

Review

Unconscious and brain plasticity: neuroscience meets psychoanalysis

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Abstract

I present some thoughts, hopefully useful for the progress of the dialogue between psychoanalysis and neuroscience. When Sigmund Freud first explored the implications of the unconscious mental processes to behaviour, he tried to adopt a neural model of behaviour in an attempt to develop a scientific psychology. About hundred years later, Eric Kandel suggested a part of unconscious ego, the procedural unconscious, while Mauro Mancini suggested that the establishment of inter-subjectivity between the mother and the infant during the pre-verbal stages of life depends on the mechanisms of implicit memory. Francois Ansermet and Pierre Magistretti, in agreement with Eric Kandel and the results of recent neurobiological research, support the notion that through the mechanisms of synaptic plasticity experience leaves a trace in the neuronal network, although some traces are not conscious. From trace to trace, from inscription to re-inscription and to the re-association of traces, the link and connection between the initial experience and the traces is somehow lost, even though the initial traces maintain a direct link with experience. Thus one could say that, as far as the establishment of the unconscious is concerned, inscription of experience separates from experience. In addition, neuroscientists suggest that effective amygdala-prefrontal connectivity predicts individual differences in successful emotion regulation. These results are very compatible with the Freudian notions on the regulation of “id” by the “ego” and with his suggestion that specific neurons of the “ ψ ” system, related with the “ego” functions, are located in the frontal cortex.

In this article I will present some thoughts, hopefully useful for the progress of the dialogue between psychoanalysis and neuroscience, a dialogue that was established since long time ago by Sigmund Freud himself. In 1914 in his work "on Narcissism" he writes: "We must recollect that all of our provisional ideas in psychology will presumably one day be based on an organic substructure" Few years later, in his work "Beyond the Pleasure Principle" (Freud 1920) [1] states again: "The deficiencies in our description would probably vanish if we were already in a position to replace the psychological terms with physiological or chemical ones... We may expect (physiology and chemistry) to give the most surprising information and we cannot guess what answers it will return in a few dozen years of questions we have put to it. They may be of a kind that will blow away the whole of our artificial structure of hypothesis".

We can see here how Freud, being an excellent neuroanatomist and a genuine son of the Enlightenment, questions his psychoanalytic theory. When Sigmund Freud first explored the implications of the unconscious mental processes to behaviour, he tried to adopt a neural model of behaviour in an attempt to develop a scientific psychology. I am talking about the "Project for a scientific psychology" (Freud: 1895/1966) [2]. This book was written in 1895 few years after his magnificent publication on the structure of the neuronal cells. Freud was the first to show the fibrous morphology of the cytoplasm of the neuronal cells (Freud:1882) [3]. Before I proceed to a discussion of the "Project ..." let me add the extremely interesting information for what I discuss in this article: in the same year, 1895, the founder of modern Neurobiology, Ramon Y. Cajal, published a book under the title "*Algunas conjeturas sobre el mecanismo anatomico de la ideacion, association y atencion*" (*Conjections on the anatomical mechanisms of ideation, association and attention*). In this book Cajal, who, for some years was practising hypnosis for the treatment of hysteria suggests an anatomical model for the creation of ideas, of the association mechanisms and of the intentional actions. Similarly, Freud in his "Project..." suggests that brain functions are based on 3 systems: ϕ , ψ , and ω . The system ϕ consists of perception neurons which receive external stimuli through the form of energy that in order to reach the system is filtered by a specific filter. The system ψ is mainly psychic, it receives inputs from the sensory periphery (ϕ system of neurons) and from internal stimuli which originate from instincts as it is sex and famine. Tonic inhibition of this interoceptive division of ψ was accordingly

assumed to be the physiological basis of executive control (the "ego").

