# MIND AND COSMOS: THE COMPLEX INTERPLAY BETWEEN MIND, BRAIN, GENE, BEHAVIOR AND ENVIRONMENT. TOWARDS AN INTEGRATED CONCEPTUAL FRAMEWORK

Nicola Luigi Bragazzi

ABSTRACT: Scientific reductionism – either epistemological (the body of scientific knowledge pertaining a given domain can explain the knowledge of other domains), ontological (the complexity of reality is just given by molecules and their interactions, and nothing more), or methodological (the knowledge of certain phenomena can be explained just taking into account simpler components) – has dominated centuries of scholarly production, discoveries and dissemination. Only recently, multidisciplinary, holistic approaches based on consilience (convergence or concordance of evidence) have emerged, suggesting that reality can be understood in terms of non-linear feedback loops and complex, multifaceted webs of interactions underlying the emergence of consciousness and self, thus overcoming the shortcomings derived from adopting a strict reductionism (mentalism versus physicalism), classical compartmentalization-based approaches or the Cartesian dualism (immaterial mind, res cogitans, versus material body, res extensa). The need of more integrated conceptual frameworks explaining the emergence of the self has led to conceiving reality and phenomena not as static, interacting concepts but as complex, dynamic, self-organizing networks and highly adaptive systems. Recently, merging biological and psychological disciplines (ranging from developmental genomics to neurobiology and neuropsychology), the US psychologist and psychotherapist John Arden has elaborated a complex conceptual framework, consisting of i) self-organization, ii) social self and social brain, iii) epigenetics, iv) psycho-neuro-immunology, v) self-regulation and self-maintenance and vi) habits and motivation. This conceptual theory integrates different complexity levels in a coherent framework and appears to be a promising proposal for exploring the emergence of self and consciousness as well as for integrating the different psychotherapeutic approaches available. Obviously, this is only the beginning of a grand theory that can shed light on the relationship between mind and cosmos, and on the complex interplay between mind, brain, gene, behavior and environment, leading towards an integrated conceptual framework.

KEYWORDS: Scientific reductionism; Dualism; Pluralism; Consilience; Mind, brain, gene and environment

Scientific reductionism – either *epistemological* (the body of scientific knowledge pertaining a given domain can explain the knowledge of other domains), *ontological* (the complexity of reality is just given by molecules and their interactions, and nothing more), or *methodological* (the knowledge of certain phenomena can be explained just taking into account simpler components) – has dominated centuries of scholarly production, discoveries and dissemination (Fang and Casadevall, 2011).

Only recently, multidisciplinary, holistic approaches based on *consilience* (convergence or concordance of evidence) have emerged, suggesting that reality can be understood in terms of non-linear feedback loops and complex, multifaceted webs of interactions underlying the emergence of consciousness and self, thus overcoming the shortcomings derived from adopting a strict reductionism (mentalism *versus* physicalism), classical compartmentalization-based approaches or the Cartesian dualism (immaterial mind, *res cogitans*, *versus* material body, *res extensa*) (Table 1).

**Table 1. The various integration levels theoretically possible.**

| INTEGRATION LEVEL | EXAMPLES OF THEORIES |
|---|---|
| Reductionism | Mentalism *versus* physicalism |
| Dualism | Cartesian theory (*res cogitans versus res extensa*) |
| Pluralistic and eclectic theories | Coexistence of different levels and perspectives, not necessarily integrated |
| Holistic theory/grand theory | Different levels coherently integrated |

The need of more integrated conceptual frameworks explaining the emergence of the self has led to conceiving reality and phenomena not as static, interacting concepts but as complex, dynamic, self-organizing networks and highly adaptive systems (Mainzer, 2008; Müller, 2017).

Recently, merging biological and psychological disciplines (ranging from developmental genomics to neurobiology and neuropsychology), the US psychologist and psychotherapist John Arden (2019) has elaborated a complex conceptual framework, pictorially shown in Figure 1.

