

# A Bridge between Psychoanalysis and Neuroscience: An Overview of the Neurobiological Effects of Psychoanalytical Psychotherapy

Journal of Psychology and Neuroscience

Research Article

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Submitted : 17 Jun 2021 ; Published : 1 Jul 2021

## Abstract

*This study sets out to investigate the mechanisms by which psychoanalytical psychotherapy can induce neurobiological changes. From Neuroscience which, in accordance with his thinking at the time, Freud never disregarded, the concepts of neuronal plasticity, enriched environment and the neurobiological aspects of the attachment process. From Psychoanalysis, the theory of transference, M. Mahler's psychological evolution model, the concept of the regulating function of the self-objects and Winnicott's holding environment concept. Together these provide a useful bridge toward the understanding of the neurobiological changes resulting from psychoanalytical psychotherapy. One concludes that psychoanalytical psychotherapy, through transference, acts as a new model of object relation and learning which furthers the development of certain brain areas, specifically, the right hemisphere, and the prefrontal and limbic cortices, which have a regulating function on affects.*

**Keywords :** Transference, Neurobiology, Attachment, Neuroscience Informed Therapy.

## Introduction

In this study my aim is to provide some data about the neurobiological changes that result from psychoanalytical psychotherapy as seen from an integration perspective. The main issue is that there is a false dichotomy in psychoanalysis, with its origins in the Cartesian dualistic model of the mind, between predominantly “psychological” and “biological” treatment.

As I will endeavour to show, following Gabbard (2000), I believe there is a neurobiologically informed psychoanalytical psychotherapy which makes the division of mental health treatment methods artificial. I will therefore begin by referring to the historical framework of Freud's and other psychoanalysts' ideas and then move on to the empirical basis of the relationship and finally to the theoretical models from both the neurobiological and psychoanalytical standpoints, concluding with the mechanisms by which psychoanalytical psychotherapy brings about the neurobiological changes .

However, I also consider these ideas to be in part speculative and more extensive research needs to be undertaken in order to have a deeper understanding of the links between psychotherapy and the neurobiological changes induced thereby.

## Historical Background

Freud has bequeathed us a discipline, which he considered to be in a state of permanent evolution, with ample knowledge of the human mind but nevertheless hypothetical and open to future revision. With reference to these factors I would like to mention in support of my argument, three studies which help

to relate psychoanalysis to neurobiology.

The first is the article “*On Aphasia*” (Freud, 1891) which for some authors (Solms, 1986, 1998; Solms & Solms, 2000) represents the most important attempt thus far to link the beginnings of psychoanalysis to Freud's earlier career as a neurologist and neuroscientist. This study introduces the concept of:

1. object representation,
2. the idea that the *psychic is a process . . . parallel to the physiological*, (Freud, 1891)
3. the structural independence of psychological facts with regard to any kind of anatomical localisation,
4. the explanation of dreams from the concept of regression, as formalised in “*The Interpretation of Dreams*”,
5. the existence of an active unconscious which enters into a dynamic relationship with the conscious ego.

From then on Freud adopted the Jacksonian model of the mind and psychopathology (the second principle of neurobiological development is referred to later).

The second refers to some of the ideas expressed in the “*Project for a Scientific Psychology*”, (Freud, 1895) such as the concept of the ego as a neuronal network and, in the field of neurophysiology, the possibility of the existence of synapse (at that time called contact barriers) two years prior to the formalisation of this concept by the English physiologist Sherrington (Mancia, 1987, Schore, 1997).

Finally I should like to mention “*Remembering, Repeating and Working-Through*”, (Freud, 1914) in which Freud gives us to understand that that which we do not remember tends to repeat itself over and over again in transference: in this sense he comments: “... *we may say that the patient does not remember anything of what he has forgotten and repressed, but acts it out. He reproduces it not as a memory but as an action; he repeats it, without, of course, knowing that he is repeating it*”.