Consciousness, which was attributed to a separate neuronal system (" ω "), was located at the motor end of the apparatus. The distinctive function of the ω system was to monitor the accumulation of drive energies within ψ . Increased drive tension generated feelings of unpleasure in ω ; motor discharge, by contrast, generated pleasure. This affective-homeostatic function was, according to Freud, the primary purpose of consciousness. He therefore always insisted that affects were conscious by definition. Affect was the *raison d'être* of consciousness (Solms and Panksepp 2012) [4]. Later on, in his book "The Ego and the Id" (1913) [5], Freud incorporated the inhibited part of " ψ ". The "id" is the part of the personality that contains all human's basic instinctual drives. Id is the only component of personality that is present by birth. It is the source of our bodily needs, desires and impulses. The id acts according to the "pleasure principle". It is defined as seeking to avoid pain or "unpleasure". According to Freud the "id" is unconscious by definition. In the "ego" Freud incorporated " ϕ ", " ω " and part of " ψ ". The "ego" acts according to the "reality principle". It seeks to please the id's drive in realistic ways that will benefit in the long term. The ego mediates between the desires of the "id" and the "super-ego". The "ego" is the organized part of the personality that includes defensive, perceptual, cognitive and executive functions. Conscious resides in the "ego", although not all of the operations of the "ego" are conscious.

In the "Project for a Scientific Psychology" Freud adopts the individual neurons theory connected to each other with synapses (contact barriers according to the terminology used by Freud). In other words he adopted a reductionist, monistic theory for behaviour. The individual neuron theory was advocated at that time by Ramon Y Cajal but until 1950ies it was not the predominant theory. Until 1950ies the predominant theory was "the network theory", advocated by Golgi. The "Project for a Scientific Psychology" was published several years after Freud's death by Maria Bonaparte and his daughter Anne Freud. Freud abandoned this model for a pure mentalistic one based on verbal reports of subjective experiences, because of the immaturity of brain science at the time. Initially, as Eric Kandel [6, 7] has pointed out, this separation may have been as healthy for psychiatry as it was for psychology. It permitted the development of systematic definitions of behaviour and

disease that were not contingent on still-vague correlations with neural mechanisms. Moreover, by incorporating the deep concern of psychoanalysis for the integrity of an individual's personal history, psychoanalytic psychiatry helped to develop direct and respectful ways for physicians to interact with mentally ill patients, and it led to a less stigmatized social perspective on mental illness. However, the initial separation of psychoanalysis from neural science advocated by Freud, was stimulated by the realization that a merger was premature. But as psychoanalysis evolved after Freud, rather than being seen as premature, the merger of psychoanalysis and neuroscience was seen as unnecessary, because neural science was increasingly considered irrelevant (Kandel:1999) [7]. The majority of psychoanalysts, , adopted the dualistic mind-body theory of Descarte. However, as Marilia Aisenstain (2014) [8] pointed up: Freud and the discovery of psychoanalysis could not have happened if Spinoza (17th century) had not posited the unity of substance and defended the notion of "materialist and substantial monism. Psychoanalysis, in fact, could only be inscribed within this current. The description of hysterical conversion is a good illustration of how intrapsychic conflicts are expressed in the body. Many years have passed since Freud introduced psychoanalysis, and brain science today is in the cusp of a revolution similar to the unravelling of the human genome in 1990's. Terms like 'consciousness' or the 'unconscious' can be discussed not only on a psychological or psychoanalytic basis but also on a neurobiological basis. This provides a possibility for a dialogue between psychoanalysis and neuroscience and as the title of my presentation suggests, this dialogue can be founded on the unconscious and brain plasticity. Although Aristotle in the ancient times and Leibnitz, Immanuel Kant, Herbart or von Helmholtz referred to the unconscious processes, it was Sigmund Freud who really pointed up and established the role of the unconscious in our behaviour and feelings.

About hundred years later, at the end of the 20th century, Eric Kandel [6, 7] suggested (Kandel: 1998, 1999) that part of our unconscious ego, what he names *procedural unconscious*, has not been repressed and is concerned with unconscious habits, and perceptual and motor skills that are mapped into procedural (implicit) memory. Many changes that have taken place during psychoanalysis concern precisely this very part of the unconscious. This progress does not depend on conscious awareness of the repressed unconsciousness as Sigmund Freud suggested. It does not, in other words,