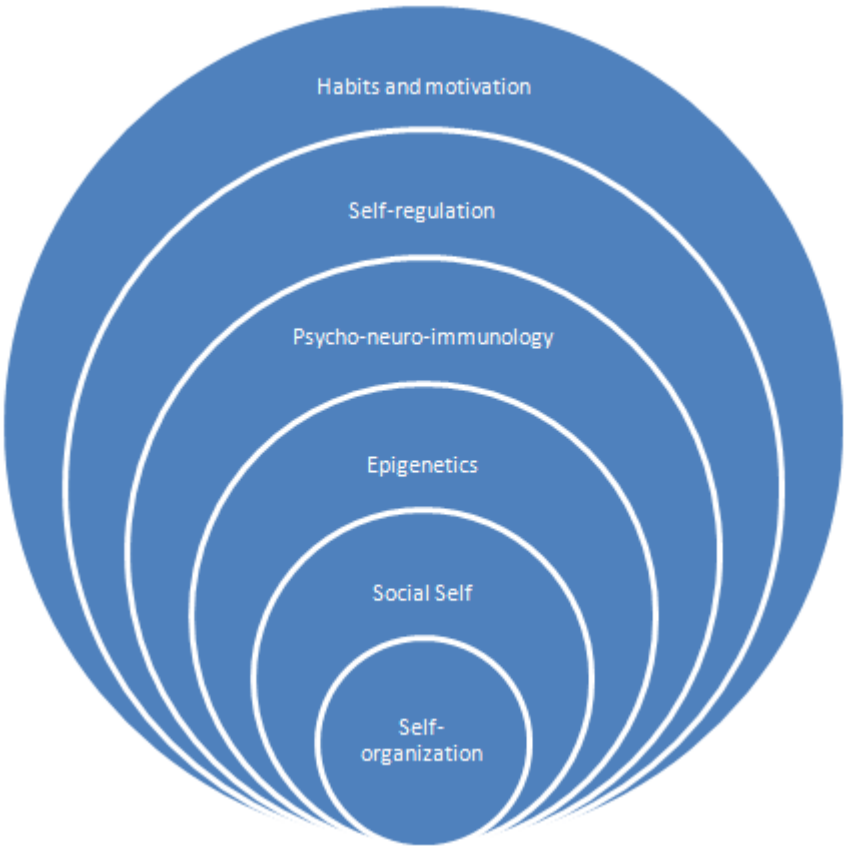


**Figure 1. An integrated, holistic model leading to the emergence of self (according to Arden).**

This multifaceted framework incorporates different subordinated sub-systems at an increasing level of complexity.

*Self-organization*: leads to the emergence of subjectivity, individuality and the ways the subject interacts with others. It explains how body, emotion and cognition merge together. There exist different mental operating systems and modules, including i) the *emotional and reward salience network* (known also as the *feeling network*, comprising of a core, composed of the bilateral anterior insula, the dorsal anterior cingulate cortex, and the sub-lenticular extended amygdala, and secondary components including the *substantia nigra*, the ventral tegmental area, the ventral striatum, the dorsomedial thalamus, and the hypothalamus,

among others), ii) the central executive network (consisting of the bilateral dorso-lateral prefrontal cortex and the posterior parietal cortex), and iii) the default-mode network (or DMN, comprising of the medial prefrontal cortex, the hippocampus, the posterior midline and the cingulate cortex). These networks are responsible of the emergence of the *material or sentient self*, the *meta-mental or meta-cognitive self* and the *mental self*, respectively. In its turn, the emotional self apparatus consists of seven systems: namely, the i) seeking, ii) fear, iii) rage, iv) lust, v) care, vi) panic/grief and vii) play systems, which enable to express and convey sentiments and emotions, such as expectancy, anxiety, anger, sexual excitement, nurturance, sadness and joy, respectively (Panksepp and Davis, 2018).

The *Social Brain* (Adolphs, 2009; Cozolino, 2017) is how the brain and the mind are wired by social experiences and contexts, thus leading to the emergence of a *Social Self*. Neural components are the right hemisphere, the orbital frontal cortex, the amygdala, the insula, the cingulated cortex (especially the anterior part), the temporal parietal junction, and the facial expression modules (FACS, Facial Action Coding System) (Ekman et al., 2002), together with the Theory of Mind (ToM) network (Schurz et al., 2014). From a cellular standpoint, spindle cells and mirror neurons (Rizzolatti and Fogassi, 2014; Rizzolatti and Sinigaglia, 2016) are key components, that play a major role in social cognition and experiences.

*Epigenetics* is the subtle, dual relationship between the biological make-up (gene, genomics and post-genomics) and mind/behaviours. Epigenetic mechanisms and processes, such as chromatin remodelling, histone modifications, nucleosome repositioning, and direct/indirect modulation of gene expression by non-coding RNAs such as microRNAs (miRNAs), are of paramount importance in ensuring proper development and stability of tissue-specific gene expression patterns in mammals, including humans. Epigenetic dysregulations can result in malignant cell transformation, providing a major link between cellular adaptation to tumour microenvironment and plasticity. Understanding epigenetic changes plays a central role not only in cancer etiopathogenesis, but also in prevention and therapy of other chronic-degenerative disorders. Modifications of specific sites of histones which are involved in the organization of the chromatin structure and in the regulation

and expression of gene transcription can induce changes in the transcription of various genes. Besides the biological makeup with its genetic/epigenetic dysregulations, lifestyles, such as nutrition and exercise/physical activity, play a major role both in the etiopathogenesis and prevention of cancer and other communicable disorders, also influencing epigenetic events.

