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Approaching the Neurobiological Scenario of Psychoanalysis

Zi-Jian Cai

Scientist, CaiFortune Consulting, No. 129, Building 6, Room 404, North Dongwu Road, Suzhou City, Jiangsu Province, 215128 PR China

Abstract: **In this perspective review, it is adopted the neurobiological interactions and conflicts of both perceived realities and acquired memories with the instinctual drives to represent such terms and interactions as unconscious/preconscious/conscious or id/ego/super-ego of the Freudian theories in psychoanalysis. During waking, it is demonstrated the interactions and conflicts of realities/memories with the instinctual drives are present in all vertebrates including humans. For the rapid eye movement (REM) sleep, it is well evidenced to process the emotional memories, while disrupt the emotional balance toward depression, supporting the Freudian psychoanalysis. For the slow-wave sleep (SWS), it was demonstrated by Cai as ameliorating the depression caused by accumulated emotional memories, supplementing a new complementary half story neglected by Freudian psychoanalysis. It was simultaneously suggested the differentiation of the noradrenergic/serotonergic activities in waking and sleep result in the differentiation of conscious and subconscious interactions and conflicts in psychoanalysis. Finally, it is briefly depicted the gradual evolution of psychoanalytic interactions and conflicts in vertebrates, substantiating the scientific basis for these core contents of Freudian psychoanalysis. In all, due to the support and extension of the core Freudian theoretical contents as unconscious/preconscious/conscious psychoanalysis from neurobiology, it is approaching a prospective neurobiological scenario of psychoanalysis.**

Keywords: **Psychoanalysis, Memory, Depression, Sleep, Serotonin, Evolution.**

I. INTRODUCTION

Psychoanalysis has been a traditional theory and therapy formulated from many clinical psychotic observations and practices, and is now a prospective field for in further neurobiological integration and investigation[1,2]. Freudian psychoanalysis has made significant achievements on the correlation between the memory and emotion. It was the Freudian psychoanalysis that pointed out early that the memories would undergo postlearning modification during both daytime accumulation[3] and dream sleep[4], while the memories and emotions would also affect with each other[5]. In this article, it is reviewed the updated achievements from neurosciences important to the core contents of traditional Freudian psychoanalysis, consolidating the scientific foundation of psychoanalysis, and integrating them together to approach a new prospective neurobiological scenario of psychoanalysis.

II. THE NEUROBIOLOGICAL TERMS FOR FREUDIAN PSYCHOANALYSIS

A. The Neurobiological terms for Freudian Psychoanalysis During Waking:

Freudian psychoanalysis is advantageous in that it provides the clear and systematic theories to illustrate the interactions and conflicts between the psychological cognition and instinctual drive in mind. Freud created the topographic theory early in his book “The Interpretation of Dreams”, hypothesizing that the mental apparatus could be divided into the systems as unconscious, preconscious, and conscious[6,7]. Later, Freud revised the topographic theory into the structural theory, dividing the psyche into the id, ego, and super-ego[6,7]. The interactions and conflicts of the three mental components in the topographic theory and structural theory represent the core contents of the Freudian systematic theories on psychoanalysis[6,7].

In humans, the acquired contents of postnatal preconscious/conscious or ego/super-ego are stored in the form of memory and language in long term, while all linguistic informations are also composed of remote and recent declarative memories, as well as procedural memories[8,9]. Whereas, beyond the memory and language, the intimate graphic and environmental inputs directly convey the surrounding realities to the individuals. In this regard, in neurobiological terms, both acquired memories and perceived realities in waking represent the preconscious/conscious or ego/super-ego, while the instinctual drives represent the unconscious or id[10,11,12]. Therefore, the interactions and conflicts of the three mental components as the core contents in the Freudian psychoanalysis are composed of the interactions and conflicts of both acquired memories and perceived realities to the instinctual drives in waking respectively[10,11,12].

During waking, as the interactions and conflicts of the three mental components are constantly present according to the topographic theory and structural theory of Freudian psychoanalysis[6,7], the interactions and conflicts of both memories and realities to the instinctual drives should also be constantly present correspondingly. According to the Freudian psychoanalysis, psychological disturbance occurs due to either failure in the transformation of instinctual drives of unconscious into the correct forms in preconscious and conscious, or the accumulation of aversive memories in the preconscious and conscious[6,7].

