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Neurological systems, structures, functions, and their relationship with cognition, emotions and behavior

Abstract

The brain is involved in the generation of brain functions, which are known to be the genesis of the psychological and spiritual mind. It is further involved in the generation of specific brain functions, which helps in the control of the body to work with complex as well as easy tasks. This leads to the formation of behaviour and its responses to the changes showered from outside. Behavioural responses and changes have always been the main and focused effects of the responses of the brain, which helps human beings and even animals deal with the environmental effects and the affected responses, as well as control of the effects, and generation of self-satisfaction. The frontal lobe gets trained during the early years of development for offering controls of motor areas of the brain and thereby control the genesis of behaviour as initiative as well as responses to the external inputs to the brain. The psychological-behavioral effects of absence of social conditioning and their negative effects play an important role in offering negative frontal controls of the motor areas, as well as the control of the responses. Response inhibition is therefore an important functional role of the Orbitofrontal cortex, which needs to be developed in the frontal cortex through training. Social conditioning plays an important role in the functional developments of the frontal controls, and it becomes an important functional role of the frontal cortex to control behaviour in a positive manner. Absence of social conditioning may therefore play a major role in the development and increase of aggressive behaviour in an individual. Thalamus plays an important role in aggressive behavioral development leading to conditions like the Amygdala hijack or Neural hijack which could be due to the absence of social conditioning in an individual. Social conditioning needs to be imparted by the social participants during the growth of a child within the school, family and the society. The members of the family and the society must play their specific roles for imparting the social conditioning effects in a growing child and individual to reduce the aggressive behaviour caused due to lack of motor control by the frontal cortex.

Volume 17 Issue 2 - 2026

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Received: February 18, 2026 | **Published:** March 5, 2026

Introduction

Frontal functional roles in the control of behaviour, thoughts, and emotions

The human brain is a complex system which has led to the development of a unique human mind. The human mind is responsible for the creation of all idea sources at the theoretical and practical levels. The human mind has been able to explore and further create scientific ideas and explaining the rational principles behind the genesis of all material items of the universe as well as the life forms and the development of the mind human being. Additionally, the human minds could create ideas about the temporal and spatial changes that occur in its environment, and could explain the scientific basis of the changes. The genesis of the human mind maybe because of the various complex subsystems of interconnection between the different areas of the brain. The frontal lobe is one of the most important part responsible for the presence and existence of the human mind. The problems in these circuit systems are responsible for many of the dis-regulation in behavior, emotion and aggression that are seen in human mind. An intense emotional behavior dis-regulation that is described as “amygdala hijacking” or “neural hijacking” is the condition where the disinhibition control centers of the frontal areas of the brain is impaired because of incorrect and inadequate social conditioning. This had led to a situation where large population group rely more on violent and aggressive action or responses without much remorse of the consequences. There is a greater need to the study the various functions of the brain from a forensic, behavioral and policy perspective so that various social conditioning and training at the early stage of brain development can be introduced. The need of the hour is the come up with models and training programs in order to introduce them in schools, home and other similar institutions which could have a long-term positive effect to human kind.

The frontal lobes have extensive interconnections with several other areas in the brain and some of them are those which control emotions, mood, and cognitive processing. The frontal lobes are the highest controlling centers of these functional systems in the brain.[1–6] There are three general anatomical divisions of the frontal cortex starting from the limbic, the precentral, and the prefrontal cortices, which have immense behavioral and psychological significance. The prefrontal cortex is subdivided into orbitolateral prefrontal cortex, dorsolateral prefrontal cortex, and anterior cingulate. The prefrontal cortex has extensive connections with various other areas of the cerebrum and subcortical areas. The interconnections of the prefrontal cortex are interconnected with the temporal, parietal, occipital areas of the cerebrum, and subcortically with the basal ganglia, thalamus, and cerebellum. These interconnections explain the extensive frontal

controls on various segments of behavior. Of the five such circuits known, three have important behavioral and cognitive basis. Of the other two, one is a motor circuit and the other is oculomotor circuit originating from the frontal eye fields.

Presence of neural structures in the brain and the sensory-motor neural connectivity in the body are the essential components, which generate the mind within the body of a living being. The neural structures inside the top of the head carry out the sensory-motor decision making as well as creation of thoughts and emotional effects, all of which contribute to the formation of the mind of the individual and the mental processes (Figure 1).