In my opinion, Freud here brilliantly anticipates modern studies about different memory types, that is to say, the field of procedural or implicit memory not available for conscious recollection and responsible for the learning of motor abilities and of certain unconscious processing of affective information (we must remember that for Freud the patient “. . . *repeats without knowing he is repeating*”), such memories working through mechanisms located in the basal ganglia, cerebellum and amygdala (motor learning and conditioned fear respectively) (Amini, Lewis, Lannon, Louie, Baumbacher, Mc Guinness, et al, 1996; Davis, 2001; Kandel, Schwartz, Jessell, 1995). In any event we should be cautious not to directly extrapolate this knowledge of the neurobiology of the memory with the characteristics and properties of the unconscious system: timelessness, free movement of the cathexis and the absence of contradiction. Therefore I consider that the study of the implicit memory could provide information about how the contents of the unconscious arise, but not how this system works:

In synthesis, if we were to study Freud’s theoretical position regarding psychoanalysis as a natural science we could define the following periods:

1. In the “*Project*” and in “*On Aphasia*”, he is trying to approximate psychoanalysis, which is still in its infancy, to a natural science in which mental phenomena are trying to establish a neurobiological correlation.
2. In the second period dominated by the studies “*The Interpretation of Dreams*” (Freud, 1900) and the “*Introductory Lectures on Psycho-analysis*” in 1916-1917, he discards any kind of anatomical location for the mental apparatus at that time and considers that psychoanalysis should establish itself on its own merits and not based on other disciplines. Consider for example this passage: “*We can avoid any possible abuse of this method of representation by recollecting that ideas, thoughts and psychical structures in general must never be regarded as localised in organic elements of the nervous system but rather, as one might say, between them*” (Freud, 1900)
3. In “*The Claims of Psycho-Analysis to Scientific Interest*” (Freud, 1913) he returns to biology and states; “*We have found it necessary to hold aloof from biological considerations during our psycho-analytic work and to refrain from using them for heuristic purposes, so that we may not be misled in our impartial judgement of the psycho-analytic facts before us. But after we have completed our psycho-analytic work we shall have to find a point of contact with biology, and we may rightly feel*

*glad if that contact is already assured at one important point or another.*”

4. Toward the end of his life in “*An Outline of Psychoanalysis*” (Freud, 1938) he returns to the search for reconciliation and considers “*The future may teach us to exercise a direct influence, by means of particular chemical substances, on the amounts of energy and their distribution in the neural apparatus.*”

Subsequently, other authors affirmed this orientation. To mention all of them would detract from the main purpose of this study, but among them for example we would like to mention Sandler (1987) who posits that psychoanalytical theory has no clear boundaries and in some instances is interwoven with various aspects of general psychology and biological sciences.

Grotstein. (1995, 1999) suggests that advances in neurochemistry and psychopharmacology have opened a window for the psychoanalytical study of serious mental disorders under more stable conditions. This author affirmed that the psychoanalyst has to be sufficiently aware of the advances in neurobiology and psychopharmacology and especially of neurocognitive research in order to understand his patients’ suffering. However he posits a “dual-track” concept which allows for an interplay between the unconscious, neurobiology and early trauma in an intrasubjective and intersubjective matrix.

### **The Empirical Basis of the Changes Resulting from Psychoanalytic Psychotherapy and Examples from Cognitive Therapy**

Basically, I refer to the following:

1. The changes in the neuroanatomical, metabolic and neurophysiological parameters resulting from cognitive behaviour therapy on obsessive-compulsive patients (OCD).
2. Changes in dream patterns in patients with affective disorders.
3. The modifications induced by psychoanalytical psychotherapy in measuring the serotonergic function in borderline patients.
4. The changes resulting from group psychotherapy in the survival of patients with metastatic breast cancer.

According to the authors, in a group of OCD patients, cognitive behaviour therapy and drug treatment using fluoxetine resulted in a diminishing of activity in the head of the right caudate nucleus as measured by positron emission tomography (PET). The normalisation of activity at this anatomic level is correlated to the improvement in the obsessive-compulsive symptoms as measured on a scale. The authors hypothesise that both treatments can contribute toward an improvement in the inhibitory processes which, when dysfunctional (the thalamus function fails to act as a “filter” blocking the excess of thought) let an excess of thought originating in the prefrontal cortex flood the cognitive process (Baxter, Schwartz, Bergman, Szuba, Guze, Mazziotta, et al, 1992).

