria included duplicate records, studies outside the proposed theme, incomplete texts, and those lacking methodological clarity. Data extraction focused on study objectives, methodologies, key findings, and relevance to the research question. The preference for review articles was justified by their methodological rigor and scientific accuracy, ensuring a comprehensive, credible, and reproducible synthesis of the existing evidence.

3.0. SELECTION AND STUDIES

3.1. The key components of the CNS are:

3.1.1. Brain:

1. **Cerebrum:** Includes the telencephalon cortex, basal nuclei, hippocampus, and amygdala, and is responsible for cognitive, motor, and emotional functions.
2. **Diencephalon:** Includes the thalamus, sensory relay, and the hypothalamus for homeostasis.
3. **Limbic System:** Involved in emotions, memory, and social behavior.
4. **Brainstem:** Composed of the midbrain motor control, reflexes, pons (movement coordination), and medulla oblongata autonomic functions.
5. **Cerebellum:** Modulates movement, motor learning, and cognitive functions.

3.1.2. Spinal cord:

1. Transmits sensory and motor information between the brain and the body.
2. Coordinates reflexes and motor activities (Radanovic, 2015; Radanovic and Márcia, 2016; Afonso *et al.,* 2022).

The brain's components, such as the telencephalon, diencephalon, limbic system, brainstem, and cerebellum, are described with their roles in motor control, cognition, emotions, memory, and learning. Limbic system dysfunctions can lead to disorders like depression, apathy, and aggressive behavior. Microscopic anatomy of neurons, glial cells, and synapses, emphasizing neurotransmitters like serotonin, noradrenaline, and dopamine, which regulate mood, anxiety, and behavior. Diagnosing neurological conditions is highlighted, considering symptoms, progression, preexisting conditions, and family history. These components work together to integrate sensory input, process information, and execute motor responses (Figure 1) (Betts, 2013; Radanovic, 2015; Radanovic, 2016; Afonso *et al.,* 2022).

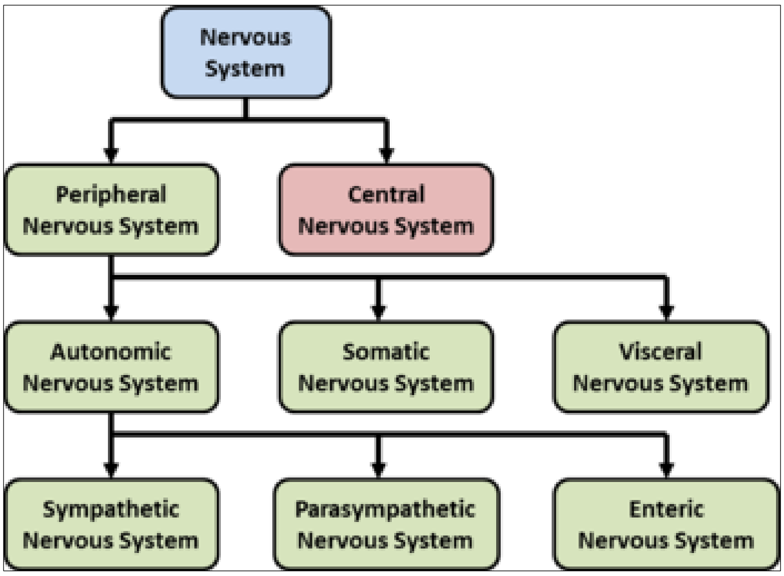

Figure 1: Divisions of the nervous system. The key components of the Central Nervous System CNS
Source: https://me-pedia.org/wiki/Nervous_system

3.1.3. Considerations about CNS:

1. **Complexity of the Nervous System:** The nervous system is intricately organized into the CNS and PNS, each with distinct roles in controlling, coordinating, and responding to stimuli. Specialized Functions of Brain Regions: Different parts of the brain, such as the telencephalon, diencephalon, and limbic system, have specialized functions related to motor control, cognition, emotions, memory, and learning.
2. **Impact of Neurotransmitters:** Neurotransmitters like serotonin, noradrenaline, and dopamine play critical roles in regulating mood, anxiety, and behavior, emphasizing their importance in mental health.
3. **Role of the Limbic System:** The limbic system is central to emotional processing, memory, and social behavior, and its dysfunction can lead to various psychological and behavioral disorders. Integration of Neuroanatomy in Learning: Understanding neuroanatomy and neurophysiology is essential for identifying, preventing, and treating learning disorders (Radanovic, 2015; Radanovic, 2016; Afonso *et al.,* 2022).

3.2. Neuroanatomy and Neurophysiology

The main components of the nervous system include the brain, which is the center of thought, emotions, and learning; the spinal cord, which coordinates movement and reflexes; the peripheral nerves, which transmit information to the brain; and the cerebral cortex, responsible for interpreting sensory stimuli such as sound, light, and smell. Each of these structures has a specific function, but they all work together, forming a complex communication network (Feder, 2009; Nicolelis, 2016; Jennifer *et al.,* 2022; Aguilera, 2023; NIH, 2024).

The nervous system's function relies on mechanisms such as neuronal plasticity, synapses, neurotransmitters, and action potentials. These components enable nerve cells to communicate, adapt to new experiences, and transmit information precisely. Plasticity, in particular, is crucial for allowing the brain to learn, develop, and recover from injuries, making it essential for learning and adapting to the environment (Feder, 2009; Nicolelis, 2016; Jennifer *et al.,* 2022; Aguilera, 2023; NIH, 2024).

Neuroanatomy and physiology study the relationship between the structure and function of the nervous system, demonstrating how the arrangement and connections between cells directly influence cognitive, motor, and sensory functions. Understanding this relationship is essential for medicine and neuroscience, as it enables advances in the treatment of neurological diseases such as Alzheimer's and Parkinson's, as well as deepening our understanding of human development and learning (Figure 2) (Feder, 2009; Nicolelis, 2016; Jennifer *et al.,* 2022; Aguilera, 2023; NIH, 2024).

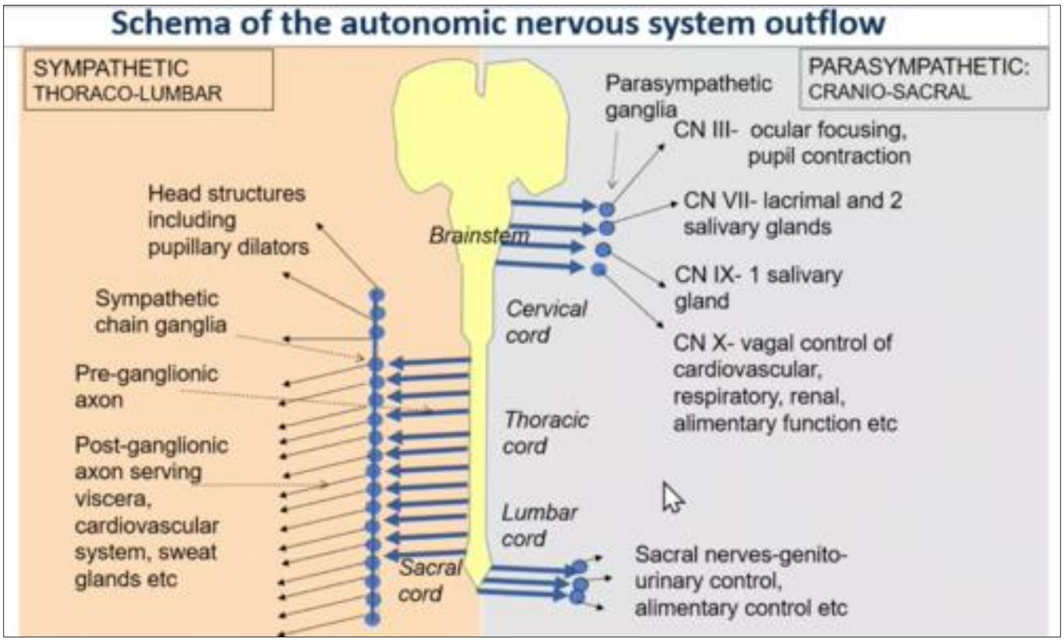

Figure 2: Neuroanatomy: In the intermediolateral horn of the thoracic cord and first two lumbar segments
Sources: © 2025 Quizlet Inc., and https://quizlet.com/gb/625241131/neuroanatomy-mcq-flash-cards/

3.2.1. Advances and new therapies in neuroanatomy

Recent years have seen significant advances in neuroanatomy, driven by cutting-edge imaging technologies, computational neuroscience, and neuroengineering. High-resolution techniques such as functional MRI, diffusion tensor imaging, and advanced 3D microscopy have enabled scientists to map neural pathways with unmatched precision. These tools offer a deeper understanding of brain connectivity and the structural foundations of cognitive and motor functions (Anderson *et al.,* 2025).

