



Theoretical Analyses

Large-Scale Brain Networks and Freudian Ego

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Abstract

Sigmund Freud, the founder of psychoanalysis, is predominantly known for his conception of the id, ego and super-ego, representing a part of his meta-psychology of the psychic apparatus. Nowadays, with the advancements in technology and science, his meta-psychological structural model of the psyche might be either confirmed or denied by comparing the account of the psychic apparatus of the classical psychoanalysis to the newest findings in neuropsychology and cognitive neuroscience. Indeed, the founded interdisciplinary project of neuro-psychoanalysis strives to answer such questions. In this article, the current thinking on the discussions around Freudian ego and its possible brain correlates is presented. In 2010, Robin Carhart-Harris and Karl Friston introduced a neuro-psychoanalytic account of the psychic apparatus, where the ego correlated with a large-scale brain network called the default-mode network. In the end of this paper, an original theoretical hypothesis is offered, supplemented with review of the literature, namely that the central-executive network and the salience network are viewed as the true representatives of Freudian ego. The offered hypothesis criticizes Carhart-Harris and Friston's postulating of the default-mode network as being the brain representative of Freudian ego.

Keywords: Sigmund Freud, meta-psychology, ego, cognitive neuroscience, brain imaging, large-scale brain networks

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In the recent decades a renewed interest or a renaissance in classical psychoanalysis is observed, one mostly related to neuroscience, particularly neuropsychology. The questions about what the ego represents in reality, how it can be scientifically studied and which its correct brain correlate is, if any at all, remain unanswered, even in today's era of cognitive science and brain imaging. Nevertheless, attention is still heavily drawn to the topic.

In the current article, the structural model of the psyche (id, ego and superego), according to Sigmund Freud's classical meta-psychology, a part of his psychoanalysis, is presented. Secondly, current hypotheses about the brain correlate of Freudian ego are reviewed and discussed, especially the hypothesis of [Carhart-Harris and Friston \(2010\)](#) that the ego is represented in the brain by a large-scale brain network called the default-mode network. Finally, after a constructive critique of [Carhart-Harris and Friston \(2010\)](#), an original hypothesis is proposed, namely that the brain correlates of Freudian ego correspond to the large-scale brain networks salience network (SN) and central-executive network (CEN). Default-mode network (DMN), the third large-scale net-

work, it is concluded, should be related to low-level secondary thought processing; it can also be related to primary level thought processing, such as the one observed in dreaming and mind-wandering, two heavily loaded situations with self-referential processing.

Methods

Hereby the methodology of a newly established discipline, called *neuro-psychoanalysis* (Cusumano & Raz, 2014; Panksepp & Solms, 2012; Solms & Turnbull, 2016) will be used. It provides a thorough account of the psychic apparatus, complemented with hypothetical correlations to brain regions and their respective functions. This allows one to compare the state-of-the-art of classical psychoanalysis with the newest research in both psychoanalysis and neuroscience. By doing that, one would be able to test the entirely speculative account of the psychic apparatus of the classical psychoanalysis (Kitcher, 1995) by comparing it with the account of the psychic apparatus, which neuropsychology and cognitive neuroscience do provide.

It is now known that Freud (1895/1953) did abandon neuroscience after the establishment of a scientific psychology in the face of the *Project for a Scientific Psychology* (Northoff, 2012). This has led to two consequences: first, the project remained purely speculative, and, second, Freud stopped following the newest research, which could contradict or accept his speculative theory (Kitcher, 1995). In fact, Grünbaum has succeeded to critique some parts of the classical psychoanalysis by performing a philosophical critique (Grünbaum, 1984).

In the following sections, the account of the psychic apparatus is presented as conceived by Sigmund Freud's classical psychoanalysis. Subsequently, this paper presents the newest findings in neuropsychology, cognitive neuroscience and neuro-psychoanalysis, which are related to the classical account of the psychic apparatus.

