



Clinical Brain Profiling Theory in a Nutshell

The plasticity theory for psychiatry is rather straightforward. It is based on two assumptions 1) Emergent properties from the brain, and 2) brain network dynamics.

Emergent properties are typically defined by the statement that the “whole is more than the sum of its parts”. This is true for systems characterized by non-linear interacting elements. The emergent properties evolving from the complexity of the brain are phenomena such as consciousness, mood and personality. One neuron, or even a large group of neurons, do not show characteristics such as consciousness, mood and personality. However the whole brain integrative activity does. Thus, in disturbances to consciousness, mood and personality, we assume that whole brain organization will be influenced.

As for the second assumption, that of brain network dynamics, the hypothesis is that mental disorders are disturbances to the optimal whole brain organizations with hubs set as Central Executive Networks for fast millisecond range plasticity, Default-Mode Network for lifelong stable plasticity and Salient Network for in-between months, weeks, plasticity adaptations . Different phenomenological manifestations of mental disorders are caused by different types of neuronal network “breakdown” patterns. These can be conceptualized in terms of disturbances to plasticity network dynamics.

Plasticity is the term reserved for interactions taking place between, and among, neuronal network systems in the brain (neurogenesis and synaptic activity), these are typically interactive with external environments via sensation (sensory systems) and actions (motor activity).

The disturbances to brain plasticity-dynamics can be defined by their time-scales and interactions with the environment. “Cognizance Plasticity” is in the millisecond range integrating brain organizations, that of Central Executive Network, from instant to instant with the emergent property of Consciousness and the capabilities of cognitive functions such as problem solving and action planning. The brain is organized as a network with connectivity and hierarchy, thus



altered Cognizance Plasticity involves disconnection or over-connection and hierarchical bottom-up or top-down connectivity alterations.

“Reactive Plasticity” is somewhat on a longer timescale. Cognizance Plasticity, that of minutes to hours, stabilizes the Cognizance plasticity in the face of perturbations caused from large alterations of environmental dynamics (i.e., stress). Large alterations of environmental dynamics, that typically characterize stressful occurrences perturb and destabilize the fast (millisecond-range) plasticity and thus requires a more lasting connectivity stabilization of Reactive Plasticity to “hold it together.”

“Adaptive Plasticity” is slower. It spans time-scales of weeks. It reflects Hebbian Dynamics creating memories where neurons that fire together increase the connections between them (wire-together). Adaptive Plasticity sustains memories, which in turn build internal representations of the environmental occurrences. In effect, the fast Cognizance Plasticity, slower Reactive Plasticity and even slower Adaptive Plasticity generate an internal model of the environmental events in the brain. Such an internal model of the world organizes brain dynamics to predict and optimize the interactions with the environment assuring optimal effective survival for the individual. The brain acts to minimize the differences (Delta) between psychophysical occurrences in the environment and the internal brain-model of these same environmental occurrences. This is done by continuous “update” of the internal model based on sensory activity and by continuous adaptive interventions in the environment via motor activity in the surrounding environment. Thus, the slower Adaptive Plasticity is the one responsible for minimizing brain-environment bias (reducing free energy or delta in mathematical physical terms). This is done with Bayesian dynamics where the brain continually makes error predictions and corrections interacting with the environment. The Salient Network subcortical hubs are probably most operational for such intermediate-range (weeks monthes) plasticity regulation activity

Finally, “Developmental Plasticity” results from life-long processes of all the above plasticity dynamics. This lifelong developmental process is often defined as “Experience- Dependent Plasticity” and is composed of long-lasting, memories embedded in the brain network-



configurations because of life-long Hebbian dynamics. The total life experiences acting on the developing brain from its first developmental stages create a lasting stable basic neural-network organization in the brain that encodes internal representations of the environment including occurrences that are more complex; those of social interactions including self and others-representations. Such neuronal network organization in the brain is basic (at rest), and is conceptualized as the “Default-Mode-Network” because it is apparent when the brain is not engaged in stimulated rapid cognitive-related action. The emergent property from the activity of basic developmental Default-Mode-Network is the Personality style, reflected in the reactions and attitudes “shaped” by the life-long experiences of the individual.

According to the above conceptualizations, psychiatric disorders can now be reformulated. Disturbances to the fast millisecond-range Cognizance Plasticity will disturb conscious integration with symptoms of psychosis and schizophrenia. Disturbances to Reactive Plasticity, the reactive stabilization of neural networks in the face of environmental perturbations, result in the emergent phenomenology of anxious sensations and anxiety symptoms. The disturbances to slower Adaptive Plasticity that optimizes internal representations and reduces predictive error will result in mood disorders. De-optimized brain with free energy increases results in the emergent property of depression and vice versa. Optimization dynamics is mood elevating i.e., possible manic symptoms. Finally, altered internal representations of psychosocial occurrences due to “immature” biased Default-Mode resting brain network organization result in personality-related distortions, which lead to ineffective, biased social interactions and an emergent property of personality disorders. Table 1 summarizes the plasticity disturbances and their phenomenological correlates



Table 1: Plasticity disturbances and their phenomenological correlates

Plasticity disturbance	Network involved	Brain system disturbance	Psychiatric phenomenology
Cognizance Plasticity	Central Executive Network	Disturbance to millisecond range integrating brain organizations. Disconnection or over-connection and hierarchical bottom-up or top-down connectivity are disturbed	Psychosis and schizophrenia (negative signs)
Reactive Plasticity	Salient Network	Disturbances to longer timescale those of minutes to hours, the stabilizing network plasticity in the face of perturbations caused from large alterations of environmental dynamics (i.e., stress).	Anxiety (general, reactive, phobia)
Adaptive Plasticity	Salient Network	Disturbance to slower time-scales, those that span hours to weeks and are responsible for reducing free energy. The differences between internal representations (memory constructs) and external environmental occurrences. De-optimization takes place when free energy increase and mismatch between internal representations and external events becomes larger	Mood disorders
Developmental Plasticity	Default mode network	Disturbances to the Default-Mode Resting brain network organization resulting in distortions of internal representations of the psychosocial world which lead to ineffective biased social interactions	Personality disorders