Therapeutic innovations are increasingly targeting specific neural structures with tailored interventions. Techniques such as optogenetics, Deep Brain Stimulation (DBS), and Transcranial Magnetic Stimulation (TMS) are being refined for higher specificity and fewer side effects. Combined with real-time imaging, these methods enable personalized treatment approaches for conditions such as Parkinson's disease, epilepsy, and major depressive disorder (Martinez *et al.,* 2025).

Regenerative medicine is another area of rapid growth. Stem cell therapy bioengineered neural scaffolds, and nanotechnology-based drug delivery systems are opening new possibilities for repairing damaged neural tissue. These strategies aim to restore function after injury or degenerative disease by promoting axonal growth, remyelination, and synaptic repair (Patel *et al.,* 2025).

Computational modeling and artificial intelligence are playing an increasingly central role in neuroanatomical research. Machine learning algorithms help to predict disease progression, optimize surgical planning, and guide rehabilitation strategies. The integration of these technologies marks a shift toward precision neuroscience, where structural mapping, functional assessment, and therapy design are seamlessly connected (Zhang *et al.,* 2025).

3.2.2 Advances and new therapies in neurophysiology

In recent years, neurophysiology has seen significant advances through the integration of advanced imaging, computational modeling, and neuromodulation techniques. Functional Magnetic Resonance Imaging (fMRI), Magnetoencephalography (MEG), and High-Density Electroencephalography (EEG) now enable real-time mapping of brain activity with remarkable precision, helping researchers better understand the dynamics of neuronal networks in both health and disease (Figure 3) (Smith, 2025).

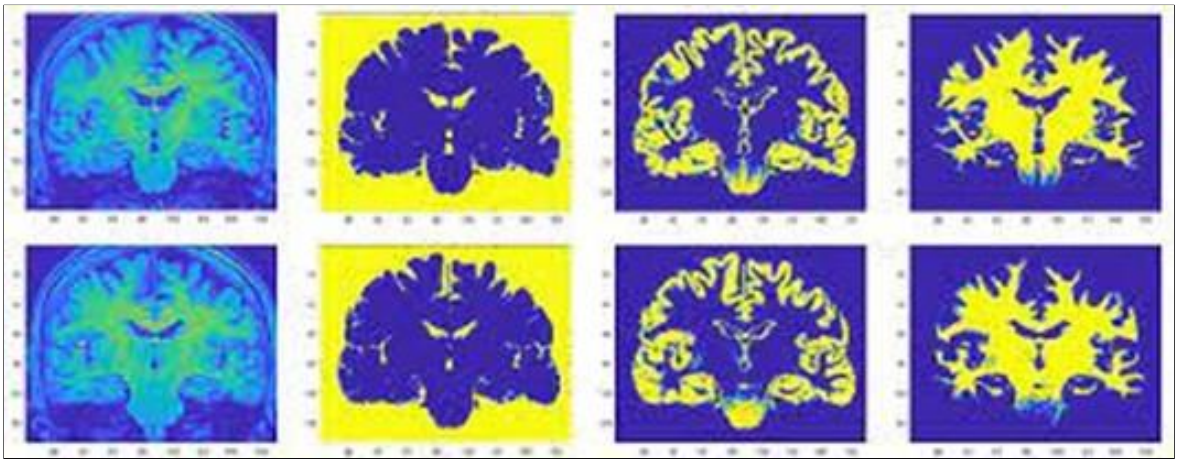

Figure 3: Neurophysiology research is advancing innovative methods to diagnose and monitor neuromuscular disorders using electrophysiology and spectroscopy in both pre-clinical and clinical settings. Existing muscle assessment techniques are often invasive, painful, and costly. Studies seek to develop rapid, simple, and pain-free approaches, offering significant potential for earlier diagnosis and improved clinical management
Sources: James Alix, Sheffield Teaching Hospitals, University of Sheffield, and https://www.sheffieldclinicalresearch.org/about/our-directorates/neuroscience-test-site/neurophysiology/

Innovations in neuromodulation, such as TMS, DBS, and Non-Invasive Vagus Nerve Stimulation (nVNS), have broadened therapeutic options for conditions like Parkinson's disease, epilepsy, and depression. These interventions target specific neural circuits, offering more personalized and effective treatment strategies (Johnson, 2025). The incorporation of bioelectronic medicine has introduced closed-loop stimulation systems capable of monitoring neural activity and delivering adaptive responses in real time. This approach enhances therapeutic efficiency while reducing side effects, representing a significant step toward precision neurotherapies (Martinez, 2025).

Moreover, neurophysiology is benefiting from advances in neuroplasticity-based rehabilitation. Techniques such as Brain-Computer Interfaces (BCIs) and Virtual Reality (VR)-assisted therapy are fostering motor and cognitive recovery in patients with stroke and spinal cord injuries, emphasizing the brain's capacity to reorganize and adapt following injury (Anderson, 2025).

3.3. Neuropsychopharmacology

Neuropsychopharmacology is an interdisciplinary field that merges knowledge from psychopharmacology and neuroscience. Psychopharmacology studies how drugs influence the brain and behavior, while neuroscience investigates the nervous system and how impulses are controlled. The main goal of this science is to understand how specific medications affect the brain, to develop new treatments for mental and neurological disorders. The operation of brain impulses involves two neurotransmitters, chemical substances that relay messages between nerve cells (Bogado *et al.,* 2012; Torales and Arce, 2017; WordPress Theme, 2023).

Studies the action of psychotropic medications on the central nervous system, focusing on the treatment of mental disorders such as depression, anxiety, schizophrenia, bipolar disorder, and Attention Deficit Hyperactivity Disorder (ADHD). These medications act on neurotransmitters such as serotonin, dopamine, and norepinephrine, which are responsible for transmitting signals between neurons and directly influence mood, cognition, and behavior (Torales *et al.*, 2014; Torales and Arce, 2017; WordPress Theme, 2023).

Alterations in the transmission process are associated with mental and neurological disorders, such as epilepsy and Parkinson's disease. Neuropsychopharmacology seeks to investigate how medications affect neurotransmitters to adjust or correct these dysfunctions, proposing new therapeutic approaches. Research in this area usually focuses on various mental disorders, such as schizophrenia, depression, bipolar disorder, eating disorders, anorexia and bulimia, sleep disorders, and anxiety disorders. An example of a frequently studied medication is selective serotonin reuptake inhibitors, used to stabilize levels of serotonin, a neurotransmitter related to being (Figure 4) (Torales and Arce, 2017; WordPress Theme, 2023; Gobb, 2024).