require the unconscious to be transported into the realm of the conscious. It, rather, consists of changes in behaviour that increase the range of the subject's procedural strategies for *doing and being*. In support of his hypothesis Eric Kandel presents the work of Louis Sanders, Daniel Stern and their colleagues in Boston who developed the idea that during the analysis there are *moments of meaning* - moments in the interaction between patient and therapist - which represent the achievement of a new set of implicit memories that permit the therapeutic relationship to progress to a new level. This progression does not depend on conscious insights; it does not require, so to speak, the unconscious becoming conscious (Kandel:1999). In my opinion these ideas, expressed almost twenty years ago, were a very good start for the dialogue between psychoanalysis and neuroscience and are in agreement with ideas expressed by psychoanalysts. Otto Kernberg [9] Professor of Psychiatry and Psychoanalysis at the Universities Cornell and Columbia suggests: "One other implication of these formulations is that the deepest layers of psychic experience that will organize the psychic apparatus are represented by peak affect states of a positive or negative quality, in the context of which the deepest aspects of the relationships between self and others are internalized, presumably at first into procedural memory, and only later on in the form of declarative or preconscious memory" (Kernberg:2006). Similarly the late Mauro Mancina [10], Professor of Neurophysiology and Psychoanalyst at the University of Milan, referring to the early experiences indicates that: "these experiences, with the fantasies and defenses they induce, cannot be repressed because the structures of the explicit memory needed for repression take two or three years to mature. Therefore, in these preverbal and pre-symbolic stages of life, when the child and its mother identify with one another, with proto-linguistic forms of communication shared affective states and a relation in which intersubjectivity implies "inter-fantasy", the infant will be able to create affective representations and store them in the implicit memory. These will form the unconscious, unrepressed structure of his mind" Therefore "a critical part of the psychoanalysts work today involves transforming symbolically and rendering verbalizable the implicit structures in the patient's mind that mark the unrepressed unconscious" (Mancina:2010). Thus, according to Mauro Mancina [10], the establishment of inter-subjectivity between the mother and the infant during the pre-verbal stages of life depends on the mechanisms of implicit memory. However,

mirror neurons (Gallese et al, 1996) [11] may, also, play a key role in the establishment of inter-subjectivity between the mother and the infant during the pre-linguistic stages of life.

The dialogue between psychoanalysis and neuroscience is impressively advanced with the work of the psychoanalyst Francois Ansermet [12] and the neuroscientist Pierre Magistretti [13]. Francois Ansermet and Pierre Magistretti, in agreement with Eric Kandel and the results of recent neurobiological research, support the notion that through the mechanisms of synaptic plasticity experience leaves a trace in the neuronal network. This network, made up of series of facilitated synapses acting in concert, represent the neuronal substrate of our memories in the explicit or the implicit or procedural memories, in other words, what makes us unique. However, Francois Ansermet and Pierre Magistretti indicate that there are traces which are not conscious. Through the same mechanisms of plasticity, through synaptic re-arrangements and re-associations with new traces that have been inscribed, an unconscious internal reality can be formed, which of course plays a key-role in the determination of the subject. Thus from trace to trace, from inscription to re-inscription to the re-association of traces, the link and connection between the initial experience and the traces is somehow lost, even though the initial traces maintain a direct link with experience. Thus one could say that as far as the establishment of the unconscious is concerned, inscription of experience separates from experience. Thus, the unconscious is not a memory system. The unconscious can therefore be seen as a discontinuity from which the subject emerges in its uniqueness. Thus Pierre Magistretti and Francois Ansermet introduce the discontinuity as a characteristic of the unconscious and continue by saying. "Through the unique interplay mediated by the re-association of traces, the universal mechanisms of plasticity result in the production of a unique subject, each time different.

One could say that in this way and paradoxically plasticity implies a determination of the unpredictable....One never uses the same brain twice....Thus we would be biologically determined not to be biologically determined, we would be genetically determined to be free". Consequently, within the framework of their extremely comprehensive theory on the unconscious, Pierre Magistretti and Francois Ansermet bring together a very daring idea on the determinism of human behavior, with which I absolutely agree. Few years

