

Sensitive dependence of mental function on prefrontal cortex

Abstract

This study offers evidence to suggest that both normalcy and psychiatric illness are sensitively dependent upon prefrontal cortex function. In general, the emergence of psychiatric symptoms coincide with diminished influence of prefrontal cortex function. The mediating influence of prefrontal cortex may be independent of molecular and regional brain dysfunctions contributory to psychiatric illness.

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Introduction

Compelling data suggest higher mental functions, executive function, awareness, consciousness, planning, strategic thinking, imagination and processing sensory input are the domain of prefrontal cortex function and in particular Brodman areas 8, 9, 10, 46.^{1,2} Recent studies have also suggested that the mediating influence of prefrontal cortex function is crucial in depression and in antidepressant strategies³ is it possible that what is true for depression may also be true for other psychiatric disorders? And if this is true, does that suggest that prefrontal cortex is endowed with a unique mediating influence of mood, normalcy and psychiatric illness? And does this suggest that a small decline of prefrontal cortex influence may have large effects in brain function and human behavior similar to the butterfly effect of complex systems?

Method

This paper will review diverse examples of the mediating influence of prefrontal cortex in normalcy and mental illness. Observations consistent with natural laws in support of them ediating prefrontal cortex influence will be presented (Table 1). Examples of diverse correlations between mental disorders and decline of prefrontal cortex will also be shown under the following headings:

- I. Phylogeny
- II. Biology
- III. Clinical observations
- IV. Neuroimaging studies

Phylogeny supports the mediating influence of prefrontal cortex function

The idea that a brain region may enjoy greater influence over nervous system is partly rooted in natural observations consistent with the biological hierarchy of diverse living organisms⁴⁻⁷ (Figure 1). A simple example is a logical one: head rules body and tail. A second example is an extension of the first. Brain rules peripheral nervous system. Of course head and body, brain and peripheral nervous system relationships are complex and bidirectional within the biological hierarchy of influence.

Governing influence of prefrontal cortex is also consistent with its highest biological complexity and evolutionary youthfulness

(Nolte2008). Further, more over the last several decades data have accumulated to suggest that relative brain size, cellular complexity and division of labor of multicellular organisms are of crucial importance for intelligence and in essence, phylogenetically the youngest biological systems have been endowed with the highest complexity and with the greatest influence.⁴⁻⁶

Neurophysiology supports the mediating influence of prefrontal cortex

In general, Broadman areas 8, 9, 10, 46 seem to correspond to prefrontal cortex and seem to be endowed with complex mental functions such as attention, concentration, executive function, self awareness production of senses, abstract thought, strategic planning mastery of impulses and will power. Evidence also suggests our ability to initiate and pursue personal goal directed behavior with integration of environmental and internal cues seem to be a major function of prefrontal cortex.² Hierarchy of influence is observed throughout living systems and in nervous system (Figure 1).

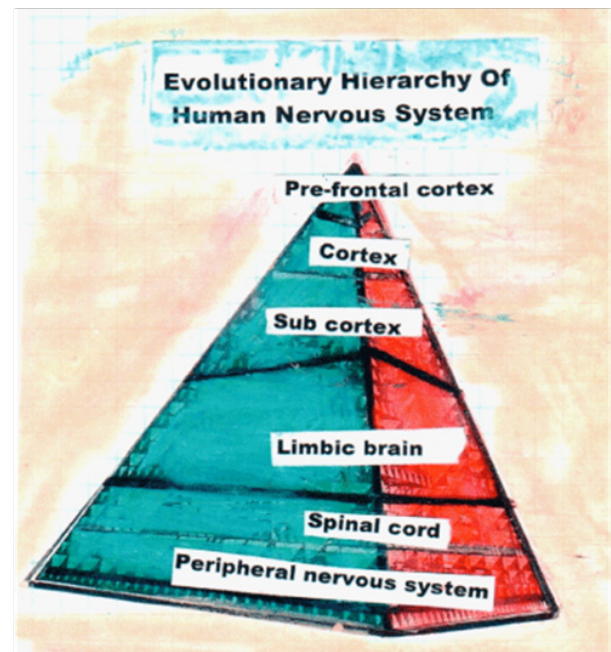


Figure 1 Evolutionary hierarchy of human nervous system.

- a) Prefrontal cortex rules motor and sensory cortex.
- b) Prefrontal cortex may override functions primarily regulated by other brain regions (remaining awake at night or limiting food intake for weight loss).
- c) Damage to Broadman area 8 is associated with loss of bladder and bowel Control.²

Understandably, this does not negate the crucial bidirectional and complex influences mediating food intake and sleep.