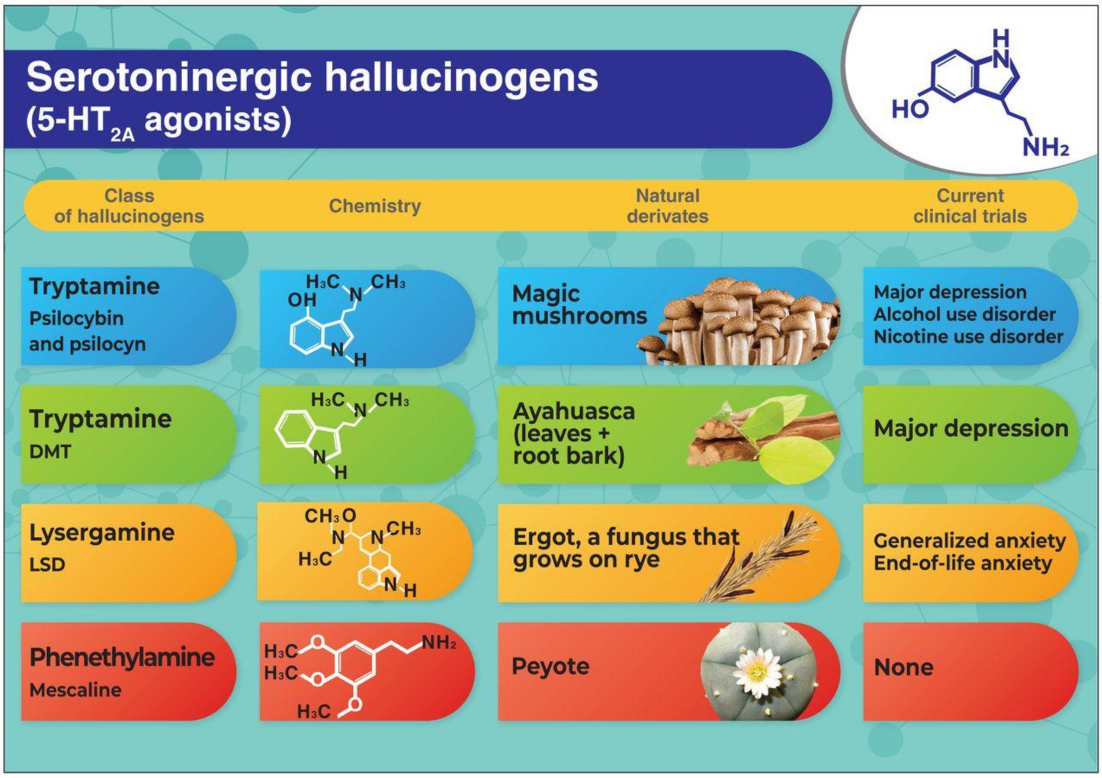

Figure 4: Simplified classification of serotonin-derived hallucinogens and efficacy in clinical trials. The top right corner shows the chemical formula of serotonin (5-HT). Related content tab for accessible version. DMT = *N*, *N*-dimethyltryptamine, LSD = lysergic acid diethylamide
Source: Doi: 10.1503/jpn.. 240037

This is a field of knowledge with a marked multidisciplinary nature, which brings together the shared interest of psychiatrists, general practitioners and neurologists, pharmacologists, and biochemists in the analysis of substances that act by modifying the functions of the nervous system and which manifest themselves in the behavior of individuals (Torales *et al.*, 2014; Valero, 2015; Torales and Arce, 2017). Despite its effectiveness, neuropsychopharmacology faces challenges, such as individual variation in response to medications and the need to find the ideal treatment for each patient. However, scientific advances have enabled the development of more specific drugs with fewer side effects and greater therapeutic potential, contributing to improved quality of life for patients (Torales *et al.*, 2014; Valero, 2015; Torales and Arce, 2017).

Beyond its role in clinical practice, neuropsychopharmacology raises important ethical issues, including the responsible use of medications, informed consent, and respect for patient autonomy. With research constantly evolving, the field seeks to understand the mechanisms of drug action better and promote increasingly individualized and effective treatments (Torales *et al.*, 2014; Valero, 2015; Torales and Arce, 2017).

3.3.1. Advances and new therapies in neuropsychopharmacology

The 35th International Congress of Neuropsychopharmacology, held in Japan, presented significant advances in the pharmacotherapy of mental disorders. Vortioxetine, a multimodal antidepressant, stood out for its ability to improve cognitive functions and reduce anhedonia symptoms that often persist after remission of depression, thereby contributing to greater functionality and quality of life for patients (EMS, 2023).

The event also addressed the therapeutic potential of psychedelics such as psilocybin and ayahuasca, with preliminary studies indicating sustained antidepressant benefits, particularly in treatment-resistant cases. However, experts emphasized the need for rigorous clinical trials and robust ethical guidelines before their widespread clinical implementation (Figure 5) (EMS, 2023).

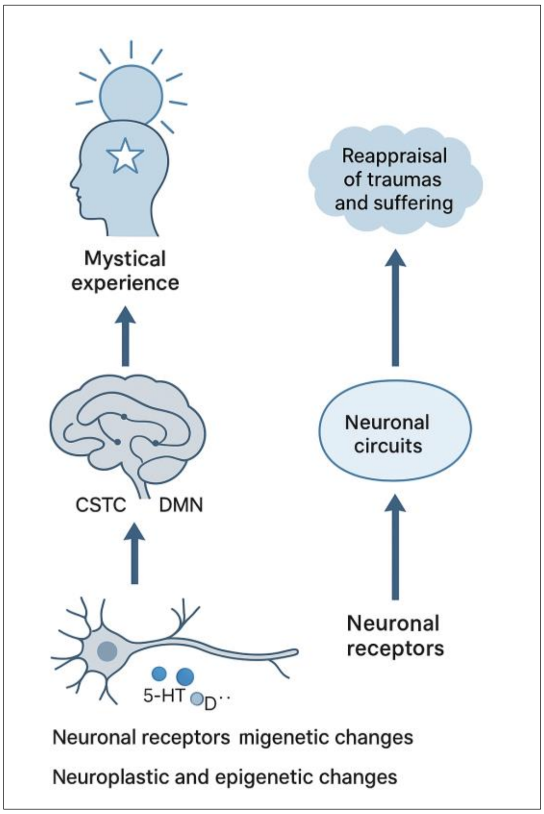

Figure 5: llustrated three hierarchical levels of the mechanism of action of psychedelics: At the bottom, they act on neuronal receptors such as 5-HT, D, and triggering neuroplastic and epigenetic changes; in the middle, they modulate neuronal circuits, including the Cortico-Striatal-Thalamic Loop Circuits (CSTC) and Default Mode Network (DMN) networks; and at the top, particularly at full doses, they induce mystical experiences and spiritual thinking, enabling the reappraisal of traumas
Source: Adapted from source image description

In antipsychotic treatment, tardive dyskinesia was highlighted as a persistent adverse effect associated with long-term use of these medications. The 2020 American Psychiatric Association guidelines recommend reversible Vesicular Monoamine Transporter 2 (VMAT2) inhibitors, such as valbenazine and deutetrabenazine, as effective strategies. The congress reinforced the integration of pharmacological innovations, psychological therapies, and emerging technologies as essential to transforming scientific advances into tangible improvements in patient care (EMS, 2023).

3.3.2. A neuropsychopharmacology open:

1. **Psychopharmacology:** Studies the effects of two medications on the central nervous system and human behavior.
2. **Pharmacokinetics:** Investigates the absorption, distribution, metabolism, and excretion of drugs in the body.
3. **Pharmacodynamics:** Analyzes the mechanisms of action of two medications and how they interact with the brain receptors.
4. **Neurochemistry:** Studies of the chemical substances present in the brain and how they affect behavior.
5. **Neurobiology:** Investigates the biological processes that occur in the brain and its relationship with human behavior.
6. **Pharmaceutical Psychology:** Studies the psychological effects of medications and their influence on behavior and cognition.
7. **Pharmacology:** The study of neuropsychopharmacology, that is, drugs that act on the central nervous system.
8. **Treatment of disorders such as:** Anxiety, affective disorders, psychotic disorders, eating disorders, and sleep disorders (Torales *et al.*, 2014; Torales and Arce, 2017; WordPress Theme, 2023).

3.4. Neuroanatomophysiology

Neuroanatomophysiology, as the foundation of neuroscience, enables us to understand how different brain areas are related to cognitive and behavioral functions, such as language, memory, perception, and decision-making. Technological advances, such as neuroimaging and electrophysiology, enable the investigation of the brain in real-time, while neuroplasticity explains how it adapts to experiences, learning, and lessons. This has a direct impact on education, patient rehabilitation, and psychotherapy effectiveness (Feder, 2009; Nicolelis, 2016; Jennifer *et al.,* 2022; NIH, 2024).

At the same time, psychological practice requires mastery of a clear and precise scientific language, essential for professional communication and the construction of knowledge. Neuroethics, in turn, guides the psychologist on the ethical and legal aspects of patient treatment, reinforcing the importance of autonomy, informed consent, confidentiality, and evidence-based practice (Jennifer *et al.,* 2022; Aguilera, 2023; NIH, 2024).

3.4.1. Examples of how structure affects function

1. **Brain development:** The way the brain develops and organizes itself has a direct impact on the way we learn.
2. **Cerebral lesions:** A lesion in a specific area of the brain can affect the corresponding function.
3. **Neurological diseases:** The duration and intensity of conditions such as Alzheimer's and other deficit systems are all affected by the neuroplasticity process.

