

Major Depressive Disorder and Non-locality of Functions in the Brain

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Abstract

There is a specific dilemma faced when the issue of brain and its functioning arises. This concerns the locality or non-locality of these functions. Many theories and arguments have been put forward in support of one or the other. Yet if a considerable look is given to this dilemma using excerpts gathered from quantum physics, one arrives at the conclusion that brain functions which are classical in outlook are non-localised. Major Depressive Disorder (MDD, that is clinical depression), has left many scientists with a lot of conjectures as regards its location. Nonetheless, we have all fallen short empirically in articulating the locality of this disorder in the brain. Can we say that this can be explained when we consider non-locality, with regards to quantum brain dynamics (QBD)?

Keywords: Major depressive disorder • Depression • Brain disorder • Non-locality • Quantum physics • QBD

Introduction

According to the WHO stats on depression: Depression is a common illness with an estimated 3.8% of the population affected, including 5.0% among adults and 5.7% among adults older than 60 years (Therefore, addition mine) approximately 280 million people in the world have depression (WHO, 2021).

Depression is the most common of the affective disorders; it may range from a very mild condition, bordering on normality, to severe (psychotic) depression accompanied by hallucinations and delusions [1-4]. Giving this a world outlook, depression is a leading cause of disability and death (on a premature stance). Depression should not be linked in par with mood swings and short-fused emotional reactions to elements of daily life. It causes prolonged feelings of sadness, loss of vitality, emptiness that is characterized by somewhat hopelessness of all that is about existence. Other symptoms include: Weight loss or gain unrelated to dieting, distorted sleeping habit (either sleeping too much or too little), energy loss or increased tiredness, Increase in purposeless physical activity, feeling worthless or guilty, difficulty thinking, concentrating or making decisions. In its extreme form, it can lead to suicide. According to WHO, The total number of people living with depression in the world is 322 million? Nearly half of these people live in the South-East Asia Region and Western Pacific Region, reflecting the relatively larger populations of those 2 Regions (which include India and China, for example). The total estimated number of people living with depression increased by 18.4% between 2005 and 2015 [5]; this reflects the overall growth of the global population, as well as a proportionate increase in the age groups at which depression is more prevalent (WHO, 2017).

Mdd Affected Areas

The regions that depression is witnessed in the brain are seen to cut across

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areas that are not in any way close to each other. According to Maclean who introduced the concept of the triune brain, he noted that the brain is composed of 3 parts namely, the prefrontal neocortex (involved in higher cognitive processes as well as regulation of emotions by their connections to the limbic region), the limbic or mammalian brain (involved in emotions which guide self-preservation and procreation of species) and the reptilian complex composed of the basal ganglia and brain stem structures (involved in routine motor function/reflexes as well as social communication such as territorial and courtship displays) [6].

In line with the findings of these separate regions in the brain, MRI scans have indicated that when directed to the gray and white matter of the brain, alteration in MDD patients in areas such as the frontal lobe, hippocampus, temporal lobe, thalamus, striatum and amygdala have been found [7,8]. However these results are not totally consistent because the spaced out topography, the different demographic and clinical characteristics that have been noticed. Recent findings have singled out the fact that due to the overlapping of these areas, the MDD "hub" (A hub is a highly connected and highly central that plays a role in global information integration) is not simply restricted to one region, but is a connectivity of complex regions [3,7], thus spanning varied circuits. Therefore instead of a singled-routed hub, a doubly-connected routed hub of the frontal-subcortical circuit [7], basal ganglia-thalamic-cortical circuit [7,9], prefrontal hippocampus circuit [10], the limbic-cortical-striatal-thalamic-cortical circuit [11], and the limbic-cortical-striatal-pallidal-thalamic [7,12] circuit. While these circuitry connection may be and is valid for MDD, that which is most common functional in MDD patient is the cortical-subcortical circuitry connection [7,13], and in this circuit, the frontal lobe, parietal lobe, thalamus, putamen, and hippocampus are considered hubs in these circuits [7,14,15].

We can therefore assert that the different regions associated with MDD includes:

- The cortical areas-the dorsal and medial prefrontal cortex, the dorsal and ventral anterior cingulate cortex, the orbital frontal cortex and the insula [16-22].
- The subcortical limbic region-the amygdala, the hippocampus and the dorsomedial thalamus [23-27].
- Brain Stem and Basal Ganglia-the striatum is the area involved here [28].