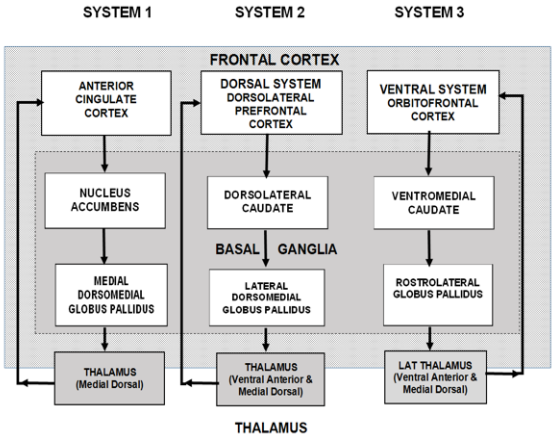

Figure 1 The 3 frontal circuits for the control of responses from the thalamus.

Frontal functional systems[5]

Neural cells providing the sensory-motor functions are present in all living beings, though the processing functions in the human being are indeed more complex, as the human brain could merely mentally conceptualize sensory-motor models of activities, before they are carried out. The mental models could be purely conceptual ones, and even only those ideas and relationships which could be materially formed are only the scientific ones. However, one could verbalize ideas, which may never have any material and real formation in the universe. The mentally formed relationships could also generate emotional effects, which could encode specific relationships and also initiate corresponding qualities, actions and responses. Such encoding in the brain occurs whenever the individual encounters any new stimulus or actions and the encoded information is retained in the memory of the individual, which is also an important information generated by neural cells, which would be stored in the brain or the neural cells.[5–10]

The orbitofrontal system

The Orbitofrontal circuit has its origin in the inferolateral Prefrontal Cortex Brodmann's area,[10,11] and 470 and has been described by Kringelbach[7] and Ugale,[8] as the it projects to ventromedial Caudate Nucleus. The Caudate Nucleus projects directly to dorsomedial Pallidum and rostromedial Substantia Nigra, and indirectly to Globus Pallidus externa and subthalamic nucleus.[3,4] The Pallidum and Substantia Nigra connect to the ventral anterior and medial thalamic nuclei and project back to the Orbitofrontal cortex. The system also has interconnection with amygdala and hypothalamus, and hippocampus. The Orbitofrontal functional system is associated with various neuropsychological facets of emotional regulation, personality, purposeful and goal directed behavior of individual. The fronto-thalamic circuits control the flow of sensory signals into the different frontal areas by which the functions of the respective cortical areas are mediated. The frontal control of the thalamus therefore can regulate the sensory inputs into the brain at the thalamic level. The controls that take place in the cortico-thalamic circuits may be part of the regulation of sleep-wakefulness states and the state of consciousness and alertness of the individual, and dispensation of drive in varying emotional states. An equally powerful mental creation is that of musical expressions, which simultaneously embodies hedonic-emotional effects in the person who sings, as well as listens to the music.

Orbitofrontal cortex is involved in response inhibition and there are several circuits emerging from this region which connect to other centers, which would control the presence and absence of responsive actions. Several of the above deficits may therefore be present in varying degrees depending on the extensiveness of the lesion, and the impairment produced in frontal circuits that connect to other cortical and subcortical regions. Loss of internal controls (response inhibition) make the patient become more environment dependent with imitation and utilization behavior[9–11] and this may be consequences of such dependency.[12] Frontal lobe lesion patients may also have presence of primitive reflexes[13–15] and their presence in adult patients is a clear indicator of frontal pathology. It was further proposed by Braver[16] that the ACC is a generic detector of processing conflicts. Impairment in spontaneous arousal of attention and ability to remain focused are other indicators of orbitofrontal pathology. These patients show impairment in being purposive and in neuropsychological states of motivation needed for goal directed activities. The debilities also lead to disruption of maintenance of mental set needed for appropriate response selection.

Clinical lesion studies have shown that lesions in the Orbitofrontal and the interconnected areas in patients result in syndrome characterized by the presence of several neuropsychological deficits. Emotional changes are the most significant of these; which bring about drastic changes in the style of functioning and self-controls used by the affected individual. The changes may consist of being less worried about oneself, with irritability, and with variable and inappropriate emotions. The person may become excessively talkative, impulsive, and outspoken, and less concerned about self and family, and need for immediate gratification leading to excessive and disinhibited activities.