The study of dreams: the cognitive behaviour therapy produced a modification in the dream structure of a group of patients with depression. The authors observed significant improvements in the REM latency, the REM density and efficacy of the dream, reminding us of the importance of sleeping and dreaming for the processing of affective laden memories and the neurocognitive process. (Thase, Fasiczka, Berman, Simons, Reynolds, 1998).

Some Finnish authors (Kuikka, Tiihonen, Lehtonen, 1998) have concluded that psychoanalytical psychotherapy in borderline patients produced changes in the serotonin transporter of the presynaptic terminals. They evaluated two patients with a diagnosis of BPD and comorbidity with moderate to severe major depression, both, prior to treatment, having diminished levels in the serotonin transporters in the median prefrontal cortex and thalamus as measured by single photon emission computed tomography (SPECT), and compared them to a group of healthy volunteers. In the patient who underwent psychoanalytical psychotherapy without medication for a year, the values of the binding sites normalised when compared to the patient with the same diagnosis but without treatment. The role of the serotonin transporters in the physiopathology of borderline disorder remains to be seen with greater precision, or rather whether the changes are due to an improvement in the depressive symptoms.

A group of patients with metastatic breast cancer who underwent group psychotherapy treatment showed a survival rate 18 months longer than those patients who did not undergo treatment. This result could be due to an improvement in the illness confrontation mechanisms, through greater supportive relationship. The authors speculate that the neuroendocrine and immune systems provide important links between emotional factors and the course of the cancer (Spiegel, Karma, Bloom, Gotteheil, 1989).

### Framework for the Study of the Relationship between Psychoanalytical Psychotherapy and Neurobiology.

The concepts which can mainly assist us in this point are taken from:

1. Neurobiological research: the general principles of cerebral development, the plasticity of the neuronal processes and animal research in the field of attachment, which proves useful when taking into account the relational aspect of psychotherapy.
2. Psychoanalysis: the transference theory, the identification and introjection processes, the evolutionary scheme of M. Mahler, Winnicott's concept of the holding environment, and from self-psychology, the notion of the regulatory function of the self-objects (Kohut, 1977). These are factors which together should interact to achieve a gradual mental representation of the self, the object and a series of affects which form a coherent bridge between them (Jacobson, 1964).

It is understood that psychoanalytical psychotherapy could work along the lines of Schore (1994) as a new learning

experience which facilitates the growth of psychological structures which in turn enable social-affective information to be stored and processed. Such experiences could persist in adulthood and would be facilitated by *neuronal plasticity* processes: changes in the functional properties of a synapse as the result of use (van Praag, Kempermann, Gage, 2000).

Psychoanalytical psychotherapy represents a new and enriched environment if we understand by this a complex combination of social and inanimate stimulation. Modern neurobiological research considers that this environment, like other learning experiences, promotes the development of gliogenesis, neurogenesis and synaptic growth in the neocortex (Schore, 1994, Gross, 2000).

It should be remembered that recent research tends to modify the dogma that 'neurons could not be reproduced' and there is sufficient evidence that even in adult life neurogenesis processes can occur, especially in the hippocampus which intervenes in the memory and learning processes (Bailey, Giustetto, Yan-You, Hawkins, Kandel, 2000).

Gould, Tanapat, Rydel, Hastings, (2000) consider that the enriched environment in guinea pigs promotes the growth of new granular cells in the hippocampus. Estrogens and exercise in rodents facilitate the growth of new cells, fundamentally in the dentate gyrus of the hippocampus. These effects are produced through a reduction in the neurotransmission of excitatory amino acids like n-methyl-d-aspartate (NMDA) and of a more gradual answer to stress, which results in a lesser sensitivity of the granule cells to the effect of adrenal steroids. Nevertheless, precaution is suggested in generalising the research on rodents and primates since:

1. the experiments were performed in controlled environments which introduce a stress variable due to relative deprivation,
2. the laboratory conditions differ from those of the natural habitat of the animals,
3. the exact life of the recently created cells is not known.