In similarity, in neurobiological terms, Cai also proposed that the emotional balance would be disrupted by the emotional memories accumulated during waking[11,12,13,14]. Besides, recently some authors have reviewed that the cortical midline structures (CMS) and default mode network (DMN) might be useful to depict some characteristics of self and ego in Freudian psychoanalysis[1], exploring further on anatomy than Cai.

B. The Freudian Psychoanalytic Interactions and Conflicts in Vertebrates:

With the neurobiological terms of psychoanalysis as the interactions and conflicts of both memories and realities to the instinctual drives, it is easy to extend to the vertebrates the core Freudian contents of unconscious/preconscious/conscious interactions and conflicts.

On the one hand, it is common knowledge that the instinctual drives are present in all vertebrates indispensably as hunger and sex during safe situations, while also indispensably as fear and aggression during aversive situations. Besides, in terrestrial vertebrates, thirst is added, while in mammals, thermoregulation and nurture is developed, indicating that the evolution of the instinctual drives toward acquisition of more complex and comprehensive instinctual functions in higher vertebrates. All these indispensable instinctual drives in vertebrates correspond to the unconsciousness or id of Freudian psychoanalysis in humans.

On the other hand, learning and memory also happens in almost all vertebrate animals. It has been demonstrated that the hippocampal learning and memory is preserved from fish to reptile to mammals[15,16]. The natural perceptions, responses and memories of animals in ecology represent their preconscious and conscious contents of realities and memories in the Freudian topographic theory of psychoanalysis.

In this regard, with the neurobiological terms of psychoanalysis as the interactions and conflicts of both memories and realities to the instinctual drives in waking, it is easy to assimilate the core Freudian theoretical contents of psychoanalysis as unconscious/preconscious/conscious interactions and conflicts in all vertebrates.

III. THE FUNCTIONS OF REM SLEEP ON MEMORY AND DEPRESSION SUPPORTING THE PSYCHOANALYSIS

The function of rapid eye movement (REM) dream sleep in emotional regulation and memory processing has been a long historical subject. More than 100 years ago, Sigmund Freud suggested that the instinctual wishes and drives should interact and conflict with the present realities and past memories exposed in dreams[6,7] as the interactions and conflicts among unconscious/preconscious/conscious or id/ego/superego[6,7]. In 1968, Dement hypothesized that the REM sleep might function as the dissipation of energy or drive[17]. In 1991 and 1995, Cai suggested that the REM sleep might complement the function of slow wave sleep(SWS) and shift the balance of emotion toward drive dissipation or even depression with retention of emotional memories accumulated during waking[11,12,13,14].

The neurobiological experiments supporting the compatibility of REM sleep with the Freudian psychoanalytic interactions and conflicts have been accumulated for long time. On the one hand, it was earlier suggested that the REM sleep could play functions in memory retention[13,14] and retrieval[13,14,16]. Recently, many experiments have shown that the REM sleep plays roles in retention of emotional memories[18,19,20,21,22]. On the other hand, REM sleep

deprivation was early reported as therapeutic against depression in humans[23,24] and ameliorative against fear in rats[25]. Recently, there have also been many reviews demonstrating that the REM sleep tends to disrupt the emotional balance toward depression[26,27,28]. In this regard, progressions for decades of years on functions of REM sleep in both memory and emotion have all been fitting well with the Freudian psychoanalysis.

It is noted that, recently Horne also suggested that the REM sleep might function to transform the internal appetite on food into the 'optimal foraging' behavior of animals[29,30], compatible with the Freudian psychoanalytic view on the REM sleep as the interactions of both memories and skills with the instinctual drives[6,7]. Likewise, Horne as well advocated to extend the relevant investigations with the more ecological approaches[29,30].