Personality changes appear as a recent change in a person, which the relatives and friends would fail to understand. The changes in the personality make-up of an inflicted person are always taken note of by others. Some of the typical changes are reported below (Figures 2–5):

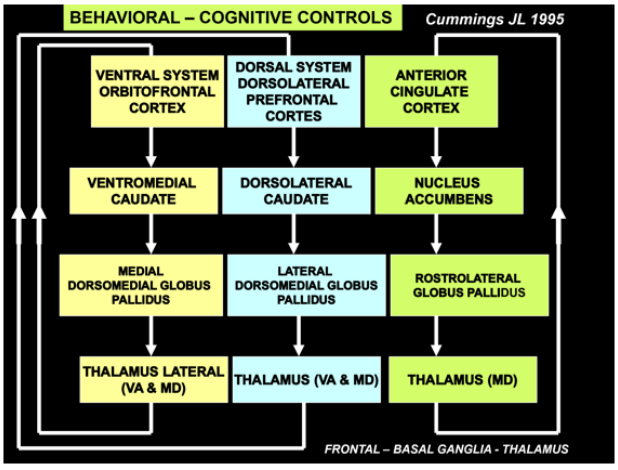

Figure 2 The three frontal circuits with the thalamus as explained by Cummings JL.[3,4,17,18]

Citation: Mukundan CR, Chetan SM, Sharma S, et al . Neurological systems, structures, functions, and their relationship with cognition, emotions and behavior. *J Psychol Clin Psychiatry.* 2026;17(2):45–52. DOI: 10.15406/jpcpy.2026.17.00851

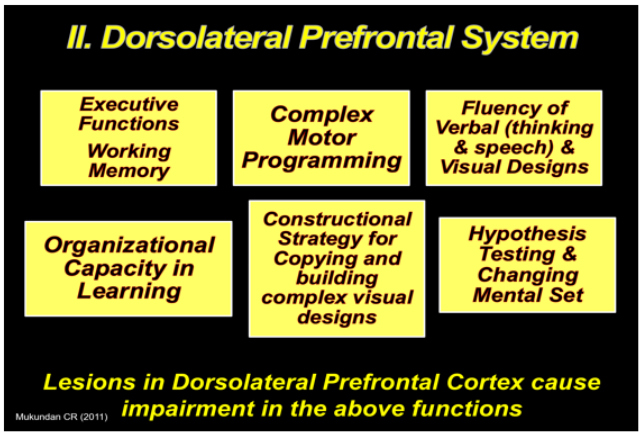

Figure 3 Showing three specific dorsolateral prefrontal control functions.

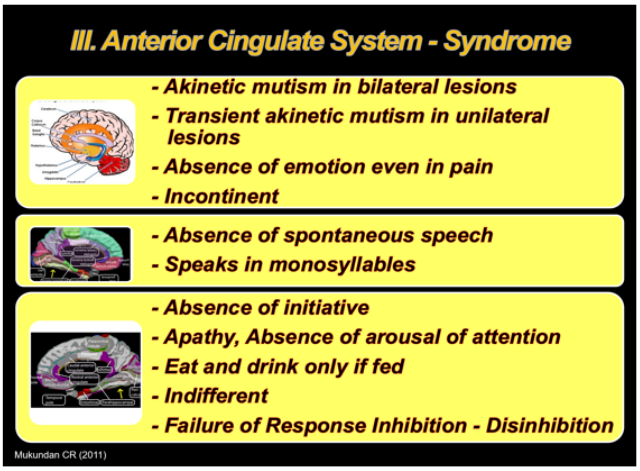

Figure 4 Showing the lesions & dysfunctions caused by anter cingulate system.

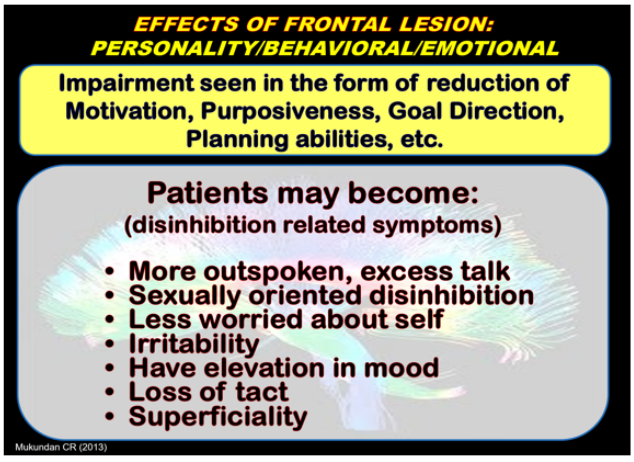

Figure 5 Showing the symptoms shown by frontal lesions or absence of frontal controls of lower brain areas.