What is notable in all that has been said here is that these areas involved in depression overlaps and as Maclean earlier notes, these areas are eons apart from each other [29], giving impetus to the theory of the overlapping of these regions.

Brain Non-locality

Non-locality is a term that is used more in quantum physics that refers more to entanglement of different systems that are spatially distinct. Thus it might appear more of a misnomer if one alludes to the issue of non-locality in the brain. However, if we allude that non-local properties occur in natural systems, as endorsed by Bell, who says that non-local processes are characteristic of most natural processes [30], we can say that it would not be out of place to say that these processes also occur in the brain, as a system. Application of this term to the Brain has witnessed a lot of nay-saying, arising from the fact of the brain as a noisy and wet system. Therefore, "it is argued, putative quantum brain mechanisms would not function at a time scale at all relevant to brain science" [31]. The proposal of the usage of quantum physics in the brain is out of the failures witnessed in a classical rendition of the operations of the brain. We know that the brain operates on an integrated scale, this is because the principle of its operation is functional connectivity [32,33]. It is worthy to note that this paper does not in any way endorse the brain as a form or sort of quantum computer, rather it asserts that there is chemical-physical-biological operations that are happening in the brain, that ought to be better explained.

The distributive theory of the brain by K. Lashley prefigured this concept of brain non-locality. K. Lashley defined the brain functioning using his experiments carried out on rats. He was able to identify that the mechanism of integration in the brain lies in the dynamic relations between the parts of the nervous system instead of the details of structural differentiation [34]. According to A. Luria, cognitive process that is associated with higher functions may represent functional systems that are not localized in narrow, circumscribed areas of the brain, but occur among groups of concerted working brain structures that individually make their own particular contribution to the organization of the functional system [35]. There are 2 principles that K. Lashley uses to define the distributive theory of brain function-the principle of mass action and equipotentiality. He defined equipotentiality as the capacity of any functional part of the brain to carry out... functions that have been lost by other parts via destruction [36]. The equipotentiality hypothesis states that each portion of any given area is able to encode or produce the behavior normally controlled by the entire area. Thus, incomplete damage within a zone is compensated for by the remaining area [37]. The principle of mass action notes that the portion of the brain that is injured is proportional to the decreased ability of memory function [38].

What brain non-locality attests to is that the dynamics of the brain are very rapid to be explained with the classical idea of neuron synapticity? As Globus and Carroll notes it, Communication between brain regions is near instantaneous via soliton signalling in the nanolevel web of protein filaments percolating through brain tissue. This accounts for what Lashley called the brain's "mass action" [39]. Furthermore, areas of the brain that are specific in function might be localized, yet their functionality spans beyond this locality. A good example is highlighted in the mirroring functioning of the brain (neuron mirroring). The area specific to this function has been noted to be contained in diverse areas of the brain such as the Supplementary Motor Area (SMA), the Primary Somato Sensory Cortex (PSSC), the Inferior Parietal Cortex (IPC), the Ventral Premotor Area (VPMA), Broca Area (BA), Wernicke's Area (WA), Fusiform Gyrus (FG), Angular Gyrus (AG), Primary Motor Cortex (PMC). A visual look at these areas will indicate how spatially distinct they are. Yet they act in near instantaneous fashion. This near instantaneous dynamic functioning of the brain defies classical understanding, thus probing further it is evident that the structures and parlance of Quantum physics, better explain this cortical phenomena.

Mdd and Brain Non-locality

According to Pandya et al., A review of the neuroimaging, neuropsychiatric and brain stimulation therapy studies of depression indicates that like other abnormalities of higher mental functions, the location of depression is

difficult to determine. Depression seems to lie in many brain regions as well as nowhere in particular..., it has been hypothesized that depression may involve abnormalities of functional connectivity involving many different brain regions. A more pure form of this conceptualization is that not only is there no particular brain region involved, but that there is no localized abnormality present at all. Depression is therefore hypothesized as an abnormality of a functional interaction of neuronal oscillations among different regions or among brain networks [40].