Finally, a critique of Carhart-Harris and Friston's ideas (2010, 2012) is presented, who correlate brain regions, namely large-scale brain networks, to some parts of the psychic apparatus (the id and the ego), which culminates with the introduction of a new original hypothesis of the brain correlates of the psychic apparatus, proving Carhart-Harris and Friston to be wrong in their suggestions, complemented by a thorough review of the relevant literature.

Freudian Meta-psychology: A Focus on the Structural Model of the Psyche

By firmly moving from medical neurology towards theoretical psychology, Freud tried to establish the foundation of a scientific psychology on the grounds of the current research in neurology at the time (Freud, 1895/1953; 1900/1997; 1911/2008; 1912/2008; 1914/2008; 1915/2008). To accomplish this, he relied heavily on neurological terms and conceptions. He was familiar with the works of John H. Jackson and Theodor Maynert (Kitcher, 1995). Later, however, he stopped following the newest neurological research and started on pure speculative grounds to build the so much desired scientific psychology. This unequivocal exclusion of neurological research in the future development of Sigmund Freud's works is identified as his main scientific fault and erroneous step (Kitcher, 1995). In his attempts in the establishment of a scientific psychology, Freud developed the methodology of psychoanalysis. Psychoanalysis among other things comprises meta-psychology, or a psychology of psychology, a discipline which includes the structural and the topographical models of the psyche (Freud, 1923/1961; Izenberg, 1976, pp. 13-69). The structural model, as well as the topographical model, are regarded

as hypothetical models (Kitcher, 1995, pp. 39-45). The topographical model of the psychic apparatus comprises the unconscious, the preconscious and the conscious parts of the psyche. By definition, every model has to remain hypothetical but opened to improvement. The structural model of the psyche has three elements: the id, the ego and the superego. The function of the id is to provide the psycho-energetic power or drive to the psyche. The ego, on the other hand, strives to maintain a homeostatic condition, even in the face of the struggle between the desires of the id and the values of the superego. Lastly, the superego represents an internalized variant of high-level societal ethical and moral norms. Freud himself uses the metaphor of the horse and the rider to represent the interaction between the ego as the rider and the id as the horse (Freud, 1933/1993, p. 210). Interestingly and intriguingly, the same metaphor can be found also in Plato's oeuvre "Phaedrus" (Thompson, 1868, p. 73-74).

With regard to neuroscience, it has to be emphasized that Freud opinionated that "our mental topography has for the present nothing to do with anatomy; it is concerned not with anatomical locations, but with regions in the mental apparatus, irrespective of their possible situation in the body" (Freud, 1915/2008, p. 118). This moment represents Freud's terminative departure from pure neurology towards pure speculative psychology.

Even nowadays there are many misunderstandings of the concept of the ego. Freud himself explained the ego as having the tasks of self-preservation, controlling movements and assigns two aspects to it, namely an internal aspect and an external one. Freud writes: "As regards external events, it performs that task by becoming aware of stimuli, by storing up experiences about them (in the memory), by avoiding excessively strong stimuli (through flight), by dealing with moderate stimuli (through adaptation) and finally by learning to bring about expedient changes in the external world to its own advantage (through activity). As regards internal events, in relation to the id, it performs that task by gaining control over the demands of the drives, by devising whether they are to be allowed satisfaction, by postponing that satisfaction to times and circumstances favourable in the external world or by suppressing their excitation entirely" (Freud, 1938/1940, p. 140).

The exact function of the ego, in summary, according to Freud, is the following:

[...] the ego is that which knows and that which can be known [...] while the id consists of "the dark, inaccessible part of our personality [...] the ego is also an agency that controls and initiates action whereas the id can only act through influencing the ego [...] Just as the id is directed exclusively to obtaining pleasure, so the ego is governed by considerations of safety [...] Due to the id's lack of concern for external reality and safety, the ego assumes the role of an executive agent [...] As a frontier-creature, the ego tries to mediate between the world and the id, to make the id pliable to the world and, by means of its muscular activity, to make the World fall in with the wishes of the id" [...] the ego is viewed as a regulating agent in charge of balancing the demands of the "irrational" id, super-ego, and constraints of the external world [...] The ego functions here via cognitive activity and perception, anticipating danger, and both preparing responses and inhibiting action (Freud, cited in Boag, 2014, p. 2).