From the point of view of neurotrophic factors, the enriched environment produces an increase in the genetic expression of the Neural Growth Factor (NGF), the Brain Derived Growth Factor (BDGF) and the Neurotrophic Factor Derived from the glial cells (NFGC). The function of these factors is to produce neuronal remodelling, synaptic growth and the elimination of connections which no longer fulfill any purpose (van Praag, Kempermann, Gage, 2000). With regard to neurotransmission, the enriched environment increases the cholinergic<sup>1</sup> neurotransmission (NT) in the hippocampus, as well as the opioid and monaminergic neurotransmitters. All of these together intercede in the learning mechanisms, synaptic plasticity and the neurogenesis process.

Post (1997), posits that the lack of stimulus in the social environment could produce down regulation of the synapse, neuronal retraction and finally neuronal death.

In synthesis, the concept of enriched environment derived from neurobiology could harmonise with the psychoanalytical concept of holding environment (Winnicott, 1965) and with the role of play as a generator of neurotrophic changes (Schore, 1994).

Psychoanalytical psychotherapy experience could therefore, through the plasticity mechanisms, contribute to neuronal growth in the frontal limbic areas of the right brain, which would have an affect regulating function. Psychotherapy therefore becomes a regulating and homeostasis factor which replaces the identification with bad objects by other new representations having a higher degree of maturity.

There are a series of principles of brain development which were investigated by Schore (1994) which further enable us to understand the neurobiological changes resulting from psychotherapy.

The first of these teaches that cerebral growth and development are produced at certain critical moments and are found to be influenced by the *social environment*. The cerebral structure is created day by day and is related to the activity of the primary carer, i.e. cerebral development is partly sensitive to experience and depends on it. According to Greenspan (cited in Schore's extensive monograph) there might be an environmental instigator for this growth in which specific conditions for the development of self-regulating and attachment systems could be given and similarly an inhibiting environment which prevents this. The mother or primary carer fulfils regulating functions which foster greater neuronal growth in cortical limbic areas, especially in the right brain related to the aforementioned systems. Mahler's (1994) evolution model enables us to relate a child's psychological development to some neurobiological theories. During the practising period of 12-18 months the formation of the socio-affective transaction with the mother begins, through which visual affective (non verbal) interaction increases the feeling of elation, the exploring and play activity of the child- The dyad bond generates high levels of feelings of pleasure and excitement which can be observed in the infant as grandiose and omnipotent behaviour. If one looks at this state from the neurobiological standpoint, it appears to be the result of sympathetic hyperactivity mechanisms measured by the activation of the dopaminergic system that originate in the ventral tegment area and project into the limbic system. Therefore, we have here another example of an enriched environment instigator of neuronal growth (Schore, 1994).

The second principle, which follows a Jacksonian model, considers that the brain develops in stages and follows a hierarchic pattern. The higher hierarchic level is determined by the prefrontal cortex which, according to Luria (2000), has a development which is dependent on the social environment. It begins when the infant is one year old and ends when he/she is about eighteen.

The third principle indicates that the genetic systems which "programme" the cerebral development are activated and influenced during the postnatal period. According to Schore the

mother's behaviour is seen as an external environment which measures the genetic differences and becomes a neuroendocrine regulator. It is worth mentioning here that a psychoanalyst such as Grotstein (1995) considers that the *self-object regulating function*, which in the first instance is the mother and then the analyst in the transference, never disappears but rather is transformed and matures. This regulating function, together with the "holding environment" in the ideas of Winnicott, provides healthy emotional experiences and is exemplified as being the object relation (attachment) which becomes an important factor for neuronal development.

The fourth and perhaps the most important principle to clarify the psychotherapy-neurobiology relationship posits that the social environment changes during infant development and *induces cerebral restructuring processes*. During this phase changes are produced in the mother-child dyad by which the first goes from being a figure which provides very primary care linked to survival, towards a change related to the socialisation processes, which, according to Schore, from a neurobiological standpoint are based on the development of the prefrontal cortex.