Years back, this response was detected as the role of the frontal cortex, and the absence of such positive decision making, was called a state of "amygdala hijacking" or "neural hijacking",[19–23] when a response may straight away be carried out without frontal-cortical judgments in the brain of an individual. The "fight and flight" phenomenon, seen in intense emotional behavior, was described as "amygdala hijacking" by Daniel Goleman[19] and "neural hijack" by LeDoux.[20–23] The co-activation of both the systems is always required to be carried out for any activity in day-to-day life. Both systems help in developing neuropsychological control abilities in every individual, through social conditioning in the early years of development and growth of a child. The socially accepted cortical controls of behavior or responses must develop during the early social conditioning period, when a child is growing.

The functional capability for peaceful and positive controls of behavior develops through the cortical controls of behavior, which does not happen when the thalamus-amygdala directly activates the motor responses, which has been called "neural hijacking". The functional role of the Orbitofrontal Cortex system that emerges from the findings of lesion studies can be summarized as that of control and maintenance of emotional drive, and monitoring anticipated and actual effects of actions initiated and being executed for achieving personal goals in terms of social approval, maintenance of mental set for facilitating the actions being executed. It further monitors the actions that are initiated as purposeful, and monitoring sensory inputs, which may include evaluation of the satisfactory effects in terms of reward appraisal and its effect on the emotional experiences (Figure 6).[24–26]

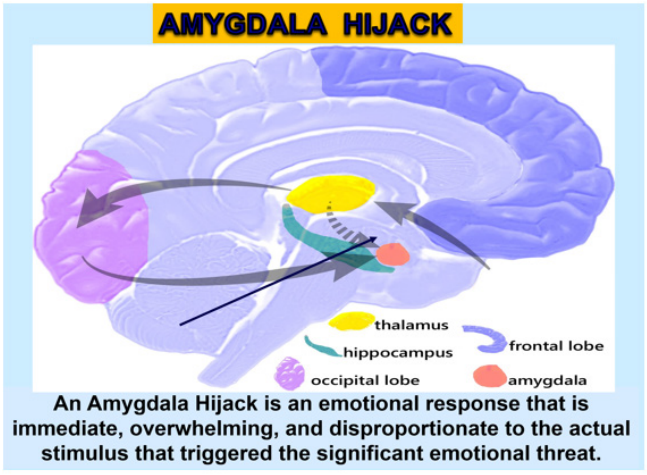

Figure 6 *Showing the amygdala hijack.*

The above effects indicate the importance of the orbitofrontal cortical areas in defining the emotional state of the individual, which affects his interpersonal relationships and navigational abilities in life. Emotional disposition must also match with the cognitive processing state of the individual. The system is considered to provide the platform required for the cognitive control of emotions. Patients with lesion in the ventromedial areas have difficulty in continuously maintaining their mental set required for persistent and continued pursuit of goals in life. The loss of focus in life will have devastating effect on the life affecting ability to take responsibilities and achieve goals. One of the most significant functional roles of the frontal lobes is in regulation of complex motor acts, in which the orbital frontal area plays important role. The orbitofrontal lobes function in conjunction with the anterior cingulate lobes for cognitive control of emotions and direct the drive in a purposeful and directed manner for achieving goals in life. The area has developed extraordinary functional capability, which makes human beings function distinctly from that of the other living beings on the earth. The orbitofrontal cortex learns the capability to take response decisions based on the needs of the individual, family, and the society, and what one wants to achieve in life, etc., by inhibiting impulsive execution of unwanted acts, which may be initiated by the

sensory-motor areas. The frontal cortical structure in human beings and its functional capabilities provided man capability to create thoughts and emotional responses about the genesis of human beings, and conceptualize the existence of higher levels of forces, which created man, and they defined the force as divine and spiritual, as the related thoughts and the drive guided people with specific goals and purposes in life. Absence of social conditioning and the resultant neural effects of the absence of positive frontal controls, instigated man to easily become violent. This has been termed as "Neural hijack".[19–23,27–31]