The ego strives to maintain the inner psychic homeostasis by applying the reality principle, that is, by slowing, modulating, transforming, inhibiting and controlling the forces of the id or avoiding accumulation of excitation, which gives rise to reasoning and executive functioning (Freud, 1900/1997, p. 432).

Freud thought of the ego first as a *bodily ego* (Freud, 1923/1961, p. 26). In this line of reasoning, Sletvold suggests that: “It [the ego] is the combined experience of the external world and the state of our own body that somehow lays the foundation for ‘the feeling of our self, of our own ego’” (Sletvold, 2013, p. 1022).

Current Hypotheses About the Brain Correlate of Freudian Ego: A Review

Nowadays, psychologists, psychoanalysts, philosophers, neuroscientists and other scholars unite together to uncover the enigma around the construction of the Freudian ego. Even a special discipline called *neuro-psychoanalysis* has been founded to answer such questions (Cusumano & Raz, 2014; Panksepp & Solms, 2012; Solms & Turnbull, 2016). The concept of self is also implicated in deep debates in neurophenomenology, neuro-philosophy, neuropsychology and neuro-psychoanalysis (Gallagher, 2000; Northoff, 2013; Northoff et al., 2006). For example, the self is regarded as constituted of qualia, as being pre-reflective or unintentional, extended or autobiographical self, an interpreter, a narrative self, a dialogical self, an emotional self, a spatial self, a verbal self, “minimal” self, proto or bodily “self”, or in, general, as being qualified as “mineness” (Northoff et al., 2006, p. 440). However, such constructs, to the author’s knowledge, are not researched with relation to Freudian meta-psychology. To be noted, the concept of self, however, differs from the concept of ego used in Freudian meta-psychology. Freudian ego is part of a structure executing particular functions, whereas the self is an experience, having the property of “mineness”.

In the last two decades three large-scale brain networks were discovered, which are listed in Table 1 and which take major functional positions in the mind-brain complex (Bressler & Menon, 2010; Carhart-Harris & Friston, 2010; Menon, 2015; Menon & Uddin, 2010; Seeley et al., 2007). These three networks are the central-executive network (CEN), the default-mode network (DMN) and the salience network (SN). In Table 1 and Table 2, the anatomy and the functionality of the three networks, as well as the meta-psychological dichotomy of Freudian primary and secondary thought processes are listed (see Table 1 and Table 2, respectively). According to Menon (Menon, 2011, p. 500; Menon, 2015, p. 605), SN should be identified as the ultimate controller in the human brain. The network basically controls and regulates the switching between DMN and CEN. SN receives sensory signals and, moreover, it receives signals from the autonomic nervous system and strives to maintain the homeostasis of the mind-brain complex.

In cognitive neuroimaging of the *self*, the focus is on *self-referential processing*, a process of thoughts with reference to the self (Kelley et al., 2002). Many brain regions were identified to be correlated to it. Such regions comprise the following ones: “ventro- and dorsolateral prefrontal cortex, lateral parietal cortex, bilateral temporal poles, insula, and subcortical regions, including brain stem, colliculi, periaqueductal gray (PAG), and hypothalamus/hypophysis [...] the medial orbital prefrontal cortex (MOFC), the ventromedial prefrontal cortex (VMPFC), the sub/pre- and supragenual anterior cingulate cortex (PACC, SACC), the dorsomedial prefrontal cortex (DMPFC), the medial parietal cortex (MPC), the posterior cingulate cortex (PCC), and the retrosplenial cortex (RSC) [cortical midline structures (CMS)]” (Northoff et al., 2006, pp. 441-442).