In all, there have accumulated many evidences for decades of years that the REM sleep plays the functions in processing the emotional memories while tending to shift the emotional balance toward depression, thereby supporting the core view of Freudian psychoanalysis that the instinctual wishes and drives should interact and conflict with both memories and skills exposed in dreams originally illustrated as the interactions and conflicts among unconscious/preconscious/conscious or id/ego/superego.

IV. THE FUNCTIONS OF SWS ON MEMORY AND DEPRESSION SUPPLEMENTING THE PSYCHOANALYSIS

Cai demonstrated that the slow wave sleep(SWS) functioned to adjust the emotional balance disrupted by accumulated emotional memories, especially against depression[11,12,13,14], and opposite to the REM sleep. The clinical observations and behavioral experiments supporting the role of SWS in emotional regulation have accumulated for a long time in many aspects, as in the followings: (a) Shorter duration of SWS has been reported to be frequently associated with depression for decades of years up to now[26,28,31]. Besides, it has also been demonstrated that sleep deprivation in healthy adults usually results in such negative mood disturbances as depression, anxiety, frustration, tension, and so on[32]. It was even reported that selective deprivation of stage 4 SWS in humans produced a depressive or hypochondriacal state[33]. In these respects, impairment of SWS would cause depression. (b) It has been adopted for decades of years to help ameliorate depression by increasing the duration of SWS in early sleep with phase advance of sleep[34,35]. In consistency, higher in the delta sleep ratio might help prevent the early recurrence of unipolar affective disorder[36]. Therefore, SWS normalization could help ameliorate or prevent depression. (c) It was demonstrated that the hippocampal lesion but not neocortical lesion caused impairment of SWS[37], while the neuronal activity in SWS increased in hippocampus but not in neocortex[38,39]. Obviously, SWS is required for the regulation of limbic functions rather than neocortical functions. In all, it is well evident that, opposite to that of REM sleep, SWS plays a role in the limbic and emotional regulation, maintaining the emotional balance against depression.

With regard to memory processing, it has been in parallel shown that SWS might help retention of declarative memory in humans[40,41], while impair memory in emotional learning tasks in animals[42,43]. At the cellular level, it was shown that SWS favored LTD[44,45] but not LTP[46,47], while REM sleep was required for LTP[48,49]. Obviously, the SWS and REM sleep are opposite in their roles in memory processing also, just as opposite in their effects on depression.

Now that the functions of SWS in memory and depression are both contrary to that of REM sleep, they are accordingly contrary to that of Freudian psychoanalysis. Therefore, the Freudian psychoanalysis only reveals and uses half of the total sleep functions to interpret and treat psychotic disorders, emphasizing the functions of REM sleep in memory and emotion but neglecting those of SWS. In this regard, Cai recently put forward that the SWS supplemented a new half story of psychoanalysis on emotion and memory neglected by Freudianism[11,12], extending the psychoanalysis from neurobiology, prospectively to improve the hypnotic and musical therapy and treatment, and so on.

V. THE NORADRENERGIC AND SEROTONERGIC ACTIVITIES DIFFERENTIATING THE CONSCIOUS AND SUBCONSCIOUS STATES IN PSYCHOANALYSIS

Subconscious was termed by Pierre Janet[50], while preconscious was likewise adopted by Freud[6,7]. In analogy, Cai as well pointed out that the memory traces in the emotional limbic forebrain corresponded to the subconscious processes under the higher control from cortical mind in waking, and were transiently regulated or suppressed by the ascending noradrenergic(NA), serotonergic(5-HT), acetylcholinergic(ACh) and dopaminergic(DA) systems in waking[11,12,13,14]. Whereas in sleep, because the NA and 5-HT systems decreased in discharge in SWS or even ceased in discharge in REM sleep[38,51,52], the emotional memory traces were gradually disinhibited and exposed in sleep for regulation or conflict with the internal drives[11,12,13,14].

NA and ACh are usually opposite in roles in regulating the emotional balance, whereas 5-HT is complex in its effects. The deficiency of brain NA or 5-HT or both may cause depression[53,54,55], while hyper- and hypo-cholinergic states may lead to depression and mania respectively[56]. Correspondingly, the effects of NA, 5-HT and ACh on the limbic activities are also different. NA is usually inhibitory and increases the ratio of signal/noise[57], whereas ACh is excitatory[58]. 5-HT influences the activity in the limbic forebrain in a more complex way, excitatory to some and inhibitory to others[59].

