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The neurophysics of psychiatric diagnosis: Clinical brain profiling

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SUMMARY

As early as the end of the 19th century Ernest Bruck declared that the brain is a physical entity and should be studied using the science of mathematics and physics. The brain is an extremely intricate physical entity and we have only recently begun to develop the conceptual tools to decipher this complexity. We can begin to comprehend many of the mental functions and dysfunctions by using insights about brain organization as a developing physical entity of connectivity structures. A comprehensive theoretical framework for the re-conceptualization of mental disorders as real brain-disorders, called "Clinical brain profiling" can be generated to make testable predictions about the etiopathology of psychiatric disorders. If validated, this framework has groundbreaking relevance for psychiatry, not only by providing an etiological diagnostic system, in itself revolutionary, but in its potential to develop effective curative interventions.

According to the proposed brain profiling all mental disturbances can be defined in a 3 dimensional space of brain disturbances (1) neural-complexity organization, (2) to neural resilience optimization dynamics and (3) to connectivity constructs for context and internal representations. Neural complexity relates to the ability of the brain to balance connectivity dynamics, neural resilience relates to brain plasticity and changeability for optimizing overall brain dynamics and contextual configurations shape the internal representations of outer world that pattern out reaction and personality styles.

Each of these organizational brain functions is predicted to involve a relatively specific neuronal circuitry system in the brain. The circuitry of the nigra-striautum-cortex, are a component of the connectivity balance stabilizers and regulators, a type of neural complexity pacemaker. Thus a patient that rates high on phenomenology related to functional psychosis indicating a disturbance to connectivity balance will have disturbances that will show up in appropriate signal processing imaging of the nigra-striautum-cortex circuitry. The circuitry of thalamus-amygdala-cortex and related pathways are relevant for neuronal matching and constraint frustration. In this respect the patients scoring high on mood and anxiety disorders are predicted to suffer from perturbation shown on appropriate imaging involving the thalamus-amygdala-cortex circuitries. The hippocampus is related to the formation of internal configurations thus those patients rating highest on parameters related to personality organization and maturation will show alterations in the hippocampal organization and activation indicating deficient organizations of internal configurations.

Introduction

As early as the end of the 19th century Ernest Bruck declared that the brain is a physical entity and should be studied using the science of mathematics and physics simultaneously. Theodor Meynert formulated what would now be called the neural computation of mental functions by declaring that when we have a thought or an idea it is represented by activations of neuronal ensembles in our brain. Thus he laid down the basic principle of computational neuroscience [1]. Interestingly Meynert used the term "Ego" to define the brain organization of interconnected ensembles of neurons. This idea was later theoretically developed, though not brain-related, by Freud who basically defined "Ego" as an evolving organization function relevant to personality and psychological development, roughly maintaining Meynert's basic idea.

These pillars of 19th century neuroscience were Sigmund Freud's inspiration. He tried to follow their footsteps, and though he strayed from neuroscience he took their ideas and developed them in a theoretical context that would become known as "Psychoanalysis".

The time has come to return to Meynert and Bruck's original concepts and apply recently developing fields of science, for example computational neurosciences, to the study of mental disorders and formulations of psychiatric diagnosis.

Using these approaches the brain system is described as a dynamic ever-changing physical entity that functions on the delicate

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balance between order and randomness manifesting activity that has only recently acquired its mathematical description in the form of non-linear dynamics and deterministic chaos formulations.

As such we need to understand that the brain operates as a balanced system sensibly acting on the border of conflicting conditions optimizing the activity of specific equilibrium balances of massively integrated neuronal ensembles. It is assumed that when optimally and flexibly balanced, the brain generates what we call "normal" brain functions. Consequently it is hypothesized that when this optimal brain dynamics is perturbed, mental disturbances arise. Since the collapse of optimal brain organization can assume various forms, mental disturbances appear in numerous different patterns of clinical manifestations.

We can begin to comprehend many mental functions and dysfunctions by using insights about brain organization as a developing physical entity of connectivity structures. A comprehensive theoretical framework for the re-conceptualization of mental disorders as real brain-disorders can be generated for testable predictions regarding the etiopathology of psychiatric disorders. This type of framework is explained here using the term "Clinical brain profiling".

Brain organization, personality and personality disorders

The human brain does not operate in a vacuum. It develops within an environmental context critical to its maturation and optimization. This environment is influenced by the brains of care givers and others. As brains interact with the environment there is bi-directional change that creates a complex psychosocial interactive environment.