In particular, it is established that the functional integrity of the default-mode network is disrupted under the influence of psychotomimetic drugs, such as psychedelic compounds, inducing a state characterized by an “ego [or self] dissolution”ⁱⁱ (Carhart-Harris et al., 2013, p. 8; Carhart-Harris et al., 2014, p. 2). In fact, both the internal-

Table 1

Anatomy and Functionality of the Three Large-Scale Brain Networks CEN, DMN and SN

Central-Executive Network (CEN)	Default-Mode Network (DMN)	Saliience Network (SN)
Anatomy		
The dorsolateral prefrontal cortex, frontal eye fields, dorsal medial prefrontal cortex, intraparietal sulcus and superior parietal lobule (Carhart-Harris & Friston, 2010, p. 1271; Dimkov, 2015, pp. 42-43)	The medial prefrontal cortex, the posterior cingulate cortex, the inferior parietal lobule, the lateral and inferior temporal cortex and the medial temporal lobes (Carhart-Harris & Friston, 2010, p. 1268; Dimkov, 2015, pp. 42-43)	The dorsal anterior cingulate cortex, the frontoinsula cortices, amygdala and ventral midbrain, substantia nigra, thalamus, hypothalamus (Carhart-Harris & Friston, 2010, p. 1271; Dimkov, 2015, pp. 42-43; Menon & Uddin, 2010; Seeley et al., 2007, pp. 2351-2352)
Functionality		
<ol style="list-style-type: none"> 1. goal-orientation (Christoff, 2013, p. 320) 2. executive functions such as: self-awareness, goal-setting, planning, initiation and self-monitoring, awareness, evaluation, prediction, anticipation, self-control, control of attention, inhibition, task management and set-shifting (Funahashi, 2001, p. 149; Koechlin, Ody & Kouneiher, 2003, p. 1181) 3. high-level cognitive functions, such as control of attention and working memory (Bressler & Menon, 2010, p. 277) 4. elaboration of plans (Barbey & Patterson, 2011, pp. 5-7) 5. environmentally-focused information processing (Palaniyappan, White & Liddle, 2012, p. 2326) 6. cognitive control (Koechlin, Ody & Kouneiher, 2003, p. 1181) 	<ol style="list-style-type: none"> 1. internally focused tasks involving autobiographical memory retrieval, envisioning the future, and conceiving the perspectives of others (Buckner, Andrews-Hanna, & Schacter, 2008, p. 1) 2. spontaneous thinking, stimulus-independent thinking and mind-wandering (Christoff, 2013, p. 323) 3. lower level thought or low-level imaginative processes (Beaty et al., 2014, p. 1) 	<ol style="list-style-type: none"> 1. integrating sensory input with visceral, autonomic and hedonic input (Seeley et al., 2007, pp. 2353-2354) 2. interoceptive feedback, emotions, homeostatic regulation and reward processing (Seeley et al., 2007, pp. 2353-2354) 3. salience detection and action on identified salience (Menon & Uddin, 2010, pp. 655-656; Seeley et al., 2007, pp. 2349, 2352)

Note. Adapted from Dimkov, 2015

ly-oriented default-mode network and the externally-oriented central-executive network are activated by psychedelic drugs as is the salience network, but their inner dynamic coherence or functional synchronization is disrupted. This leads to a state of an “unconstrained cognition”, a state characterized by a partial or complete absence of the regulatory functions of the ego or the self (Carhart-Harris et al., 2012, p. 1).

Finally, many authoritative authors identify or are prone to identify the default-mode network (DMN) as a brain representative or a brain correlate of the Freudian ego, arguing that it is the ultimate master, regulator or controller in the brain (Carhart-Harris & Friston, 2010; Carhart-Harris & Friston, 2012; Carhart-Harris et al., 2012; Carhart-Harris et al., 2013; Carhart-Harris et al., 2014; Carhart-Harris, Mayberg, Malizia & Nutt, 2008; Lemogne, Delaveau, Freton, Guionnet, & Fossati, 2012; Northoff, 2011, p. 100; Northoff, 2012; Northoff & Bermpohl, 2004; Speth et al., 2016; Tagliazucchi et al., 2016). These authors consider the self as being identical to Freudian ego. Therefore, any self-referential processing, according to them, is a function of the ego. In fact, the ego is rather a salience detector with the additional ability through efferent connections to induce motoric actions or to “ignite” imagery. The important question here is which network of the abovementioned three