In synthesis, I believe that acquiring a language provides a good example for understanding the interaction between the innate and that acquired through the environment in the sense that one is born with the capability of learning a language, thus the potential therefor is to be found in the DNA, but the capability to use that language and be able to communicate is learned socially (Chomsky, 1965; Eisenberg, 1995).

To sum up, *cerebral development and therefore in part, that of the personality has to pass through successive and perhaps permanent processes of organisation, disorganisation and restructuring*, until it begins to form more stable structures. I suggest, while trying to avoid oversimplification, that these processes are equivalent to the regression mechanisms and subsequent reorganisation, steps which are necessary to the consolidation of the personality.

### Transference and Neurobiology

We know from Freud (1912) about the double meaning of transference by which one is transformed into a kind of resistance and the other proves to be an important tool for analytical treatment. We also remember that for Freud, transference has a repetitive aspect (it is worth asking ourselves whether the mental representations and the sensory experience register, both by means of neuronal pathways, do not configure the neurobiological basis for transference) and represents yet another way by which the unconscious reveals itself. Here again we find Kandel's ideas about procedural memory useful. Freud declares: "*The unconscious impulses do not want to be remembered in the way the treatment desires them to be, but endeavour to reproduce themselves in accordance with the timelessness of the unconscious and its capacity for hallucination*".

Taking these concepts into account, one of Levin's studies contributes some interesting ideas about the relationship

between transference interpretation and neurobiology. In this author's view, the concepts of memory priming and working memory, make it possible to consider transference within the cognitive and neurophysiological field. The transference interpretations that have a highly metaphoric component allow us to interrelate sensory processes and memory complexes (Levin, 1997)

This occurs as follows:

- The relationship chain which can be established in the analytical treatment using transference as a tool, enables us to connect neuronal networks which are specifically related to the processing of sensory information (note the importance of this concept in relation to the working of the unconscious and its capacity to show itself by means of hallucinations).
- Transference interpretation enables the mind to connect several levels of its own experience simultaneously.
- The possibility of activating working memory\*\* mechanisms.
- Transference understood as a form of learning enables a greater number of neuronal networks to be brought together, which in turn allow for a more adequate processing of affective and cognitive information. In synthesis we can regard the transference interpretation as a learning mechanism which operates under two mechanisms:
  1. Through the tendency of repetitive compulsion being able to apprehend mechanisms and dominate them so that they do not become completely new information which floods the mental apparatus,
  2. In the context of a teaching-learning dyad (analyst/patient), the relation with the analyst acts as a new model of identification which allows for the modification of rigid and stereotyped patterns and schemes into others having a higher degree of plasticity which represent more evolved and integrated schemes. Following Levin's model we can consider that this integration model and changes in level based on transference interpretation permit a change from those phylogenetically older (primitive forms of mental function) levels to those which are more flexible and evolved (more mature forms of mental function). In this way, by means of transference, the brain creates a hierarchical database *'that makes emotional sense of the world of human relations.'*

### Attachment as a Connecting Bridge between Psychoanalysis and Neurobiology

The concept of attachment was defined by Bowlby (Bowlby, 1969; Fonagy, Target, Gergely, 2000) as being an internal work model (mental representations of the self and objects related by a series of affective states), which implies the child registering the memories of its proximity and contact experiences with its carer.

Attachment represents an open socioaffective system which fulfils homeostatic functions, regulating the emotional

experience and creating the bases for future experiences of security with the objects.

In this sense, Hofer (1984), in a study on the biological implications of the process of grief, speculates that social interaction might be a regulator of homeostatic rhythms and mechanisms (attachment). The author posits whether social interaction in human beings is capable of synchronising biological rhythms and also whether the internal representations of the object are like a neural network of endowed qualities of affect. However, arising from these ideas, I believe it is possible to find a new connection between the psychoanalytical concept of object relations and neuroscientific research in the field of biological study of attachment and affects (Sandler and Sandler, 1998).