The evidence that there is a distribution of this abnormality that defines depression gives credence to the non-locality of functions in the brain. As Zhang et al., notes that contemporary findings in what pertains to depression does not indicate that it is due to local lesions, but is a multiloop disorder [41], affecting many localized area of the brain. In order to further deepen this finding, we asserted above that depression affects the structural network hub of the brain. The Structural brain hubs have been identified by diffusion tensor imaging and the nodes normalized to an intramodular degree higher than what were defined as hubs [42,43]. Anterior cingulate and paracingulate gyri; calcarine fissure and surrounding cortex; hippocampus, insula, middle occipital gyrus, middle temporal gyrus, precuneus, putamen, superior occipital gyrus, superior parietal gyrus, dorsolateral part of the superior frontal gyrus; medial part of the superior frontal gyrus, thalamus [44-49], this is seen in Figure 1.

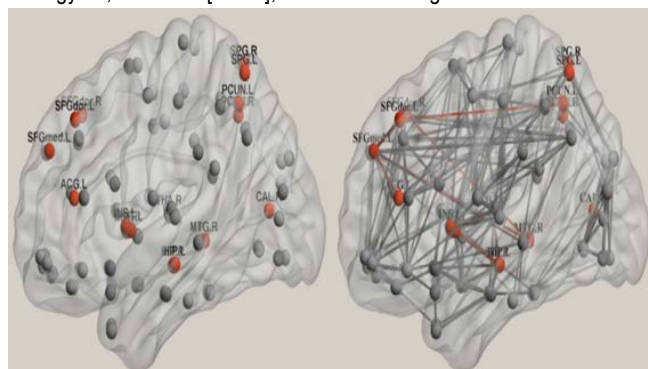


Figure 1. Prognosis.

The use of non-locality in the brain does not indicate that there are no areas that are specific to functions in the brain (what I refer to as elementary). These areas are simple. What is being said here is that simple areas are localized, but the complex function of the brain arises from the distributed (non-local) manner of the brain. This is because the simple neurons that perform this elementary functions.

- Receive from the same input sources.
- Project to the same output targets.
- Interact instantaneously.

Complex functioning, as noted, are carried out by the distributed instantaneous combination of simple functions which are localized in spatially distinct areas of the brain.

Discussion

A prognosis

Depression thus does not affect a specified area of the brain, but affects all areas. Depression is an abnormality of the brain that targets the complex functioning of the brain. A cursory look at the hubs that MDD affects, leads to the conclusion that the whole brain is involved. The attendant effect of MDD is classically witnessed in that

- There is more cortisol in the brain and this lasts for long period, which eventually leads to the hindering of the production of more neurons,

particularly in the hippocampus. This will eventually lead to the shrinking in size of the hippocampus.

- The prolonged exposure to cortisol in the brain that is triggered by MDD leads to an increase in the size of the amygdala (that part of the brain that is localized for emotional responses).
- There is also seen brain inflammation, which is also an effect of MDD.

This inflammation of the brain, witnesses to a reduced amount of oxygen in the brain, a phenomena known as Hypoxia.

All these abnormalities in the brain, eventually shows itself in the attitudinal characteristics of a depressed person. In depression, the brain system is still in operation, it is still functional, with parts communicating with other parts, yet in an abnormal manner. The non-locality of the brain attests to the fact that the brain is entangled to a larger system that is considered as its thermal bath. This system is the environment. It is in such entanglement, that the brain is able to function, not as a closed or isolated system, but as an open one. Any means in which this abnormality can be treated must take into consideration this fact of non-locality and entanglement of the brain to the environment. This abnormality of the brain that is seen in depression is not caused by the enlargement or reduction of parts of the brain (all these are attendant effects). We might allude that its causes include: Genetic, abuse (physical, sexual or emotional), death or a loss, the use of certain substances, etc. Yet it is evident that since the brain is an open system, entangled to the environment, the environment is as important as the brain itself in what pertains to MDD. Therefore we cannot consider this abnormality in isolation; it has to be considered as it really is which is the fact of the brain's constant interaction with the environment.

Conclusion

MDD is an issue that is still being studied. We can attest that better understanding has been attained to now than we had it 10 to 15 years ago. Therefore we believe that more in-depth understanding is in the offing. While there are anti-depressant drugs, it remains certain that these drugs do not cure depression as their effect is only temporary. Antidepressant medications increase the functioning of neurotransmitters such as serotonin, norepinephrine and dopamine, thereby lessening the effect of depression. How does the environment contribute to MDD, since the brain is entangled to it? More research in this aspect is required. However for now, that which is nouvelle is to note that MDD cannot be considered in the brain as isolated, but should be considered in the brain as an open system that is entangled to its thermal bath the environment.

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Conflicts of Interest

The authors declare no conflicts of interest, financial, or otherwise.

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