The wonderful positive control of the frontal lobes, and the positive need for the practice of enhancement of social conditioning for the control of the negative effects of violence,[32,33] continues to occur with the human society. However, if a society accepts violence and related activities as normal responses for the safety of their people, such frontal inhibition of violence related activities would not take place, as violence is accepted as a normal response to several responses people may suffer from. Deciding and practicing social values are based on the strong social discipline developed in a society, which will be the value system based on which training the frontal lobes for controlling behaviour, may take place. We are aware that terrorism and violence are commonly practiced actions by a few individuals, based on the support given by a few persons known to them. There may be no frontal inhibition of such activities, which may not occur in those individuals, as love and affections are not the strength of the individual. This needs to be studied and verified. On the other hand, frontal lobe support and activation may take place in these individuals, who have developed the capacity to experience love and affection for fellow persons. Normally focus is given to experiences and expressions of love and affection by individuals in the society, which may play an important role for the cultivation of the frontal ability to support violent activities. If a person has not developed this capability as a child, there may never be a frontal inhibition of violence. While exercising devotional states, all children are expected to practice along with adults, focusing the mind on the theme, when each mind learns to focus its attention on the specific idea and feel blessed, as well as mentally experience capabilities of the theme, or the divine forces in the mind. The personally attended state, as it happens in hypnotic states, helps the individual believe in the theme and the force, and they accept them as sublime and divine states, providing immense neuropsychological strength to the mental state.

The orbitofrontal cortex is the area engaged in the neuropsychological conceptualization of purposes and goals for oneself. It has also the capacity to imagine and conceptualize the same in other individuals, thereby understanding and empathizing or not agreeing with their feelings and thoughts. Loss of motivation, purposiveness, planning, and initiative could occur because of orbitofrontal lesions, and the pathogenesis of the area appear to give major personality impairment to the individual. It will derail social behavior, interpersonal relationship, as well as occupational interests of the individual. The orbitofrontal areas may be hypothesized to control the mind, with capacity to release the drive required to initiate actions and keep the actions executed for the control of actions for achieving the goals. When these are negative symptoms, they could be further worsened by the presence of positive symptoms arising out of disinhibition, and the consequential loss of frontal control on the other functional systems of the brain. Personality changes are usually coupled with emotional changes either in the form of excessiveness of emotions, emotional withdrawal, or inappropriateness and vacillations of emotions. It is the result of absence, impairment or loss of the mechanism of regulation, which leads to either excessive or under expression of emotional arousal. These changes may appear in an acute or insidious manner, depending on the actual onset and progress of pathology in the brain. What needs to be emphatically understood in this context is the fact that these functions need to be cultivated first in the brain during the brain developmental stages. The opportunities available for the cultivation of such functions and abilities may vary from child to child, and their variations account for the differences seen in adult individuals in these domains. Developing these functions may be possible even in an adult brain, but may pose greater difficulties and problems unless the whole process is strategically managed. It must be apparent that these skills cannot be acquired in the classroom alone by a child, but needs to be acquired in the larger sphere of life. Social conditioning of a child during the developmental stages is an important requirement for the adequate brain development in each growing child.

Emotions are experienced in varied forms including empathy, when one is capable of producing the same emotions seen in another person. Orbitofrontal Cortex and Anterior Cingulate Cortex are found to have a special role in emotional empathy.[34,35] Empathy is an important aspect of Theory of Mind, by which we explain social interactions at the affective and cognitive levels. Empathy is experienced at emotional and cognitive levels, at the orbitofrontal cortex, especially right ventromedial areas, which are considered related to emotional empathy.[36–38]

Dorsolateral prefrontal system

The Dorsolateral Prefrontal Circuit originates in the dorsolateral region (Brodmann's areas 9 and 10) of the brain and projects to the dorsolateral head of the Caudate Nucleus. The Dorsolateral Caudate, in turn connects directly to dorsomedial Globus Pallidus Interna, rostral Substantia Nigra and indirectly to Globus Pallidus Interna and Substantia Nigra through the Globus Pallidus Externa via the Subthalamic nucleus. The Pallidum and nigra project to ventral anterior (VA) and medial dorsal (MD) thalamic nuclei. The thalamic structure in turn, connects back to the dorsolateral prefrontal cortex forming a total feedback loop. Lesion in the dorsolateral prefrontal cortex and the connecting circuits results in the impairment of various controls needed for executive functions, as well as cognitive processing. Several of the original studies in which the dysfunctions of Dorsolateral Prefrontal cortex were identified, based on which normal cognitive processing models were developed by Luria,[39–41] Lezak,[42,43] Teuber.[44,45] Lesions in the circuit were found to affect impairment in the following function, like Executive Functions and Working Memory, Motor Programming, Hypothesis Testing, Changing Mental Set, Verbal and Design Fluencies, Organizational Capacity in Learning, and Constructional Strategy for copying Complex Designs.