The ascending NA, 5-HT and ACh systems respond in turn to the changes in activity of the limbic forebrain. The limbic forebrain structures send efferents to the NA, 5-HT and ACh systems[16], while the limbic-reticular coupling[16] would transfer the coupling effects. It has been demonstrated that the hippocampus can directly regulate the activity of raphe nuclei where many 5-HT neurons locate around[60,61].

Even though the emotional balance is regulated by the four ascending systems during waking, their emotional regulation can only last transiently. Presumably, memory accumulation in the limbic structures is an infinite process, so that the range of activity changes in the NA, 5-HT, ACh and DA systems for adjusting the disturbed emotional balance would also be required to be limitless. Therefore, the ascending NA, 5-HT, ACh and DA systems would finally be neither competent nor able to cope with the infinite emotional imbalance[11,12,13,14], manifesting as the transient nature in emotional regulation. Such explanation is supported by some observations. Evidences for decades of years have demonstrated that total sleep deprivation in humans can produce an antidepressant effect to depression[35,62,63], mediated by the changes in catecholaminergic metabolism[62,64], notably the 5-HT system[65,66,67]. However, the effective duration of such antidepressant effect can last only for one or a few days[35,62] or even shorter when naps interrupt the period of sleep deprivation[62,63]. In contrast, phase advance to increase the SWS following total sleep deprivation can prolong the transient antidepressant effect of total sleep deprivation[35], clearly demonstrating the transient nature of 5-HT system against depression from total sleep deprivation, and the long-lasting nature of SWS against depression.

During waking, the novel signals presented may elicit an increase in the rates of discharge of the NA and 5-HT systems[38], so as to suppress the emotional memories stored in the limbic system with their net inhibitory effects[57,59], turning the memories there into the subconscious suppressed state. The NA and 5-HT systems thus alert the behavioral states from internally oriented modes to externally oriented modes catching the novel, stressful or informative stimuli[52,68,69]. After falling into sleep, it is required for the NA and 5-HT systems to decrease discharge to reduce vigilance and turn the behavioral state to internal reorganization[52,68,69]. Therefore, in sleep the emotional memories accumulated in the limbic system are released and exposed to reorganization, with the SWS responsible for producing LTD and ameliorating depression, while the REM sleep responsible for producing LTP and reducing drives[11,12,13,14]. The latter memory processing and emotional regulation during REM sleep is exactly the subconscious regulation or conflict of memory and emotion exposed during dream sleep as proposed in Freudian psychoanalysis[11,12]. On the other hand, the interaction or conflict of memory/perception with emotion during waking likewise represents the conscious psychological interactive or conflicting processes of Freudian psychoanalysis[11,12]. In all, it is the differentiation of NA and 5-HT activities in waking and sleep that causes the respective differentiated conscious and subconscious regulation of memory and emotion in psychoanalysis.

It is noted that Hobson also recognized that the differentiation of NA, 5-HT and ACh systems in waking and REM sleep differentiated the brain in information processing during the two states, with the waking state oriented more to external and the REM sleep oriented more to internal[70,71]. Even though not sufficiently explicit on the interactions and conflicts of the memories to the instinctual drives, such opinion as well implied compatible with the conscious and subconscious differentiation of waking and sleep.

In all, it is summarized in Figure 1 all the neurobiological processes demonstrating the core contents of Freudian psychoanalysis.

VI. EVOLUTION OF PSYCHOANALYTIC INTERACTIONS AND CONFLICTS DURING WAKING AND SLEEP

With the neurobiological terms and processes as the interactions and conflicts of both memories and realities to the instinctual drives representing such terms and interactions as unconscious/preconscious/conscious of Freudian psychoanalysis, it becomes possible to depict the evolution of these core Freudian psychoanalytic interactions and conflicts in vertebrates.