ago in an international psychiatric meeting I concluded my presentation under the title "Experience: A major determinant of brain architecture" as follows: "Brain architecture can be modified by experience and such modifications of brain map may contribute to the biological expression of individuality. The structure of human brain, although limited by the general framework of the genetic material, is continuously under reform by the experience and the activity of the brain itself. It can be identified as a paradox that one of the characteristics of the evolution of the human species is the selection of genes that permit to *escape* from them, in the sense that they give the possibility of considerable plastic changes of brain architecture and presumably human behavior. Therefore the structure of our brain is a result of our personal history and our mind is not confined in the form of inflexible networks. On the contrary our mind is a historical, cultural and social phenomenon". Within the concept that I described above, considering the trace, another dimension has to be taken into account, namely the emotional connotation of such traces (Magistretti and Ansermet: 2008) [12, 13]. Perception does not only originate from the external world through exteroceptive pathways but also through interoceptive pathways which inform the brain about the state of our body which is essential for our feelings of pleasure and displeasure. As a result traces are linked to somatic states which are carried out along the chain of the trace re-associations in the unconscious level. Thus the body is in play in the establishment of individuality. One cannot think the mental without the somatic. About 2500 years ago Hippocrates indicated that from the brain and from the brain only, arise our pleasures, joys, laughter and jests, as well sorrows, pains, grief's and tears...Today he would add: pleasures, joys, laughter and jests, as well sorrows, pains, grief's and tears also produce the brain itself.

I regard that amygdala can be a good example in order visualize some of the mechanisms that make possible the association of an external stimulus with a somatic state. Several experimental data indicated that in amygdala an external stimulus, for example an acoustic specific stimulus, can be associated with the somatic state of fear (Pascoe and Kapp, 1985) [14]. This association is established through the facilitation of specific synapses in the basolateral nuclei of amygdala. After the establishment of such an association, the associated stimulus can induce fear and anxiety reactions through the activation of facilitated neuronal networks of amygdala. Afferents from the amygdala project to the hypothalamus, which can alter the state of the Autonomic Nervous System and

through the hypothalamus the secretion of hormones, and to the periaqueductal gray matter in the brain stem, which can evoke behavioral reactions via the somatic motor system (Pare et al: 2004) [15]. Amygdala also projects to cortical areas and this pathway is important for the perception of the emotional experience a component of consciousness. However, this experience has to be distinguished from what is happening inside the amygdala. The associations that are established there, the cause of autonomic, motor and conscious reactions, remain in the unconscious level and brain imaging studies indicate that under certain conditions can induce post-traumatic stress reactions.

Hundred years ago, Freud recognized that consciousness also entailed an interoceptive affective aspect and he suggested that this aspect defined the original “purpose of consciousness” and therefore he supported the notion that “the brain knows more than it admits” (Freud 1911) [5]. That is why Antonio Damasio was moved to say that “Freud insights on the nature of affect are constant with the most advanced contemporary neuroscience views (Damasio 1999) [16]. Similarly Josef Le Doux (1999) [17], in the laboratory of whom was realized most of the pioneering research on the function of amygdala, emphasized, few years ago: “when electrical stimuli applied to the amygdala of humans elicit feelings of fear, this is not because amygdala “feels” fear, but, instead, because the various networks that the amygdala activates ultimately provide working memory with inputs that are labeled as fear. This is all compatible with the Freudian notion that conscious emotion is the awareness of something that is basically unconscious.

As I mentioned above, amygdala projects to several regions of cerebellar cortex. One of the major projections is to the ventral medial prefrontal cortex (vmPFC). Recent studies suggest the involvement of different regions of the prefrontal cortex in the modulation of amygdala reactivity and the mediation of effective emotion regulation. The strength of amygdala coupling with orbitofrontal cortex and dorsal medial prefrontal cortex predicts the extent of attenuation of negative affect following reappraisal. Effective amygdala-prefrontal connectivity predicts individual differences in successful emotion regulation (Banks et al. 2007 [18], Etkin et al. 2011 [19], Moravetz et al. 2017 [20], Townsend et al 2013 [21]). These results are very compatible with the Freudian notions on the regulation of “id” by the “ego” and with his suggestion that specific neurons of the “ ψ ” system, related with the “ego” functions, are located in the frontal cortex.