Lesion in thalamus

1) Lesions of the anterior and medial parts of the thalamus may lead to memory dysfunction. Bilateral lesions may produce severe form of memory deficits. Unilateral lesions may produce material specific, verbal or visual type of memory disturbances.[46–50]

2) Verbal memory may often be spared after right thalamic lesions,[46] and visuospatial memory may be preserved after left thalamic lesions.[49,50]

3) Anteromedial thalamic lesions (both left and right) associated with long-term anterograde memory deficits and often accompanied by deficits in retrograde memory. Short-term memory is found to be unaffected, although may be impaired in large thalamic lesion.

4) In thalamic lesions, procedural memory remains intact and autobiographical memory either preserved or impaired for recent events.[49,50]

5) Behavioural changes concomitant to memory problems in thalamic lesions are increased irritability and disinhibition.[48,50]

6) Lesions affecting the tuber thalamic structure result in the most severe form of cognitive deficits. The deficits include dysphasia, verbal paraphasia, comprehension deficits, impaired visuospatial processing, and verbal memory.[51]

7) Daum and Ackerman[50] reported a case of 63 years old woman with lesion (infarct) in the pre-median thalamic area exhibiting impaired immediate recall in verbal and visual modalities in the presence of intact IQ and attentional function.

8) Sala[51] observed persistent global amnesia in right thalamic stroke.

Dysfunctions caused by lesions of fronto-subcortical circuits

The Frontal cortex is connected to the thalamus through subcortical structures viz., dorsal and ventral; caudate, Nucleus Accumbens, medial, lateral and rostro lateral Globus Pallidus. Lesions in the subcortical structures and thalamus can also breakdown the above functional systems and bring about certain characteristic neuropsychological deficits. These deficits are shown in the table below. Lesions in the subcortical structures and thalamus can also breakdown the above functional systems and bring about certain characteristic neuropsychological deficits. These deficits are shown in the table below. The Frontal cortex is connected to the thalamus through subcortical structures viz. and the lesions in the different frontal lesions may produce the following deficits.

Frontal inhibitory controls

Striatum – dorsal: May remain confused and disinterested.[52]

Striatum – ventral: Disinhibited, euphoric, inappropriate compulsive features.[52]

Caudate–medial: Mood disorder, irritability, explosive behavior, apathy, obsessive- compulsive features.[52] Deficits in Wisconsin Card Sorting test, decreased verbal fluency, poor recent memory.[18]

Nucleus accumbens: Apathy.[17,18]

Globus pallidus: Apathy, psychic akinesia, reduced spontaneous activity, impaired initiative.[17,18]

Dysfunctions caused by lesions of fronto-subcortical circuits

The Frontal cortex is connected to the thalamus through subcortical structures viz., dorsal and ventral; caudate, Nucleus Accumbens, medial, lateral and rostro lateral Globus Pallidus. Lesions in the subcortical structures and thalamus can also breakdown the above functional systems and bring about certain characteristic neuropsychological deficits. The Orbitofrontal cortex and the basotemporal cortex have under their direct inhibitory control various other areas of the brain. The Orbitofrontal and the Basotemporal cortical structures are called the controlling centers, and the remaining cortical and subcortical areas are the controlled areas of the brain. Release of inhibition is the necessary requirement for the controlled areas to get activated and function or process the tasks centered in their areas. Such inhibition facilitates optimum functioning of a functional system. The functional efficiency could be increased or decreased depending on the needs of situation by the controlling centers. Damage to the controlling centers and the connecting tracts would release the controlled centers from inhibitive control leading to hyper activation of the controlled areas and the consequent deviations and abnormalities of functions associated with these areas. Disruption of frontal – subcortical circuits has been considered major cause of behavior disinhibition,[17,18,53] which prevents frontal control on behavioral manifestations. The two controlling areas are the Orbitolateral prefrontal cortex and the Basotemporal cortex.[54]

The release of inhibition leads to disinhibition of the controlled areas and the following are the major inhibitive circuits and disinhibition symptoms, when hyperactivation takes place because of lack of inhibitive controls. The afferent inputs into the Orbitofrontal areas help in the monitoring and regulation of the sensory and motor events and in the absence of such regulation these events become hyper active.