3.4.2. Importance of neuroanatomophysiology

Understanding the relationship between the structure and function of the nervous system is fundamental for medicine, neurology, and psychiatry. This helps to develop more effective treatments for neurological conditions, such as cerebral lesions, Alzheimer's, and Parkinson's, as well as helping to better understand the scientific basis for learning and development (Nicolelis, 2016; Jennifer *et al.,* 2022; NIH, 2024).

3.4.3. Advances and new therapies in neuroanatomophysiology

Recent advances in neuroanatomophysiology have shifted from symptom-oriented approaches toward precision, circuit-level interventions. DBS now employs high-density leads, closed-loop sensing, and adaptive algorithms, enabling real-time modulation based on neural biomarkers. These improvements have broadened DBS applications, optimized clinical outcomes, and reduced side-effect profiles (Provenza *et al.*, 2023).

Minimally invasive technologies, such as MRI-guided Focused Ultrasound (FUS), have entered clinical practice for transient blood-brain barrier (BBB) modulation. Early trials in Alzheimer's disease and brain tumors demonstrate safe, reversible BBB opening and enhanced therapeutic delivery, particularly when combined with monoclonal antibodies, leading to larger-scale efficacy studies (Rezai *et al.*, 2024).

Gene and cell-based therapies have reached significant milestones in neuroanatomophysiology. SMN-targeting gene therapy, including onasemnogene abeparvovec, has improved survival and motor function in spinal muscular atrophy, while stem cell–derived dopaminergic neuron grafts in Parkinson's disease have shown survival and early functional gains, suggesting potential for long-term restoration of neural circuits (Figure 6) (Chongmelaxme *et al.*, 2025; Dall, 2025; Tabar *et al.*, 2025).

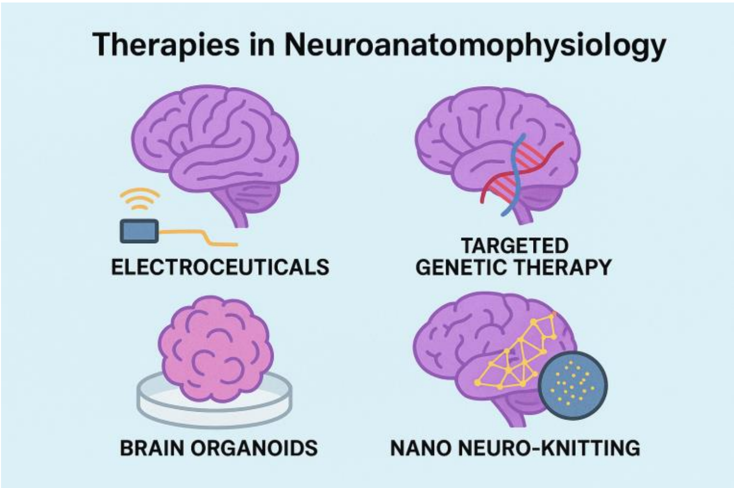

Figure 6: **The figure presents four advanced therapies in neuroanatomophysiology: Electroceuticals for brain stimulation, targeted genetic therapy for precise gene correction, brain organoids for disease modeling, and nano neuro-knitting for neural regeneration**
Source: Doi: 10.0000/dalle.therapies.neuroanatomophysiology.202

Brain Computer Interfaces (BCIs) now integrate advanced biocompatible electrodes with machine learning to support rehabilitation, communication, and closed-loop therapeutic systems. Alongside neuromodulation, BBB-targeted delivery, and gene/cell therapies, BCIs are positioning neuroanatomophysiology as a field moving toward highly specific, disease-modifying interventions (Zhang *et al.*, 2024).

3.5. Neurodivergence

Neurodivergence refers to a condition in which a person presents neurological, behavioral, communication, and learning differences outside the norm expected by society. This approach recognizes and celebrates diversity across the neurological spectrum, including conditions such as autism, ADHD, dyslexia, and others (Figure 7) (Espinoza, 2012; Vera, 2018; Einstein Hospital Israelita, 2025; Mingrone, 2025; Tua Saúde, 2025).

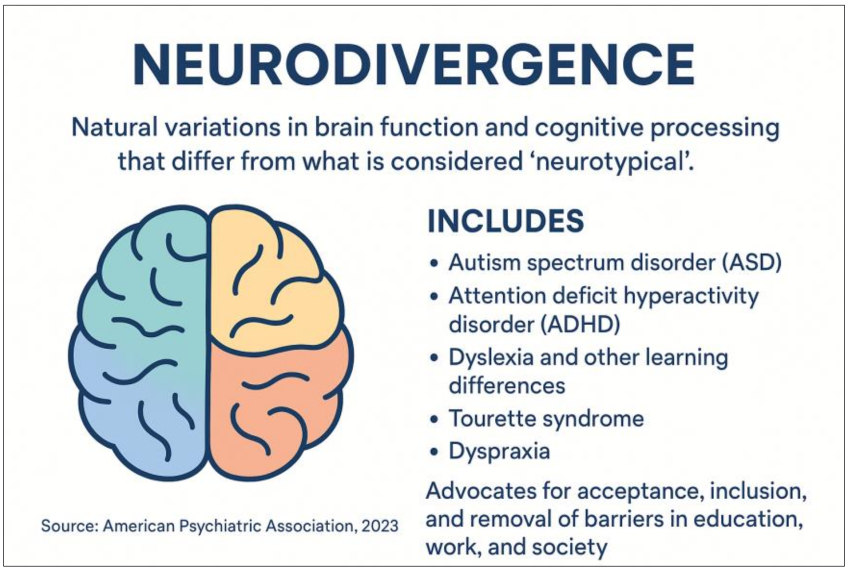

Figure 7: Describes neurodivergence as natural differences in brain function and cognition from the neurotypical norm, including Autism Spectrum Disorder (ASD), ADHD, dyslexia, Tourette syndrome, and dyspraxia, highlighting acceptance, inclusion, and barrier removal in society
Source: American Psychiatric Association (2023), neurodivergence overview

Neurotypical refers to the neurocognitive pattern considered typical or conventional in a society. A neurotypical person has brain functioning that fits cultural expectations. Some atypical neurocognitive conditions are considered neurodivergence:

1. **ASD:** Affects communication, social interaction, and behavior, and may include hyperfocus, restricted interests, and sensory sensitivity. ADHD is characterized by inattention, impulsive, and hyperactivity, with a high potential for affecting academic performance and organizational skills.
2. **Bipolar affective disorder:** Causes intense mood swings, alternating periods of euphoria with episodes of deep depression.
3. **Borderline personality disorder:** marked by intense emotional instability, fear of abandonment, impulsivity, and unstable relationships, with rapidly changing emotions.
4. **Obsessive-compulsive disorder:** Involves obsessive, repetitive, and unwanted thoughts and compulsive behaviors or rituals to relieve the anxiety caused by obsessions.
5. **Giftedness:** Intellectual or creative performance well above average, with a high learning ability, hyperfocus, and emotional sensitivity.
6. **Dyslexia:** Difficulty identifying words, fluency, and understanding written texts.
7. **Dyscalculia:** Related to difficulties in understanding numbers, calculations, sequences, and numerical logic (Espinoza, 2012; Vera, 2018; Einstein Hospital Israelita, 2025; Mingrone, 2025; Tua Saúde, 2025).

3.5.1. Symptoms of neurodivergent people

The symptoms of a neurodivergent person vary widely depending on the specific condition and the person affected. Here are the general symptoms associated with different forms of neurodivergence:

1. **Difficulties in socialization:** An inability to interact effectively and satisfactorily with others. This can manifest as problems initiating or maintaining conversations, understanding social norms, or establishing close relationships.
2. **Lack of empathy:** It refers to difficulty understanding or recognizing other people's emotions and perspectives. Individuals with a lack of empathy may have difficulty putting themselves in others' shoes or responding appropriately to their emotions.
3. **Problems understanding specific words:** Difficulty understanding the precise meaning of certain words or phrases. This can manifest as difficulties with figurative language, metaphors, or technical vocabulary.
4. **Preference for routine activities:** Indicates a tendency to seek out and enjoy activities that follow a predictable pattern or structure. People with this preference may experience discomfort or anxiety when faced with changes in their routine and may have difficulty adapting to new situations.