A. The Evolution of the Waking State:

With regard to the waking state, it is common knowledge that the instinctual drives are present in all vertebrates indispensably as hunger and sex during safe situations, while also indispensably as avoidance and aggression during aversive situations. These instinctual drives are preserved in all vertebrates. Besides, in terrestrial vertebrates, thirst is added, while in mammals, thermoregulation and nurture is developed. The addition of these instinctual drives latter in vertebrates indicates the evolution of these instinctual drives toward acquisition of more complex and comprehensive instinctual functions in higher vertebrates. All of the instinctual drives correspond to the unconsciousness or id of Freudian psychoanalysis, as well as their evolution toward more complexity.

Learning and memory also occurs almost in all vertebrate animals. It has been demonstrated that the hippocampal learning and memory is preserved from fish to reptile to mammals[15,16]. The perceptions, responses and memories of the animals represent their perceived realities and acquired memories, corresponding to the conscious and preconscious in the topographic theory of Freudian psychoanalysis, while manifesting as preservation in vertebrate evolution.

It is noticed that the Freudian theories on psychoanalysis in humans were early formulated from the clinical observations of psychosis[5,6,7]. Likewise, in this paper most neurobiological processes of Freudian unconscious/preconscious/ conscious interactions and conflicts are illustrated in depression. It has been demonstrated in rodents as well that depression is produced by various stressors in various forms[72,73]. In this regard, the phylogenetic conservation of depression in mammals provides the convenient animal model to further investigate the neurobiological basis of Freudian psychoanalysis.

B. The Evolution of the REM Sleep:

With regard to the REM sleep, it has recently been sketchily depicted the evolution of REM sleep[10]. The function of atonic REM sleep as improvement of muscular efficiency was early acquired in evolution in reptiles[74,75], ostrich[76] and platypus[77]. Later, the retention of emotional memories was added to the REM sleep with desynchronized forebrain sleep in mammals including armadillo[78]. Finally, disinhibition of sexual drives was added to the REM sleep in humans[10].

Likewise, herein it is in parallel worked out the gradual evolution of Freudian psychoanalytic interactions and conflicts during REM sleep in vertebrates. The atonic functions of REM sleep, to decrease the muscle tone for improving the muscular efficiency and resulting in reduction in bodily motivation, were acquired early in evolution in reptiles[74,75], ostrich[76] and platypus[77], so that the reduction of muscular motivation from drives of Freudian psychoanalysis during REM sleep was also acquired early in evolution in reptiles, ostrich and platypus. Later, the retention of emotional memories in REM sleep of Freudian psychoanalysis was added as the desynchronized forebrain sleep in mammals including armadillo[78]. At last, the disinhibition of sexual drives in REM sleep of Freudian psychoanalysis was added to the humans[10].

C. The Evolution of the SWS:

With regard to SWS, it is preserved in all birds and mammals in evolution[13,14], characterized as the synchronized slow wave during sleep in the forebrain. Even in dolphins without REM sleep[79,80], SWS is still present as alternative asymmetrical hemispherical synchronization[79,80], and even as many short periods a day, each lasting about 90 seconds in the Blind Indus dolphin[81].

Likewise, in evolution the new half story of psychoanalytic interactions and conflicts supplemented by SWS is also preserved in all birds and mammals, as adjusting the emotional balance disrupted by accumulated emotional memories, especially against depression.

D. The sectional summary:

In all, it is summarized in Figure 2 all the relevant evolutionary processes in vertebrates.

VII. PERSPECTIVES

As neuropsychoanalysis emphasizes revealing the underlying psychological brain processes of patients, it would be more accurate and scientific than the modern behavioral approaches and therapies, and would thus reoccupy the predominant role in psychiatric diagnosis and therapy in future[1]. As illustrated above, the core Freudian contents of unconscious/ preconscious/conscious psychoanalysis can be demonstrated from the related achievements in neurosciences, as the

interactions and conflicts of both memories and realities to the instinctual drives. Besides, the neurobiological achievements in further supplement the functions of SWS as the new half story of psychoanalytic interactions and conflicts, as adjustment of the emotional balance disrupted by accumulated emotional memories, especially against depression. Due to the support and extension of these core contents of Freudian psychoanalysis from neurobiology, it is expected to begin approaching the prospective neurobiological scenario of psychoanalysis.