Table 2

Comparison of the Primary and Secondary Thought Processes

Characteristic	Primary Thought Process	Secondary Thought Process
Principle of functioning	Principle of pleasure	Reality principle
Topography, Structure	Unconsciousness, Id	Consciousness, Ego
Possible Neural Correlates	<ul style="list-style-type: none"> • Limbic and paralimbic structures • Default-mode network (?) 	<ul style="list-style-type: none"> • Central executive network • Salience network
States	Dreaming, hypnagogia, reveries, delirium, epilepsy aura, psychosis, intoxications (e.g. psychedelic experience), mind-wandering (?)	Normal waking state
Means	<ul style="list-style-type: none"> • Condensation • Displacement • Symbolization 	<ul style="list-style-type: none"> • Differentiation • Clarity • Adequacy
Features	<ul style="list-style-type: none"> • Timelessness • Illogicity • Ideation • Subjectivity • Emotionally charged • Seek instant discharge • Free, random associations • Lack of control 	<ul style="list-style-type: none"> • Time oriented • Logic • Thinking • Objectivity • Emotionless/Minimal emotion • Seek delayed discharge • Meaningful associations • Presence of control

Note. Adapted from Dimkov, 2015, p. 21

large-scale brain networks is the master in the brain, if there is one at all. Is the brain solely a circus without a master?

Discussion – An Introduction of an Original Hypothesis: A Critique of Current Hypotheses About the Brain Correlate of Freudian Ego

The hypothetical positions of Carhart-Harris and Friston (2010, 2012) that the *default-mode network* is the brain correlate of Freudian ego and that it represents the ultimate master of the brain have already been criticized. For example, Rizzolatti, Semi, and Fabbri-Destro (2014, p. 147; emphasis added) comment critically that: “*The ego of Friston and Carhart-Harris appears to be not involved in secondary (logically structured) processes but rather in primary processes characterizing that part of ego that mediates unconscious process.* In fact, DMN is active when mind is free to wander towards past memories, future projects, and previous personal experiences [...] It appears, therefore, that the DMN might correspond to that part of Ego that Freud considered as unconscious”. This view of DMN points towards an involvement of this large-scale brain network in primary process thinking (ideation), a function of the id, not of the ego *per se*.

Starting from the critical position of Rizzolatti, Semi, and Fabbri-Destro (2014) and building upon it, Dimkov (2015, pp. 42-46) rejected the hypothesis of Carhart-Harris and Friston (2010, 2012) as being inconsistent (see also Menon, 2011, p. 500; Menon, 2015, p. 605). Dimkov’s arguments are the following (Dimkov, 2015, pp.

42-46). First, it has been established that salience network (SN) monitors both internal (somatic) and external environments (Menon, 2011, p. 500; Menon, 2015, p. 605). When a salient feature is detected, either positive or negative, salience network engages the central executive network (CEN). Then both CEN and SN search for the most appropriate response. Finally, a motor action is executed. When SN and CEN systems are overloaded, the default-mode network (DMN) is activated. DMN mediates three types of thinking, namely spontaneous thinking, stimulus-independent thinking and mind-wandering (Beaty et al., 2014, p. 1), which all represent low-level thought processes, which are imaginative. Moreover, it has been found that DMN is active when individuals are engaged in internally focused tasks such as “autobiographical memory retrieval, envisioning the future, and conceiving the perspectives of others” (Buckner, Andrews-Hanna, & Schacter, 2008, p. 1). These functions appear as low-level secondary thought processes (i. e., imaginative thought processes) (Beaty et al., 2014, p. 1) or even as primary process ideation, because they are related to thinking processes, such as spontaneous thinking, stimulus-independent thinking and mind-wandering. As the boundary between the primary and the secondary processes is not a clear-cut one, the concept of a third thought process was developed to fill this gap (Dimkov, 2015, 2016, 2018). The latter uses simultaneously both primary and secondary thought processes. Thus, DMN’s functions can be identified as third process thinking.