The principal characteristics of Bowlby's model make it possible to understand how attachment is the template upon which all subsequent relations are built. These characteristics are as follows:

1. All other forms of relationship emanate from this prototype (transference)
2. They remain stable throughout the person's life
3. Attachment functions outside conscious experience
4. They are resistant to change

From the neurobiological viewpoint, attachment has been studied in animals through different behaviour, for example

1. The beginning and keeping up of maternal behaviour,
2. Separation distress vocalisation which represents a measure of ultrasonic vocalisations emitted by rat pups as a way of expressing the stress of early separation,
3. The formation of links between pairs (social attachment) which enables reproduction, accompaniment, social dominance and grooming.

It appears that the interaction between various neurotransmitters and neuropeptides is decisive for the beginning and keeping up of attachment. Insel and Winslow (1998) consider that neurotransmitters intervene in the separation-attachment processes which produce anxiety effects such as serotonin. For example, drugs which increase the synaptic availability of this neurotransmitter, such as chlomipramine, fluoxetine and citalopram, tend to diminish the number of vocalisations emitted through stress. Norepinefrine and neuropeptide, like opioids, vasopressin (avp) and the hormone oxytocine (oxy), which have receptors with a high concentration in areas of high dopaminergic innervation such as substantia nigra and pallidum, are also involved in the attachment processes. (Insel, Winslow, 2001). In this sense, oxy in interaction with estrogens appears to be important in expediting the commencement of maternal behaviour in rats. Oxy administered to a nulliparous rat initiates the motivational changes essential for motherly care. Another function of this neurohormone appears to be related to pair-bond formation and facilitates the development of preference for a particular partner (Insel, Winslow, 1999).

A series of *cerebral circuits*, called ‘care circuits’ by Panksepp (1998), have been studied in *guinea pigs*. In this instance one is dealing with intrinsic cerebral circuits which promote nutritional and care behaviour on the part of the mother, and occasionally on the part of the father. Neuroanatomically speaking, they comprise the Bed Nucleus of the Stria terminalis (BNST) and the Anterior Cinguli Cortex. For this author it seems probable that the social links and maternal behaviour have arisen from phylogenetic evolutionary processes and ‘*it is now widely accepted that all mammals inherit psychobehavioural systems to mediate social bonding as well as various other social emotions, ranging from intense attraction to separation-induced despair.*’ In short, oxy-avp (especially in females), opioids, prolactin (prl) and social learning intervene at the beginning and for the maintenance of maternal behaviour, the social learning concept being important insofar as the oxy can only exercise its action if it is found to be complemented by social links.

The endogenous opioids whose receptors are widely distributed in the limbic system, seemingly intervene in pair-bond formation, some researches having proved that the administration of agonist opioids diminish the distress induced by separation experiences (Insel, Winslow, 1999). Pleasure and pro-social activities, such as cleanliness, games and social exchange, activate circuits related to opioids and oxy and, although a very increased opioid activity could inhibit the maternal capacity of the child carer, in general this opioid increase becomes a pro-social behaviour inhibitor as may be seen, for example, in extreme cases such as autism, a disorder where a slight improvement may be obtained from the administration of antagonist opioids.

In short, for the various attachment processes the following neuroanatomic structures appear to be necessary: phylogenetically older regions of the brain, for example the Nucleus Accumbens, BNST, Anterior Cingulate Cortex, Preoptic Area Dorsomedial Thalamus and the Olfactory Bulb (in rodents) and the mesolimbic path which also appears to be involved in the motivational aspects of behaviour. In humans it seems that those pathways which mediate the hedonic response to psycho stimulants, evolve as neuronal systems for attachment (Insel, Winslow, 2001).

Neurochemically an intact serotonergic system is required and the interaction of this neurotransmitter with type 5HT1a and 5HT1b receptors set in motion a chain of events with lasting consequences as a response to the stress mediated by glucocorticoid receptors in the hippocampus; oxy which fulfils functions related to maternal attachment, enabling a union between environmental stimuli and memories of maternal relationship, opioids, vasopressin, prl and dopamine through type D2 receptors which, according to recent research in animals, are found to be related to the preferred choice of mate (see Insel’s study).