5. **Difficulty adapting to change:** Refers to the difficulty adjusting to or accepting changes in the environment, routines, or expectations. People with a lack of adaptability to change may experience anxiety, irritability, or discomfort when faced with new or unexpected situations.
6. **Auditory, tactile, visual, or olfactory sensitivity:** Experiences increased sensitivity or reactivity to sensory stimuli such as sounds, textures, lights, or odors. This can manifest as discomfort, irritability, or sensory overload in response to certain stimuli.
7. **Low self-esteem:** Indicates a negative evaluation of oneself and a lack of confidence in one's abilities and worth. People with low self-esteem may feel insecure, undervalued, or incapable of facing life's challenges.
8. **Intellectual deficiency or superiority in development:** Refers to significant disparities in the development of intellectual abilities compared to the population average. This can manifest in areas such as IQ, academic performance, or specific cognitive abilities.
9. **Inability to control impulses:** The inability to regulate impulses or reactive behaviors, which can lead to impulsive or inappropriate actions without considering the consequences.
10. **Rigid body movements and stereotypies:** Refer to repetitive and limited patterns of body movement, which may include repetitive gestures, unusual movements, or rigid postures. This may be associated with conditions such as autism spectrum disorder or Tourette syndrome (Espinoza, 2012; Vera, 2018; Einstein Hospital Israelita, 2025; Mingrone, 2025; Tua Saúde, 2025).

3.5.2. Symptoms of neurodivergent people

1. **Social interaction:** Difficulties understanding unwritten social norms and social cues can hinder the formation of meaningful relationships and participation in social activities.
2. **Communication:** It may be difficult for some neurodivergent people to express their thoughts and feelings effectively, as well as to understand nonverbal language or social inferences in communication.
3. **Mental health:** Neurodivergent people may be at greater risk of experiencing mental health problems, such as anxiety, depression, or stress, due to the challenges associated with their condition and difficulties adapting to social expectations.
4. Stigmatization and discrimination: A lack of understanding and acceptance of neurodiversity can lead to stigmatization and discrimination, which can affect the self-esteem and emotional well-being of neurodivergent people.
5. Autonomy and independent living: Being neurodivergent can mean facing challenges in living independently and carrying out daily activities, such as self-care, managing money, or planning for the future (Espinoza, 2012; Vera, 2018; Einstein Hospital Israelita, 2025; Mingrone, 2025).

3.5.3. Challenges faced by neurodivergent people

1. Social Interaction.
2. Communication.
3. Mental health
4. Stigmatization and discrimination.
5. Autonomy and independent living.

Neurodivergent people face several challenges, including difficulties with social interaction, verbal and nonverbal communication, and increased vulnerability to mental health problems. They also face stigmatization and discrimination, which can impact their self-esteem. Furthermore, they may face obstacles in achieving autonomy and living independently (Conversion, 2025; Formare, 2025).

3.5.4. Recent advances and new therapies in neurodivergence

In 2025, Digital Therapeutics (DTx) reached new maturity in the treatment of neurodevelopmental disorders. Clinical guidelines now incorporate FDA-cleared game-based interventions for ADHD, supported by trials showing improvements in attention and executive function. These tools increasingly integrate real-time data analytics and adaptive algorithms to personalize therapy (Lee *et al.*, 2025).

Randomized trials in 2025 demonstrated that combining targeted cognitive training with pharmacotherapy enhances treatment effects in ADHD. Home-based delivery models using secure cloud platforms have expanded access, particularly for underserved populations, while maintaining adherence through gamified feedback (Dang *et al.* 2025). Neurofeedback interventions also gained prominence in 2025, with systematic reviews confirming cognitive and behavioral benefits in autism spectrum disorder. Protocols now emphasize individualized electrode placement and frequency modulation to optimize neural plasticity and functional outcomes (Figure 8) (OpenAI, 2025; Rezaee *et al.*, 2025).

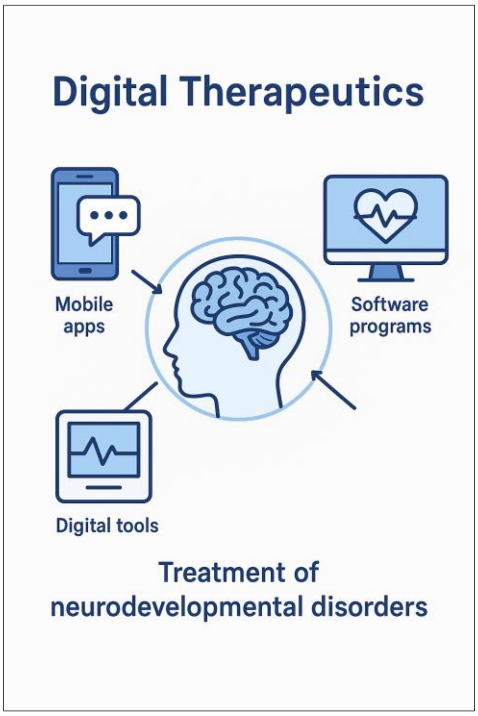

Figure 8: Digital Therapeutics (DTx) are evidence-based interventions delivered through digital platforms, such as mobile applications, software programs, and connected devices, to prevent, manage, or treat medical conditions. In neurodevelopmental disorders, DTx can enhance cognitive skills, improve behavioral regulation
Source: Figure created by DALLE (2025)

The integrative and participatory approaches in 2025 emphasized multimodal therapies merging neuromodulation, digital tools, and behavioral strategies tailored through biomarker profiling. This shift reflects a growing focus on functional improvement and patient-led outcome priorities in neurodivergence research (Lee *et al.*, 2025).

3.5.5. Examples of neurodivergence include:

1. Dyslexia.
2. Autism Spectrum Disorder.
3. Attention Deficit Hyperactivity Disorder.
4. Tourette Syndrome.

3.6. Neurodiversity

Neurodiversity is a concept that recognizes and values the different ways in which human brains function. The term promotes the idea that variations such as autism, ADHD, dyslexia, and others should not be seen as disorders or diseases, but rather as natural forms of human diversity (Conversion, 2025; Formare, 2025).

According to this perspective, all individuals have unique neurocognitive functioning. Some follow what is considered a typical pattern known as neurotypical, while others differ from this norm and are referred to as neurodivergent. These differences do not imply inferiority but instead represent alternative ways of perceiving, processing, and interacting with the world (Conversion, 2025; Formare, 2025).

This concept gave rise to a social movement for neurodiversity, which seeks to increase visibility for neurodivergent individuals, promote acceptance of cognitive differences, and ensure their rights are respected. It also challenges the traditional medical view that often sees these differences as something to be fixed or cured (Conversion, 2025; Formare, 2025).

3.6.1. Advances and new therapies in neurodiversity

In 2025, imaging-transcriptomics approaches marked an important advance in neurodiversity research. Ferrari *et al.* (2025) developed a deep learning classifier, Integrating Resting-State fMRI with spatial gene expression profiles, achieving an AUC of 0.89 and identifying gene modules linked to brain regions critical for autism diagnosis. Causal modeling of fMRI time-series also improved Autism Spectrum Disorder (ASD) classification. Duan *et al.* (2025) introduced a causality-based deep learning framework with 71.9% accuracy and 75.8% AUC, revealing the precuneus and cerebellum as key hubs in differentiating ASD from controls (Figure 9) (Biswal *et al.,* 2010).