Extension of psychoanalysis to the animals helps elucidate the evolution of psychoanalytic interactions and conflicts in vertebrates. It is perspective in that it helps provide the testable scientific basis of psychoanalysis that many authors have advocated[2], as well as makes it possible for the experimentation of many relevant pharmacological mechanisms and effects.

It is necessary to point out that the neurobiological compatibility and extension of Freudian psychoanalysis mainly results from the studies on depression rather than mania[12]. As aversive learning happens more frequently for most individuals in environments, when extending such results from depression to mania, it is necessary to be cautious[12]. Obviously, more investigations are required on this issue in future, paying more attention to revealing the prospective correlations between the neurobiology of mania and Freudian psychoanalysis, as well as those between the neurobiology of schizophrenia and Freudian psychoanalysis.

VIII. CONCLUSIONS

In this perspective review, with the convenience of neurobiological terms of Freudian psychoanalysis as the interactions and conflicts of both perceived realities and acquired memories representing the preconscious/conscious or ego/super-ego to the instinctual drives representing the unconscious or id, it is reviewed these core theoretical contents of Freudian psychoanalysis from the related achievements in neurosciences.

During waking, the instinctual drives as hunger or sex in safe situations and fear or aggression in aversive situations are preserved in all vertebrates, while thirst is added in terrestrial vertebrates, and thermoregulation along with nurture is developed in mammals. Besides, the natural perceptions, responses and memories of animals in ecology represent their preconscious and conscious contents in the Freudian topographic theory of psychoanalysis. In this regard, the Freudian psychoanalytic interactions and conflicts of both realities and memories to the instinctual drives are present in both humans and other vertebrates.

During the REM dream sleep, it is reviewed many experimental results showing that emotional memories are processed during REM sleep, while the REM sleep has also been demonstrated for decades of years as tending to shift the emotional balance toward depression, indicating these functions of REM sleep comply well with the views of Freudian psychoanalysis that the learned memories would conflict against the disinhibited drives during dream sleep.

During the SWS, it is reviewed its functions on adjusting the emotional balance against depression, and on memory reorganization, including its recent remarkable findings that SWS favored LTD but not LTP at the cellular level. Therefore, SWS plays functions on depression and memory in contrary to that of REM sleep, and would supplement a new half of sleep regulations on memory and emotion that the psychoanalysis neglects at present.

In addition, it is pointed out that the activities of the ascending noradrenergic and serotonergic systems are differentiated in waking and sleep, resulting in the respective differentiated conscious and subconscious interaction and conflict of memory and emotion, while matching this most secret issue of psychoanalysis to the modern neuroscience.

Finally, it is briefly depicted the gradual evolution of psychoanalytic interactions and conflicts in vertebrates, further substantiating the scientific basis of Freudian psychoanalysis. During waking, the Freudian psychoanalytic interactions and conflicts of both realities and memories to the instinctual drives are preserved in all vertebrates. During the REM sleep, there acquired the atonic functions early in reptiles, ostrich, and platypus in evolution, resulting in the reduction in motivation from drives. Later there added the processing of emotional memories in all those mammals with desynchronized forebrain sleep. Finally, there added the sexual drive dissipation in humans. During the SWS, it is conserved in all higher vertebrates including mammals, birds and some reptiles, characterized as the synchronized slow wave during sleep in the forebrain, and therefore it is conserved in the functions of SWS supplemental to psychoanalysis as adjusting the emotional balance disrupted by accumulated emotional memories.

In all, because of the extensive support and significant extension of these core Freudian theoretical contents of unconscious/preconscious/conscious psychoanalysis from neurobiology, it is hoped to begin approaching the prospective neurobiological scenario of psychoanalysis. As the neurobiological compatibility and extension on Freudian

psychoanalysis mainly results from the studies on depression, more investigations in future would be devoted to revealing the prospective correlations between the neurobiology of mania and Freudian psychoanalysis, as well as those between the neurobiology of schizophrenia and Freudian psychoanalysis.

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