References

- (1) Freud S. (1920). Beyond the Pleasure Principle. In Standard Edition of the Complete Psychological Works of Sigmund Freud. Vol. 18, London, Hogarth Press.
- (2) Freud S. (1895/1966) Project for a scientific psychology. In The Standard Edition of the Complete Psychological Works of Sigmund Freud. Strachey J (ed) Vol 1: 295-397, London, Hogarth Press.
- (3) Freud S. (1882) Über den Bau der Nervenfasern und Nervenzellen beim Fluskrebs, Sitzungsber. Math. Naturwiss. Cl. K. Akad. Wiss (Wien) 85, 9-48.
- (4) Solms M., Panksepp J. (2012). The “Id” knows more than the “Ego” admits; Neuropsychanalytic and primal consciousness, perspectives in the interface between affective and cognitive neuroscience. *Brain Sci.* 2, 147-175.
- (5) Freud S. (1911). Formulations on the two principles of mental functioning. In Standard Edition of the Complete Psychological Works of Sigmund Freud. Vol. 12, pp 215-226, London, Hogarth Press.
- (6) Kandel E. R. (1998) A new intellectual framework for psychiatry. *Am. J. Psychiatry* 155, 457-469.
- (7) Kandel E. R. (1999) Biology and the future of psychoanalysis: a new intellectual framework for psychiatry revisited. *Am. J. Psychiatry* 156, 505-524.
- (8) Aisenstein M. Thinking: an act of the flesh. Meeting of “The International Neuropsychanalysis Society” Cape Town, February 2014.
- (9) Kernberg O. F. (2006). Psychoanalytic affect theory in the light of contemporary neurobiological findings. In *Beyond the Mind-Body Dualism: Psychoanalysis and the Human Body*. Zacharopoulou (ed) 106-117, The Netherlands: Elsevier.
- (10) Mancia M. (2010). Implicit memory and unexpressed unconscious. In *Dialogue of Psychoanalysis and Neurobiology: Theoretical and Therapeutic Aspects*. Issidorides M, Vaslamatzis G, (eds) 21-32, Athens: Theodor Theohari Cozzica Foundation.
- (11) Gallese V., Fadiga L., Fogassi L., and Rizzolatti G. (1996) Action recognition in the Premotor Cortex, *Brain* 119, 593-609.
- (12) Ansermet F. and Magistretti P. (2007). *Biology of Freedom*, New York: Other Press.
- (13) Magistretti P. J. and Ansermet F. (2008) Neuronal plasticity: a new paradigm for resilience. *Schweizer Archiv. fur Neurologie und Psychiatrie* 159, 475-479.
- (14) Pascoe J.P. and Kapp B.S. (1985) Electrophysiological characteristics of amygdala central nucleus neurons during Pavlovian fear conditioning in the rabbit. *Behav. Brain. Res.* 16, 117-133.
- (15) Pare D., Quirk J. E. and LeDoux J. E. (2004) New vistas in amygdala networks in conditioned fear. *J. Neurophysiol.* 156, 1-9.
- (16) Damasio AR. (1999). Commentary on J. Panksepp’s “Emotions as viewed by psychoanalysis and neuroscience. An exercise in consilience”. *Neuropsychanalysis*, 1, 38-39.
- (17) Le Doux J. (1999). Psychoanalytic theory: clues from the brain. *Neuropsychanalysis*, 1, 38-39.
- (18) Banks SJ., Eddy KT., Angstadt M., Nathan PJ., Phan KL. (2007). Amygdala-frontal connectivity during emotion regulation. *Soc. Cogn. Affect Neurosci.* 2, 303-312.
- (19) Etkin A., Egner T., Kalisch R. (2011). Emotional processing in anterior cingulate and medial prefrontal cortex. *Trends Cogn. Sci.* 15, 85-93.
- (20) Moravetz C., Bode S., Baudevig J., Heekeren H.R. (2017). Effective amygdala-prefrontal connectivity predicts individual differences in successful emotion regulation. *Soc. Cogn. Affect Neurosci.* 12, 569-585.
- (21) Townsend J.D., Tomisi S.J., Lieberman M.D., Sugar C.A., Bookheimer S.Y., Altshuler L.L. (2013). Frontal-amygdala connectivity alterations during emotion downregulation in bipolar I disorder. *Biol. Psychiatry*, 73, 127-136.