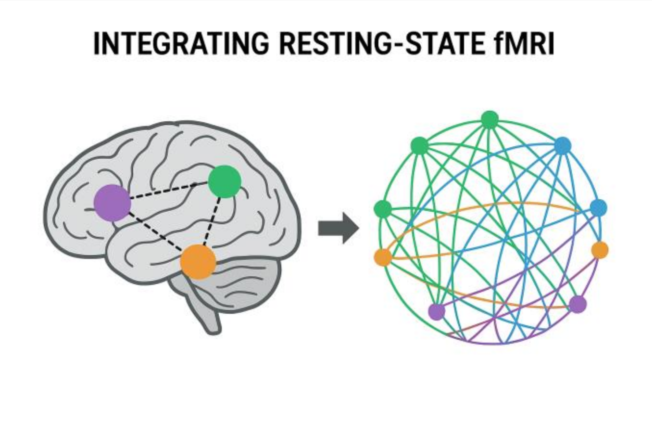

Figure 9: Resting-State Functional Magnetic Resonance Imaging (rs-fMRI) is a non-invasive method that maps brain activity by detecting spontaneous blood oxygen level changes while the subject is at rest. It reveals functional connectivity between brain regions, aiding the study of neural networks and potential biomarkers for brain disorders

Source: Doi: 10.1073/pnas.0911855107

Therapeutic progress in 2025 emphasized neurodiversity-affirming interventions, including self-determination programs and Naturalistic Developmental Behavioral Interventions (NDBIs), promoting autonomy and strengths-based support over normalization (Zaks, 2025).

Conferences such as the Stanford Neurodiversity Summit facilitated collaboration between researchers, clinicians, educators, and neurodivergent individuals, promoting inclusive, evidence-based strategies and disseminating recent therapeutic innovations (Stanford Neurodiversity Project, 2025).

3.7. Disorders of the nervous system

Neurology is the branch of medicine that focuses on disorders of the nervous system. It plays a key role in the prevention, diagnosis, treatment, rehabilitation, and research of neurological conditions. Neurological diseases include any disorder that affects the central nervous system (the brain and spinal cord) or the peripheral nervous system, nerves, and muscles (Kokudeva *et al.,* 2024; Cunha *et al*., 2025; Europa Press, 2025).

Some of the most common neurological disorders are dementias (such as Alzheimer’s disease), stroke, epilepsy, Parkinson’s disease, multiple sclerosis, and migraine. However, other important conditions include neurodegenerative and neuromuscular diseases like Amyotrophic Lateral Sclerosis (ALS), muscular dystrophies, and voice disorders such as dysphonia. In Spain, it is estimated that neurological diseases affect around 7 million people, representing 16% of the population. As life expectancy continues to rise, the number of people living in these conditions is expected to grow significantly in the coming decades (Etessam, 2020; Damasceno *et al.*, 2023; Kokudeva *et al.,* 2024; Europa Press, 2025).

3.7.1. Causes of neurological conditions

The reasons why a person develops a neurological disorder are diverse and often complex. They can be grouped as follows:

1. **Genetic origin:** Some disorders are hereditary, passed from generation to generation, or caused by spontaneous genetic mutations.
2. **Acquired factors:** External and lifestyle-related conditions also play a major role. For example:
3. **Chronic alcoholism:** Can cause irreversible nerve damage.
4. **Brain injuries:** Due to tumors or stroke, are well-known causes.
5. **Exposure to environmental toxins, industrial chemicals, or certain viruses:** May trigger or contribute to disease development.
6. **Congenital vs. Acquired Disorders:** Congenital disorders are present at birth, often due to fetal development issues.
7. **Acquired disorders:** Develop throughout life due to the factors mentioned above or other conditions.

This distinction is key to understanding prognosis and treatment options (Kokudeva *et al.,* 2024; Cunha *et al*., 2025; Europa Press, 2025).

3.7.2. Common neurological disorders

Although the list is extensive, here is a selection of some of the most well-known and prevalent neurological conditions, illustrating their diversity:

1. **Alzheimer’s disease:** A common form of dementia that affects memory, thinking, and behavior. It is progressive, worsening over time due to the abnormal buildup of proteins in the brain.
2. **Parkinson’s:** A neurodegenerative disorder primarily affecting motor control, characterized by tremors, stiffness, slowness of movement, bradykinesia, and balance issues. It is linked to the loss of dopamine-producing neurons.

3. **Multiple sclerosis:** A chronic autoimmune disease in which the immune system attacks the myelin sheath, the protective layer covering nerve fibers in the central nervous system. This disrupts communication between the brain and the body, causing a wide range of neurological symptoms that vary in severity and recurrence.
4. **Epilepsy:** A chronic disorder marked by recurrent, unprovoked seizure episodes of abnormal and excessive electrical activity in the brain. Seizures may present in various forms, from brief lapses in attention to violent muscle spasms.
5. **Stroke cerebrovascular accident:** Occurs when the blood supply to part of the brain is interrupted by ischemic stroke, or a blood vessel ruptures, causing bleeding hemorrhagic stroke, preventing brain tissue from receiving oxygen and nutrients. It is a medical emergency that may cause permanent brain damage, disability, or death.
6. **Migraine:** More than just a severe headache, migraine is a recurring neurological disorder characterized by episodes of intense, often pulsating pain on one side of the head, usually accompanied by nausea, vomiting, and sensitivity to light and sound, photophobia, and phonophobia. Some people experience an aura before the pain.
7. **Peripheral neuropathy:** Damage to the nerves outside the brain and spinal cord, peripheral nerves. It may be caused by diabetes, infections, toxins, or nutritional deficiencies. Common symptoms include weakness, numbness, tingling, and pain, typically in the hands and feet.
8. **Amyotrophic lateral sclerosis:** A progressive neurodegenerative disease that affects motor neurons in the brain and spinal cord, which control voluntary muscle movement. Over time, it causes muscle weakness, difficulty speaking, swallowing, and eventually breathing.
9. **Huntington's disease:** A progressive hereditary disorder that leads to the degeneration of nerve cells in various areas of the brain. It affects movement, causing involuntary movements known as chorea, cognition, and mood, typically beginning in adulthood.
10. **Brain tumors:** Abnormal growths of cells within the brain or spinal cord. Tumors may be benign, non-cancerous, or malignant, cancerous. Symptoms depend on the tumor's location, size, and growth rate and may include headaches, seizures, vision or hearing problems, personality changes, and motor or sensory deficits.
11. **Meningitis and encephalitis:** Inflammations of the membranes covering the brain and spinal cord, meningitis or the brain tissue itself, encephalitis, often caused by viral, bacterial, or fungal infections. These Apioceridae infections require urgent medical attention and typically involve symptoms like high fever, severe headache, stiff neck, confusion, and seizures.
12. **Narcolepsy:** A chronic sleep disorder characterized by overwhelming daytime drowsiness, uncontrollable sleep attacks, and sometimes cataplexy, sudden loss of muscle tone (Etessam, 2020; Damasceno *et al.*, 2023; Kokudeva *et al.,* 2024; Cunha *et al*., 2025; Europa Press, 2025).

3.7.3. Technological drivers of innovation

1. Artificial Intelligence (AI).
2. Enhances early diagnosis, predictive analytics, and treatment planning.
3. Improves drug delivery and imaging at the cellular level.
4. Precision medicine.
5. Tailor's treatment based on individual genetics and biomarkers.

3.7.4. Early detection & diagnosis

1. Advanced imaging technologies: fMRI, PET scans with AI integration.
2. Innovative biomarkers: Detect disease earlier and more accurately.

3.7.5. New therapeutic approaches

1. Gene therapy.
2. Stem cell therapy.
3. Neurostimulation.
4. Targeted treatments for: Alzheimer's Disease, Parkinson's Disease, Multiple Sclerosis, and Epilepsy.

3.7.6. Challenges to overcome

1. Disease heterogeneity: Individual variability complicates diagnosis and treatment.
2. Technological barriers: Blood-brain barrier limits drug delivery.
3. Ethical issues: Use of AI in healthcare decision-making.
4. High costs & infrastructure needs: Especially in low-resource settings.

3.7.7. The need for integration into clinical practice

Standardization of diagnostic methods. Accessibility and affordability of new technologies. Global collaboration to share research and treatment models ((Damasceno *et al.*, 2023; Kokudeva *et al.,* 2024; Cunha *et al*., 2025).

3.7.8. The path forward

Continued development in AI, nanotechnology, and stem cell therapies. Emphasis on**:**

1. Standardized clinical protocols.
2. Ethical frameworks.
3. Equitable resource distribution.
4. Role of scientists, clinicians, and policymakers in shaping the future (Damasceno *et al.*, 2023; Kokudeva *et al.,* 2024; Cunha *et al*., 2025; Europa Press, 2025).