Motor inhibition - disinhibition

The Orbitofrontal and basotemporal areas have connectivity with medial and dorsal Frontal structures, and subcortically with Striatum. The Orbitofrontal cortex and the Basotemporal cortex share anatomical connections, which control the association between frontal – initiated volitional regulations and psychomotor behaviors, and the release of Limbic - related emotional drive for initiation and execution of actions. Impulsiveness, loss of tact, uncontrolled speech, impersistence, inappropriate perseveration, restlessness, and hyperactivity, pressure of speech, decreased need for sleep and difficulty for intentional focusing of attention (distractibility) are some of the frequently observed disinhibition symptoms seen in Orbitofrontal lesion patients. The Schema theory proposed by Schmidt[55] explains the need and general rules of motor programming that can be applied in different environmental and situations contexts. The motor programming model put forth by Schmidt and Lee[56] later explains the frontal control required for movement in their generalized motor program (GMP), which takes into account the nature and type of movements, their timing, sequences, and the forces to be used. On the other hand, the model suggested by Goldberg[57] explains the neural strategy for navigation across space and time, and the role of supplementary motor area and other brain centers in carrying out propositional and navigational movements across space and time. As against this, the conditioned responses, which are controlled by the Supplementary Motor Area (SMA) and the Arcuate Premotor Area (APA), are elicited by a stimulus. The same differences are applied in the production of speech in which one kind of speech is spontaneous and controlled from the Supplementary Motor Area, whereas the other kind is repetitive and controlled by the APA. The emotional controls in the brain originates in the limbic system (especially the amygdala), and the prefrontal cortex.

Instinctive behavioral inhibition – disinhibition

Human beings also have a share of instinctive behavior, which is not learnt but expressed as response to specific stimuli, from a genetic repertoire. Maternal instincts, sexual instincts, and survival instincts are some of them. These appear in animals and human being without social learning and have been called the phenomenon of imprinting.[58] Anthropological beings can interfere with their expressions and modify them only by strong volitional efforts.[59] Expression of some of these instincts is considered to be under the control of Orbitofrontal cortex. The Orbitofrontal cortex has direct efferent connections to hypothalamus, amygdala, and brainstem biogenic amine nuclei. The Orbitofrontal cortex mediates instinctive behavior through this

connectivity. Disruption of the frontal control of the subcortical areas results in hyperactivation of the instincts. Hypersexuality, hyperphagia, and aggressive outbursts are some of the clinical examples of such disinhibition, seen in these patients.[54]

Intellectual & sensory inhibition - disinhibition

The Orbitofrontal - Basotemporal cortex has connections to dorsal temporal and parietal areas. Both visual and auditory input areas have connectivity with the frontal lobes. The connectivity of the Wernicke's auditory speech receptive area is with the Broca's area in the left frontal cortex, required for expressive speech, which allows the receptive area monitors both inner (thoughts) and expressed speech, producing awareness of speech created and recreated within.[60–62] Hallucinations as a release phenomenon[63] can be attributed to the release of controls exerted by a control center on the controlled system, because of lesion either in the control center or network, which are used for the control of the latter areas. In other terms, the hyperactivity of the controlled system is the resultant of the inhibitory control of the controlling station. Release of the controlled areas from inhibition of ventral frontal and temporal areas may lead to intellectual and sensory inhibition. Grandiose and paranoid ideas, flight of ideas are examples of such intellectual disinhibition. Visual and auditory hallucinations are examples of sensory disinhibition (Figure 7).