It has been found that CEN and DMN are functionally antagonistic, so that the former inhibits the latter (Chen et al., 2013). There is an *anti-correlation* between the two networks with interesting characteristics such as the following one: “the high degree of temporal anti-correlation between the DMN and task-positive network [CEN/SN] is thought to reflect a low frequency toggling between their associated psychological functions of introspective and self-referential thought and extrospective attentional orienting, respectively, allowing an individual to remain alert to unexpected environmental events” (Broyd et al., 2009, p. 282). Moreover, SN also negatively regulates DMN in such a way that when SN is active DMN gets deactivated (*anti-correlation*) (Chen et al., 2013). Importantly, *SN regulates the interactions or the dynamic switching between CEN and DMN* (Bressler & Menon, 2010; Di & Biswal, 2014). SN is defined as a system that integrates sensory input with visceral, autonomic and hedonic input, interoceptive feedback, emotions, homeostatic regulation and reward processing (Seeley et al., 2007, pp. 2353-2354). The functions of SN and CEN apparently correspond to the theoretical construct of Freudian ego (the rider). DMN appears to be related to cognitive control, low-level secondary process thinking (Beaty et al., 2014, p. 1)ⁱⁱ, and primary process ideation (the horse). In sum, “the default mode network (DMN) [...] is preferentially activated during times of introspection and self-evaluation. By contrast, activity in the central executive network [...] and salience network [...] is temporally anti-correlated with activity in the DMN and maximally active during active and contextually meaningful information processing”, whereas “while SN and CEN activity across studies is seen to be greater as objective uncertainty increases, the DMN is recruited to a greater degree as subjective confidence increases”, and that “exogenously (CEN and SN) and endogenously (DMN) focused brain systems play fundamentally contrasting roles in the evaluation of environmental certainty and its transferral to subjective awareness”, where “the SN plays a crucial role in switching between these competing modes of brain function in diverse settings” (White, Engen, Sørensen, Overgaard, & Shergill, 2014, pp. 192, 196-197).

Regression in the name of the ego is related to creativity (Suler, 1980, pp. 147-150). This regression represents a simultaneous activation of CEN and DMN giving rise to “a rare combination of goal-directed and undirected thought processes, as well as cognitive and affective components” (Christoff, 2013, p. 326; Beaty et al., 2014). The concept of regression in the name of the ego represents a regression towards a lower level of functioning, that is, towards primary thought process functioning and with accordance to the principle of pleasure (Bush,

1969, pp. 159-169; Dimkov, 2015, 2016, 2018; Joffe & Peterson, 1981, pp. 337-340; Knafo, 2002, pp. 26-29; Kris, 1952; Martindale, 1999, pp. 138-139; Silverman, 1965; Suler, 1980, pp. 147-150). Regression in Freudian sense is implicated in the process of creativity (Freud, 1908/1959; see Freud, 1910/1958; Suler, 1980, pp. 147-150). For example, creativity can be viewed as a kind of disinhibition, which allows the generation of novel and useful ideas, involving both primary and secondary thought process features. In this line of reasoning, it has been found that CEN and DMN work jointly in creativity (Beaty et al., 2014; Beaty, Benedek, Kaufman, & Silvia, 2015; Bendetowicz et al., 2018; Bressler & Menon, 2010; Christoff, 2013, p. 326; Jung, Mead, Carrasco, & Flores, 2013; Takeuchi et al., 2012; Wei et al., 2014). This is in agreement with the concept of regression in the name of the ego, namely that both primary and secondary thought processes are recruited simultaneously in creativity (Bush, 1969, pp. 159-169; Dimkov, 2015, 2016, 2018; Joffe & Peterson, 1981, pp. 337-340; Knafo, 2002, pp. 26-29; Kris, 1952; Martindale, 1999, pp. 138-139; Silverman, 1965; Suler, 1980, pp. 147-150). This double activation is most probably supervised by SN and corresponds to an intermediary process, conceptualized as third thought process (Dimkov, 2015, 2016, 2018).