According to Cunha *et al.* (2025), recent advances in the diagnosis and treatment of neurological diseases driven by artificial intelligence, nanotechnology, and precision medicine are significantly enhancing early detection and enabling more personalized therapies. Innovative approaches such as gene therapy, stem cell treatments, and neurostimulation have shown promising results in conditions like Alzheimer's, Parkinson's, multiple sclerosis, and epilepsy.

However, major challenges remain, including disease complexity, technological barriers such as the blood-brain barrier, ethical concerns, and high treatment costs. Integrating these innovations into clinical practice requires standardization, greater accessibility, and global collaboration. The future of neurological care will depend on overcoming these obstacles to ensure treatments become more effective, equitable, and widely available (Cunha *et al*., 2025).

In 2025, neurology continues to evolve at a rapid pace, with cutting-edge developments reshaping clinical practice. Below are five critical advances that every physician, whether in inpatient or outpatient care, should be familiar with:

1. Gene therapies for neuromuscular diseases

Gene therapies are now a practical option for several rare neurological disorders, particularly spinal muscular atrophy and hereditary dystrophies. These treatments aim to correct underlying genetic mutations, often yielding remarkable outcomes, especially when initiated early. New studies are expanding the scope of these therapies to conditions like amyotrophic lateral sclerosis and Duchenne muscular dystrophy (Brown and Patel, 2023; Topol *et al.,* 2023; American Headache Society, 2024).

2. AI and predictive algorithms in neurology

Artificial intelligence is transforming diagnostic workflows. AI-driven software, trained on thousands of imaging datasets, can now detect subtle abnormalities in MRI and CT scans with unprecedented accuracy and speed.

3. Expanded use of neuromodulation techniques

DBS has moved beyond Parkinson's disease and is now being used in Refractory epilepsy. Movement disorders. Resistant depression. Obsessive-compulsive disorder. Meanwhile, non-invasive techniques like Transcranial Magnetic Stimulation (TMS) are gaining popularity in outpatient settings. Neurologists and psychiatrists must be aware of current indications, expected benefits, and risks to successfully incorporate these therapies into individualized treatment plans.

4. Biomarkers for early dementia diagnosis

It has revolutionized the early detection of neurodegenerative diseases like Alzheimer's. The use of tau and beta-amyloid levels in Cerebrospinal Fluid (CSF), and now blood tests, along with functional neuroimaging, enables diagnosis before clinical symptoms appear (Figure 10) (Benabid *et al.,* 2009; Smith and Lee, 2024; Böse *et al.,* 2025; Fgmedflix, 2025).

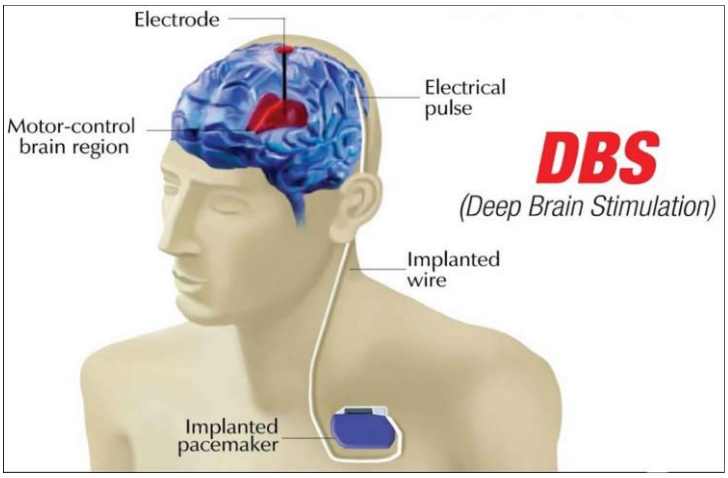

Figure 10: Deep Brain Stimulation (DBS) is a neurosurgical technique that places electrodes in targeted brain regions to deliver precise electrical signals. This approach helps control severe symptoms in conditions like Parkinson's disease, essential tremor, dystonia, and epilepsy, especially when drug therapies are not effective
Source: Doi: 10.1016/S1474-4422(08)70291-6

5. Updated guidelines for chronic headache management

Chronic headaches remain one of the most frequent neurological complaints. Recent insights into pathophysiology have led to the development of targeted therapies, such as anti-CGRP monoclonal antibodies, significantly improving outcomes in chronic migraine (Brown and Patel, 2023; Topol *et al.,* 2023; American Headache Society, 2024; Smith and Lee, 2024; Böse *et al.,* 2025).

6. Recent advances in neuropsychology

We are transforming the way patients with cognitive impairments receive rehabilitation, offering fresh hope for improved function and independence. Among the most promising developments is the adaptation of Cognitive Behavioral Therapy (CBT) for individuals with brain injuries or neurodegenerative diseases, allowing them to adopt practical tools such as memory aids to maintain autonomy. Cognitive stimulation therapy is also gaining attention for its ability to slow cognitive decline in dementia through structured mental exercises that strengthen memory and reasoning (Figure 11) (Kolb and Whishaw, 2015; Kallio *et al.,* 2016; Leahy *et al.,* 2018).

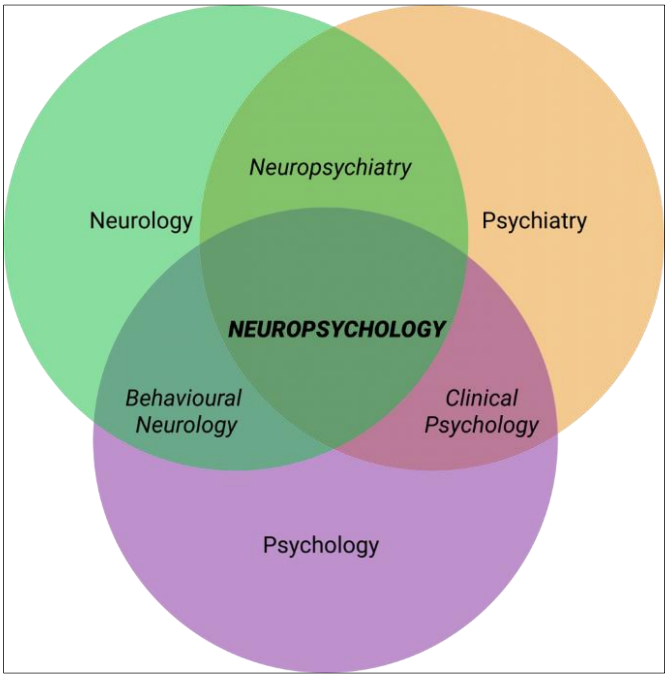

Figure 11: Neuropsychology focuses on understanding how brain function shapes behavior, thinking, emotions, and personality traits. It looks at how conditions affecting the brain, such as injuries or illnesses, lead to changes in these areas and whether the causes are physical, organic, or related to mental health. In many situations, both factors contribute, and the field aims to clarify their respective roles

Source: https://www.macmillanlearning.com/college/product/Fundamentals-of-Human-Neuropsychology/p/1464176957

Non-pharmacological innovations are expanding treatment possibilities. Neurofeedback, which trains patients to regulate brainwave activity, has shown measurable benefits in enhancing focus and reducing impulsivity in those with ADHD. Similarly, virtual reality technologies provide immersive environments that stimulate memory, spatial orientation, and problem-solving skills, making rehabilitation more engaging and effective (Manera *et al.,* 2016; Hirshberg *et al.,* 2019).

In parallel, Transcranial Direct Current Stimulation (tDCS) emerges as a painless, non-invasive technique that applies low electrical currents to the brain, with early studies indicating improvements in working memory and processing speed for various cognitive disorders. Together, these approaches represent a shift toward more personalized, engaging, and technologically advanced neuropsychological care, one that aims not only to manage symptoms but also to restore meaningful aspects of daily living (Brunoni *et al.,* 2018).

3.8. Differences between neuropsychopharmacology, neuroanatomophysiology, neurodivergence, and neurological diseases

Neuropsychopharmacology, neuroanatomophysiology, neurodivergence, and neurological diseases represent conceptually distinct yet interrelated domains in neuroscience and clinical practice. Understanding their differences is essential for advancing research, diagnosis, and therapy (Takakusaki, 2017; Bloomfield *et al.*, 2019).