*Psycho-neuro-immunology (PNEI) and its variants (including psycho-neuro-endocrino-immunology, or PNEI)* reflect the complex, non-linear interactions between the psychological apparatus, the neurological, immunological and endocrinological systems.

*Self-regulation and self-maintenance* include all those circuits that finely tune, regulate immunity, gene regulation and expression as well as homeostatic processes (including sleep and circadian rhythm). Alterations of this complex circuitry result in sleep disturbances, immune dysregulation, impaired gene expression and the potential insurgence of chronic-degenerative disorders.

Finally, *habits and motivation* have as neural substrates the motivation-pleasure circuits, which are responsible of feelings, sensations and behaviours like appetite, reward, gratification, expectations and seeking novelties/taking risks. These circuits can be subdivided into i) central executive-based, ii) attention-based, ii) social-emotional and reward-based circuits. The key player involved in this complex circuitry is the *nucleus accumbens* (Berridge and Kringelbach, 2015). The lower loop includes as operating networks/modules the emotional and reward salience network and the DMN, also involving the orbitofrontal cortex, the caudate nucleus and the thalamus. The middle loop involves the anterior cingulate cortex, the *dorsostriatum*, the *globus pallidus* and the thalamus (Chuhma et al., 2011). The upper loop comprises the central-executive network, mainly involving the dorsolateral prefrontal cortex, the caudate nucleus and the thalamus. Alterations of these circuits lead to disturbances, such as addictions (including alcohol and substance use, and behavioural addictions, like gambling, excessive shopping, gaming, internet and smart phone use, food and sex addictions, among the others) (Derevensky et al., 2019; Grant et al., 2010).

All these complexity levels are briefly overviewed and summarized in Table 2.

**Table 2. The various complexity levels underlying the emergence of self and consciousness according to Arden.**

| COMPLEXITY LEVEL | OPERATING NETWORKS/MODULES | COMPONENTS | CELL TYPE | MAJOR NEURO-TRANSMITTERS, GROWTH FACTORS, SIGNALLING MOLECULES AND MEDIATORS | DUSTURBANCES |
|---|---|---|---|---|---|
| Self-organization | Emotional and reward salience network (known also as the feeling network) | Bilateral anterior insula, dorsal anterior cingulate cortex, sub-lenticular extended amygdala, *substantia nigra*, ventral tegmental area, ventral striatum, dorsomedial thalamus, and hypothalamus | Spindle cells, mirror neurons | Serotonine | Anxiety disorders, post-traumatic stress disorder, schizophrenia, frontotemporal dementia, and Alzheimer's disease |
| | Central executive network | Bilateral dorso-lateral prefrontal cortex and posterior parietal cortex | | | |
| | Default-mode network | Medial prefrontal cortex, hippocampus, posterior midline and cingulate cortex | | | |
| Social self and social brain | Social brain circuitry and vagal brake, Theory of Mind (ToM) network | Orbital frontal cortex, amygdala, insula, temporal parietal junction, cingulate cortex and Facial Action Coding System (FACS) module | Spindle cells, mirror neurons | Endogenous opioids and oxytocin | Anxiety disorders, depression |

| | | | | |
|---|---|---|---|---|
| Epigenetics | Circuitry involved in gene regulation and expression | | Telomerase, transcription factors (TFs) | Immune dysregulation, impaired gene expression, and related co-morbidities |
| Psycho-neuro-immunology | Immune, neurological, and endocrinological systems and circuitry involved in gene regulation | | Interleukins, cytokines and other signalling molecules | Inflammatory, autoimmune and auto-inflammatory disorders |
| Self-regulation and self-maintenance | Immune system and circuitry involved in gene regulation and expression, and homeostatic processes (including sleep) | | Brain-derived neurotrophic factor (BDNF), insulin-like growth factor type I (IGF-I), nerve growth factor (NGF), vascular endothelial growth factor (VEGF) and other growth factors (GFs) | Immune dysregulation, impaired gene expression, sleep disturbances and related co-morbidities |
| Habits and motivation | Motivation-pleasure circuits (lower, middle and upper loops) | *Nucleus accumbens* Medium spiny neurons | Dopamine | Addictions, including behavioural addictions |

This conceptual theory integrates different complexity levels in a coherent framework and appears to be a promising proposal for exploring the emergence of self and consciousness as well as for integrating various disciplines (biology, anthropology, psychology, and so on) and different psychotherapeutic approaches available. Obviously, this is only the beginning of a grand theory that can shed light on the relationship between mind and cosmos, and on the complex interplay between mind, brain, gene, behaviour and environment, leading towards an integrated conceptual framework.

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