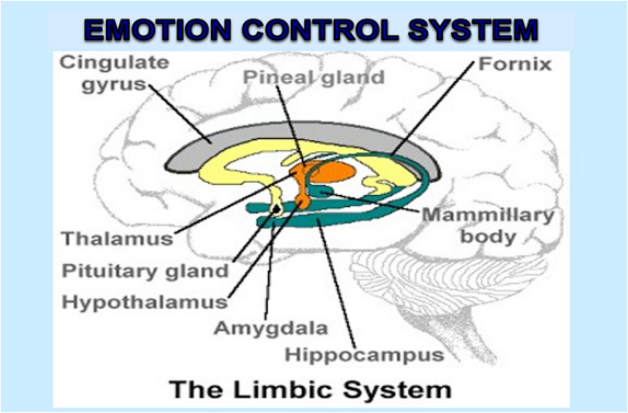

Figure 7 *Limbic controlling emotions.*

Several single case reports of post-lesion cases have implicated presence of lesion, mainly in the temporal lobes and then in the frontal lobes, as the reason for hallucinations and delusions.[64–69] Dierks[70] first reported in 3 schizophrenic patients with auditory hallucinations in whom the fMRI activation was localized maximally in the transverse temporal gyrus of the dominant hemisphere, and to lesser levels in the posterior superior temporal gyrus, middle temporal gyrus, frontoparietal operculum, and even in hippocampus, amygdala and sensorimotor cortex. However, the activation was the combined effect of auditory hallucination and motor pressing task that they used in the study. Shergill[71] using fMRI showed in 6 schizophrenic patients had maximum activation in the right inferior colliculus, right and left insula, left Para hippocampal gyrus, right temporal gyrus, right thalamus, middle frontal and anterior cingulate gyri, and right inferior and superior temporal lobe during auditory hallucinations. They concluded that auditory hallucination may be part of defective monitoring of inner speech as the same areas are involved in the production of inner speech. The loss of connectivity between the Wernicke's and Broca's area has been implicated as the cause of auditory hallucinations in schizophrenic patients in other reports also.[72–78] Lesion in the connecting pathways between the listening centers and talking centers of brain disables the ability to monitor the source of self-generated speech in thinking making the patient believe that the thoughts or speech have come from outside. Braun[64] suggests that lesions of the right hemisphere rather of the left hemisphere may be the cause for the production of visual hallucination in schizophrenic patients.

The neural disinhibition model of visual hallucinations is not as clear as that of the auditory model, in which the lesion is hypothesized primarily in the frontal and temporal connectivity circuit. In remembrance, presence of visual imageries produces neural activation in the primary visual cortex and visual secondary association cortical areas, which are to be monitored by the frontal cortex, which help one to know that the imageries are part of a process of remembrance and hence self-initiated. A frontal pathology can render such monitoring difficult or impossible, and the affected person would consider that the imageries are produced by real sensory inputs.

Emotional inhibition – disinhibition

The paralimbic areas are under the inhibitive control of the Orbitofrontal and Basotemporal cortex. Loss of inhibitive control in this system may lead to emotional disinhibition. The brain structures associated with emotions are several, which shows the complex nature of emotional experiences and expressions, and regulation of emotions. The structures closely associated with emotions are Amygdala and Hippocampus, Fornix and Para hippocampal gyrus (both are connecting pathways), Thalamus and Hypothalamus, Ventral Tegmental Area, Septum and the Brainstem, the Cingulate gyrus and Orbitofrontal cortex (prefrontal). All these structures are also associated with several other independent functions and additionally they play a role in emotions. Paul MacLean[79] puts forth the "Triune Brain" theory, and has placed the "limbic brain" as the second brain structure, which developed according to evolutionary needs of life. This was followed by the "neocortex" that developed mainly in mammals, especially in human beings. Accordingly, there are three brains put together in the human brain of which brain structure called the "Reptilian brain complex", consisting of the Basal Ganglia, Brainstem and the Cerebellum form the first structural brain complex. This brain took control essential of physical survival as it controls vital functions and "flight or fight" responses. The second brain, the "Limbic system" consists of mainly the Amygdala and the Hippocampus. Human emotions have passed through extended developments because of interpretive possibilities of the external stimuli. Cognitive interpretations run parallel to the physiological expressions of emotional states and together they form complex experiences and expressions of emotions. The Orbitofrontal cortex plays most significant role in such interpretations and controls, which receive inputs from the entire sensory cortex of the brain. These interpretations and controls take emotional responses beyond the territories of "flight or fight". As the controlling centers and the controlled centers normally function in great harmony, losing the controls because of lesion anywhere in the neocortex and more specifically in the Orbitofrontal cortex would naturally take away those immense cognitive features of human emotions. The affected patient may express more of the "reptilian emotions", and the dis-inhibitive effects may be seen as euphoria, elation, irritability, flight, or fight responses.

Acknowledgments

None.

Funding

None.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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