Neuropsychopharmacology investigates how pharmacological agents affect brain function and behavior by targeting neurotransmitter systems, receptor pharmacodynamics, and synaptic modulation, linking molecular changes to clinical outcomes. The neuroanatomophysiology elucidates the structural and functional organization of the nervous system, detailing neuronal circuits, connectivity, and electrophysiological mechanisms underlying sensory, motor, cognitive, and autonomic functions. Neuropsychopharmacology builds upon the mechanistic insights provided by neuroanatomophysiology, which in turn establishes the anatomical and physiological framework necessary to interpret drug actions (Takakusaki, 2017; Bloomfield *et al.*, 2019).

In juxtaposition with the neurodiversity paradigm, neuropsychopharmacology employs a biomedical framework focused on symptom modulation via pharmacological intervention and measurable functional outcomes. The neurodiversity perspective, on the other hand, treats neurodevelopmental variations such as autism spectrum disorder and ADHD as natural cognitive diversity, emphasizing inclusion, environmental adaptation, and identity affirmation. Although pharmacotherapy may be used when symptoms impair function, the underlying philosophies differ: neuropsychopharmacology seeks remediation, whereas neurodiversity prioritizes acceptance and social integration (Takakusaki, 2017; Dwyer, 2022).

The distinction between neuropsychopharmacology and neurological diseases lies in their domains of focus. Neurological diseases such as Parkinson's disease, multiple sclerosis, stroke, or epilepsy are defined by identifiable pathological processes like neurodegeneration, vascular injury, or inflammation, and often demand multimodal strategies including pharmacologic, surgical, and rehabilitative approaches. Neuropsychopharmacology contributes therapeutic agents designed to modulate neural circuits or neurotransmission to alleviate symptoms or potentially influence disease trajectory, but it remains a single facet within a broader therapeutic schema (Everaert *et al.*, 2010; Ouellette *et al.*, 2021; Zamora-Moratalla *et al.*, 2021).

Neuroanatomophysiology and neurodivergence differ in scope and epistemic framing. Neuroanatomophysiology supplies mechanistic explanations by mapping brain structure and physiological processes, from the cellular to the systems level. Neurodivergence denotes enduring cognitive, behavioral, and perceptual variations not necessarily pathological, arising from genetic, developmental, or environmental factors. The intersection occurs when anatomical or physiological studies reveal correlations of neurodivergent traits, yet the two frameworks diverge fundamentally: one describes underlying mechanisms, the other recognizes cognitive diversity (Takakusaki, 2017; Dwyer, 2022).

Comparing neuroanatomophysiology and neurological diseases highlights their relationship between normative function and dysfunction. Neuroanatomophysiology defines normal neural organization for sensation, motor control, cognition, and homeostasis, whereas neurological diseases represent deviations from this baseline caused by injury, degeneration, or malformation. Recognizing these deviations relies on an understanding of normal anatomy and physiology to accurately diagnose and guide interventions (Tables 1-2) (Everaert *et al.*, 2010; Ouellette *et al.*, 2021).

Table 1: Comparison: Neuropsychopharmacology and Neuroanatomophysiology

Field	Scope	Purpose	Illustrative Examples
Neuropsychopharmacology	Investigates the influence of drugs on nervous system activity, especially regarding mental states, cognition, and behavior.	To understand drug mechanisms to treat or manage neurological and psychiatric symptoms.	Administration of multimodal antidepressants like vortioxetine, which targets multiple serotonin pathways.
Neuroanatomophysiology	Studies the organization and functioning of the central and peripheral nervous systems.	To clarify how various components of the nervous system operate individually and interact collectively.	Research into how the prefrontal cortex supports executive planning, the hippocampus facilitates memory, and the spinal cord transmits reflexes.

Sources: Armstrong, 2017; Keene, 2020; Bear *et al.,* 2021; Very well Mind, 2021; Wikipedia, 2025a; Wikipedia, 2025b

Table 2: Comparison: Neurodivergence and Neurological Disorders

Concept	Definition	Characteristics	Examples
Neurodivergence	Natural variations in brain structure and function within the human population.	Typically, developmental and not inherently pathological.	Autism, ADHD, dyslexia, and high intellectual ability.
Neurological Disorders	Pathological conditions that disrupt sensory, cognitive, or motor functions of the nervous system.	Generally linked to identifiable causes and require medical care.	Alzheimer's disease, Parkinson's disease, multiple sclerosis, and epilepsy.

Sources: Armstrong, 2017; Keene, 2020; Bear *et al.,* 2021; Very well Mind, 2021; Wikipedia, 2025a; Wikipedia, 2025b

The neurodivergence and neurological diseases differ fundamentally in prognosis and social framing. Neurodivergence includes lifelong cognitive and behavioral differences such as autism or ADHD that may persist without progressive pathology. In contrast, neurological diseases such as Alzheimer's disease, ALS, or stroke often involve progressive or acquired pathophysiology. While comorbidity is possible, the clinical objectives differ: neurodivergence emphasizes accommodation and inclusion, whereas neurological diseases require diagnosis, disease-modification, and symptom management (Ouellette *et al.*, 2021; Dwyer, 2022; EXT Conversion, 2025).

3.9. Neurodivergent vs. neurodiversity: What's the difference?

Many people often confuse the terms neurodivergent and neurodiversity. It's important to differentiate them, as although they are often used interchangeably, they don't share the same definition. Neurodivergence refers to neurological functioning and development that differs from what is considered common or typical (Conversion, 2025; Formare, 2025).

Neurodiversity refers to natural variations in brain function, just as there are numerous differences associated with height, gender, sexual orientation, weight, and eye color. Emphasize that these brain variations are normal and should not be considered a disease. On the contrary, it celebrates diversity and individuality in the way we think, act, and connect with society (Conversion, 2025; Formare, 2025).

3.10. What is the difference between neurotypical and neurodivergent?

The distinction between neurotypical and neurodivergent individuals relates to how the brain interprets information and interacts with the environment. The neurotypical term refers to people whose neurological development and functioning align with what society considers conventional or expected, without conditions such as autism, ADHD, or dyslexia (Costa, 2025; Doctoralia, 2025).

In contrast, the term neurodivergent was introduced to describe individuals whose brain functions differ from these typical patterns. This difference is not considered a disorder, but rather a reflection of the natural diversity of human neurology. It includes people with ASD, ADHD, dyslexia, dyspraxia, and other cognitive or sensory processing conditions. These terms play an important role in recognizing and valuing the different ways people think and perceive the world, encouraging a more inclusive and respectful society that embraces individual differences (Costa, 2025; Doctoralia, 2025).

3.11. Neuropedagogy or neuroeducation

It is an interdisciplinary field that merges insights from neuroscience, psychology, and education to inform teaching–learning processes. It emphasizes how understanding brain mechanisms such as cognition, memory, emotion, and neuroplasticity can guide effective curriculum design and instructional strategies (Carew and Magsamen, 2010; Elgavi-Hershler, 2023; Martínez García, 2025).

Teacher training grounded in neuropedagogy principles fosters professional competence by enabling educators to leverage empirical findings on motivation, executive functions, and learning processes. Embedding these principles in pre-service and in-service training can enhance educational outcomes by aligning pedagogical approaches with neural and emotional developmental processes (Devonshire and Dommett, 2010; Jones and Kahn, 2017; Pathak and Verma, 2025).

Emerging neurodidactic content tailored for younger learners illustrates how neuropedagogy can be translated into learning activities aimed at cognitive development. For example, structured tasks that harness neuroplasticity and scaffold working memory offer tangible applications of neuroeducation in early schooling environments (Pathak and Verma, 2025).

4. CONCLUSION

The combined study of neuroanatomophysiology and neuropsychopharmacology provides an integrated framework for understanding the nervous system in both health and disease, linking the structural and functional organization of neural circuits with the pharmacological mechanisms that influence cognition, emotion, and behavior. This interdisciplinary perspective bridges basic neuroscience and clinical practice, enabling more precise diagnostic and therapeutic approaches. Differentiating neurodivergence, which represents natural variations in brain functioning such as autism spectrum profiles or ADHD, from neurological disorders, which involve structural or functional impairments producing clinically significant symptoms, is essential for accuracy, inclusivity, and effective treatment planning. Advances in neuroimaging, biomarker discovery, and targeted pharmacotherapies are transforming early detection and personalized care, while psychosocial considerations enhance patient outcomes and quality of life.

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