Symptoms of great many psychiatric disorders correspond to diminished influence of prefrontal cortex

Clinical and statistical evidence: Consistent with its natural role any decline of pre-frontal cortex influence should adversely affect normal behavior and executive function, logical thought, reasoning, mastery and suppression of impulse control.² In fact, symptoms often

associated with great many psychiatric disorders may include illogical thinking, impaired planning executive function or inadequate mastery of impulse control. And although psychiatric symptoms may have diverse an atomical and molecular origins they almost always reflect some decline of prefrontal cortex function (Table 1). For instance schizophrenia, bipolar illness, depression, attention deficit disorder, obsessive-compulsive disorder and addictive disorders present with symptoms that correlate less than normal functioning and influence of prefrontal cortex. Schizophrenia and bipolar disorder almost always suggest illogical thinking. Depression presents with poor impulse control and impaired concentration.

There seems to be clinical evidence supported by neuroimaging data to support diminished prefrontal cortex influence in psychiatric disorders (Table 2). Several pathophysiological clues may demonstrate there dominant role of prefrontal cortex function as the common final target from diverse psychiatric dysfunctions. For instance psychosis chronic pain and anxiety may lead to prefrontalcortex dysfunction demonstrable by neuroimaging and clinical evidence.^{8,9}(Table 2).

Table 1 Sensitive dependency of human mental function on prefrontal cortex influence

Sensitive Dependency of Human Mental Function on Prefrontal Cortex Influence			
Evidence	Observation	Example	
Phylogeny	Youngest=Most influential	Head rules body and tail	
Biology Brain	governs nervous system	PFX rules motor cortex	
	Diminished PFX glucose metabolism	ADD, OCD ,Depression Schizophrenia	
Neuro Imaging	Diminished executive function	Diminished judgment	Diminished motivation
	Poor impulse control	ADD , OCD, Depression Schizophrenia	

Table 2 Sensitive dependency of human mental function on prefrontal cortex influence

Sensitive Dependency of Human Mental Function on Prefrontal Cortex Influence			
Evidence	Observation	Example	
Phylogeny	Youngest=Most influential	Head rules body and tail	
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It has been demonstrated that abnormal amygdala function is a crucial precursor of some endogenous depression⁹. This may suggest, chronic over load from a dysfunctional amygdala may lead to decline of prefrontal cortex function and depression. The same observation may be true for chronic pain. The data from schizophrenia is also informative. The progression from acute psychosis to chronic schizophrenia offer further evidence of decline of executive function and neuroimaging evidence of prefrontal cortex dysfunction. Note worthy is the observation that the predominant symptoms of an acute psychosis represent imbic hyper activation and sensory overload overwhelming prefrontal cortex whereas chronic schizophrenia is marked by serious prefrontal cortex dysfunction.

In summary chronic pain, psychosis and amygdala dysfunction diverse conditions of diverse pathophysiology and etiology-may lead to prefrontal cortex dysfunction with diminished prefrontal cortex mediating influence.

Neuro imaging evidence: in many psychiatric disorders the influence of prefrontal cortex is diminished shown by decreased metabolic activity in prefrontal cortex or its connections.

Evidence from neuroimaging studies is consistent with metabolic abnormalities either in prefrontal cortex or in the top down connections diminishing its influence in almost all psychiatric disorders (Table 1 & 2). Diminished metabolic activity in prefrontal cortex has been shown in schizophrenia,¹⁰⁻¹² depression,^{13,14} in depression associated with diabetes,¹⁵ depression associated with Parkinson’s disease, depression associated with stroke, depression associated with Huntington’s disease,¹³ bipolar disorder,¹⁶ addictive behavior,¹⁷ obsessive-compulsive disorder. Reduced functional connectivity within cortical limbic loop has been shown in obsessive-compulsive disorder^{18,19} and depression.²⁰ There is evidence of pharmacological treatment improving brain connections in obsessive compulsive disorder.²¹

Discussion

Clinical observations, neuro imaging and statistical data suggest that brain function may be sensitively dependent upon the mediating influence of prefrontal cortex. It seems that the emergence of psychiatric symptoms may coincide with prefrontal cortex influence falling below a threshold necessary for normal function. Diminished prefrontal cortex influence may have diverse origins:

Functional disconnection between prefrontal cortex and other brain regions

Any disruption of communication between prefrontal cortex and other brain regions would represent diminished influence of prefrontal cortex. This is consistent with the observations from studies of people with schizophrenia and obsessive-compulsive disorder.^{10,18}

Primary prefrontal cortex dysfunction

Any prefrontal cortex dysfunction represents diminished influence. A possible example may be attention deficit disorder.

Secondary prefrontal cortex dysfunction

Chronic abnormalities associated with sensory overload may contribute to prefrontal cortex decline (depression, pain, schizophrenia). The mediating influence of prefrontal cortex does not negate other crucial influences contributory to psychiatric illness. The limitations of this study include its theoretical architecture and lack of experimental validation. Also it is based upon subjective projections.

Conclusion

It seems that brain function is sensitively dependent on the mediating influence of prefrontal cortex and some decline of PFX influence may be a prerequisite for the emergence of psychiatric symptoms. The mediating influence of prefrontal cortex for normalcy and mental illness is a new paradigm which may offer therapeutic benefits. Further validation of this thesis is necessary. Its potential therapeutic benefits may make it worthwhile of further scientific scrutiny and validation.

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Conflicts of interest

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