Finally, DMN is hyperactive and its main nodes are hyperconnected in depression (Carhart-Harris, Mayberg, Malizia, & Nutt, 2008; Menon, 2011, p. 496), representing a sign of a reduced CEN/SN inhibitory tone onto DMNⁱⁱⁱ (Bressler & Menon, 2010), just as Freud thought that depression represents a lack of sufficient libidinal tonus from and within ego (reduced object cathexis), resulting in decreased focus onto external environment and towards the future (Carhart-Harris, Mayberg, Malizia, & Nutt, 2008; Freud, 1917/1957).

On the one hand, from the above, it is suggested that the functions of the DMN are utterly unessential to survival and it starts to function when the external environment does not provide novel stimuli or when the externally-oriented brain networks are exhausted. Furthermore, this network functions spontaneously and thus corresponds to a regression, thus representing a low-level secondary thought processing or a third thought processing when functioning together with CEN during creativity, which represents a simultaneous activation of DMN and CEN. On the other hand, the functions of the two other networks, CEN and SN, thus presented, are identified to be the functions of the ego and the related secondary thought process and the principle of reality. SN monitors for salient stimuli and recruits CEN and the motor cortex for the execution of the established plan to act on identified salience, which is utterly essential for survivor.

Conclusion

Freudian meta-psychology attracts attention even today. The questions about what the ego is and which its brain correlate is remain unanswered. Today, however, by the means of neuroimaging methods and via the discipline of neuro-psychoanalysis, one can correlate brain structures to the structures comprising the structural model of the psyche (id, ego, superego) developed by Sigmund Freud's meta-psychology. In the current article, the debate on the brain correlate of the ego was presented and discussed. Many contemporary authors suggest that the default-mode network should correspond to Freudian ego (e.g. Carhart-Harris & Friston, 2010, 2012). A new hypothesis was suggested: the salience network jointly with the central-executive network correspond to the ego that Freud wrote about. The third large-scale brain network, the default-mode network (DMN), according to the analysis, does not belong to the ego but rather comprises low-level secondary thought process functions in comparison with the genuine secondary thought process functions of CEN and SN. During a third thought process (a thought process of creativity), DMN is co-activated with CEN, which normally does not hap-

pen due to the anti-correlation (functional antagonism) between the two large-scale networks. In fact, DMN appears to function as a third thought process, an intermediary process between the primary and the secondary ones.

Notes

i) There are also reports that 5-HT_{2A} receptor partial agonism leads to a decreased inner functional connectivity among large-scale brain networks along with an increased inter functional connectivity among the same large-scale brain networks (Kraehenmann et al., 2017a; Kraehenmann et al., 2017b; Müller, Dolder, Schmidt, Liechti, & Borgwardt, 2018; Nichols, 2016, p. 273; Northoff et al., 2006, p. 450; Palhano-Fontes et al., 2015). All psychedelic drugs act as 5-HT_{2A} receptor partial agonists (Aghajanian & Marek, 1999). With respect to the destabilizing effects of psychedelic drugs, it should be emphasized that “5-HT_{2A} receptor agonism leads to desynchronization of oscillatory activity, disintegration of intrinsic integrity in the DMN and related brain networks, and an overall brain dynamic characterized by increased between-network global functional connectivity, expanded signal diversity, and a larger repertoire of structured neurophysiological activation patterns” (Swanson, 2018, p. 11).

ii) Beaty et al., 2014, p. 1: “the ability to generate creative ideas is characterized by increased functional connectivity between the inferior prefrontal cortex and the default network, pointing to a greater cooperation between brain regions associated with cognitive control and low-level imaginative processes.”

iii) According to Bressler and Menon (2010), CEN and SN exert an inhibition on DMN. Thus, when CEN and SN are active, DMN should be inactivated and vice versa (functional anti-correlation).

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Competing Interests

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