The young brain has the basic flexibility necessary for change, but is less orderly than the mature brain and needs a structuring environment to develop stable optimization capabilities. From a sociological perspective this is called "education" and "upbringing." In biophysical language it could be defined as sets of repeating structuring input signals and stimuli. The newborn grows within the context of a family structure that is composed of "structuring brains" (of mother and father) that enable a stable stimuli-repeating environment for the child.

Ramon I Cajal stated that information is embedded in the connections of neural networks in the brain [2], Donald Hebb [3] stated that when groups of neurons fire together synchronously the connection between them strengthens, thus recurring stimuli that repeatedly activate neuronal ensembles embed the information from these stimuli in the form of strengthened connectivity patterns within the neural tissue. "Experience–dependent-plasticity" is the modern term for describing the embedding of internal representations of outer-world experiences within the brain organization. Plasticity in this context would be the term that describes altered connectivity organization and other brain changes such as pruning of synapses and neuronal growth [4].

"Matching complexity" [5] and "Free energy" [6] are concepts relevant to the way the brain create an internal model of the world, one that is concordant, flexible and adaptable with the ever-changing occurrences in the real world. "Matching complexity" describes how the statistical configurations in patterns of inputs create statistical correlates of neural activations by forming input-related synaptic connectivity strengthening among neural ensembles in the brain. "Free energy" describes Bayesian statistics in the brain responsible for ongoing reductions between internal activations of the brain and sets of input patterns. Based on these insights we can begin to understand how the brain creates and maintains a flexible updated adaptable model of reality.

Carl Rogers [7] suggested that the best vantage point for understanding behaviour is from an "internal frame of reference" of the individual himself. He called this frame of reference the "experiential field" that encompasses the private world of the individual. According to Rogers, "organismic evaluation" is the mechanism by which a "map" (i.e., the internal configuration) of the experiential field assesses the psychological events of everyday life [7]. Object relations psychologists talk about internal objects that create the internal reference according to which, we perceive ourselves and others. These descriptions ultimately explain how we react and behave in psychosocial contexts and thus explain our personality traits and development.

We can now begin to define personality as the result of evolving flexible ever-changing neural-networks constructs and organizations in the brain that provide for the adaptable interactions and behaviour with the environment and other behaving brains. With this definition we can now begin to approach personality disorders from a brain-related perspective.

If during development, for some reason, markedly unusual, erratic and unbalanced experiences occur, then Hebbian neural organization would be impaired and experience-dependent-plasticity processes would reflect biased experiences creating internal representations that can be markedly removed; i.e. mismatching of real-world occurrences. Such a mismatch would cause non-adaptive attitudes or responses and behaviour due to the disparity between what an individual perceives (according to his internal representations) and what is actually occurring.

Using these definitions, psychotherapy is a method that uses an interpersonal encounter where corrective experiences are therapeutic. This most probably happens by experience-dependent-plasticity in which repeated corrective experiences (Hebbian dynamics) create the connectivity changes needed to form internal perceptions that would form more adaptive and less conflicting and tormenting experiences for the patient [8].

This novel understanding of personality disorders can enable new approaches to treatment. For example plasticity-enhancing medications can provide effective psychotherapeutic interventions to enhance brain plasticity that would allow for effective changes. Bringing the brains of patients to early-age childhood-plasticity can have enormous relevance for correcting childhood traumas and biases.

Brain dynamic optimization, emergent properties and affective disorders

Optimization is typically defined as the ability of a system to evolve until it approaches a critical point and then maintain itself at that point.

If a particular dynamic structure is optimal for the system, and the current configuration is too static, then the more adaptable configuration will be more successful. If the system is currently too erratic, then the more static mutation will be selected. Thus, the system can adapt in both directions to converge on the optimal dynamic characteristics.

Emergent properties are synergistic. Emergent properties are those properties of a system that are part of the system as a whole and cannot be understood based on the characteristics of the elements considered in isolation. Thus, the characteristics of the system are more than the sum of the attributes of the elements of the system.

For example, considering mental functions as emergent properties from brain organization, in 1962 Rosenblat stated that "neurons have never been demonstrated to possess psychological functions (e.g., mood, awareness, intelligence). Such properties presumably emerge from the nervous system as a whole" [9]. It is evident from brain research that microcircuits of neurons possess more properties than those that can be deduced from our understanding of the single