I consider that psychoanalytic psychotherapy *can function as a new attachment link, like a central organiser that enables the*

*restructuring of cortical and limbic connection patterns with an affect regulating function.* These concepts are supported by neurobiological research. Panksepp considers that there is a ‘window’ of opportunities in species like the human being by which the attachment processes may occur variably in time, in other words that they are not ‘all or nothing’ processes and therefore can reappear in adults and produce the aforementioned changes.

### Synthesis and Conclusions

What will the action mechanism in psychoanalytical psychotherapy be like?

1. Psychotherapy can function as a learning experience that facilitates the growth of psychic structures which provide for the storage and processing of socio-affective information. This latter concept could become clearer if we consider part of a quotation from the last Nobel Prize winner for Medicine, Eric Kandel, who said: ‘*insofar as psychotherapy or counselling is effective and produces long-term changes in behaviour it presumably does so through learning, by producing changes in gene expression that alter the strength of synaptic connections and structural changes that alter the anatomical pattern of interconnections between nerve cells of the brain,*’ (Kandel, 1998).
2. The therapeutic relationship should be able to reverse the misattunement processes which are produced in the dyadic mother-child relationship. The analyst has to strive for this using the affective processes within the framework of transference-countertransference.
3. In the context of a prolonged relationship with the therapist, it is possible to internalise identifications which allow the emergence and development of adaptive mechanisms. It is in this sense that Lewis (2000) considers that clinical and empirical studies which support the idea that mental growth is based on the development of a strong affective bond with others to be important and when the inevitable interruptions or alterations of these links occur they can be repaired.
4. Transference as a principal tool for change during treatment may be seen in the neurodynamic sense as being a property emerging from the memory system to code and store attachment patterns and the socio-affective processing of early relationships. In this sense one can understand and relate the concept that the Kleinian school gives to transference that the origin of the same is in the first stages of object relationship (Klein, M. 1991).
5. The relationship with the therapist promotes the development of the prefrontal cortex and limbic areas, especially in the right brain, and the reconnection of cortical and limbic circuits in that same hemisphere, in this way providing for the replacement of old pathological identifications by new, more mature ones. This might be possible since according to Post, there could be a neurodynamic representation of the object in neuronal circuits and networks, i.e. for this author, the presence of

new objects could produce a synaptic remodelling based on the previously mentioned plasticity mechanism through long-term neurophysiological potentiation processes and neuronal facilitation.

6. *Psychoanalytic experience may contribute to the neuronal growth in the prefrontal areas of the right brain through the neuronal plasticity mechanism which is considered to be continuing to mature even in an adult* (the window of opportunities). However, the affective experience which manifests itself in transference can induce structural changes in the form of a new pattern of neuronal growth in the aforementioned places.
7. In this way, psychoanalytical psychotherapy in very disturbed patients can be seen as a new enriched environment which permits affective regulation and a greater impulse control, thus contributing to an improvement in the object relationships which are almost always perturbed in these patients.
8. The hypotheses mentioned under this heading permit the understanding as to how the neurobiological changes resulting from psychoanalytical psychotherapy help borderline patients to help themselves from feeling they are “orphans from reality” as Grotstein says, i.e. the alterations produced by precocious traumas, which in the case of borderline personality disorder are derived from family violence and sexual abuse, can be reverted.

### Conclusions

The ideas expressed in this paper should be considered tentative because firstly, it is difficult to extrapolate research performed on animals to the human being, and secondly, the studies of cerebral changes induced by psychotherapy are still speculative and should be confirmed.

Taking these limitations into account, we can in any event consider that brain research and its relation to the aforementioned psychoanalytical concepts could become a bridge between the brain and the mind without falling into oversimplifications or simple correlation to cerebral activity.

Lastly, I believe that the hypothesis of the British empiricist philosophers, among them Locke, regarding the human mind as a tabula rasa should be submitted to criticism and investigation, likewise the continental Kantian philosophy about the innate in our personality, since day by day research continues into how the brain and the mind are socially constructed from environmental experiences (Eisenberg, 1995; Quartz, 1999).

*No one is fitted to begin the materialistic study of the brain unless he has a good knowledge of psychology.*

- John Hughlings Jackson (1931)

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