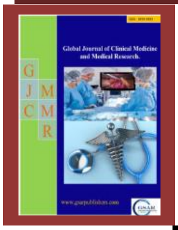

Global Journal of Clinical Medicine and Medical Research [GJCMMR]
ISSN: 2583-987X (Online)
Abbreviated key title: Glob.J.Clinic.Medici.Medica.Res.
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journal-gjcmmr-home/

A Review on Science of Attention and Developmental Studies in Neuro Science

BY

Juturi Ravi Kumar Reddy[*1], Kasarala Suresh[2], S. Shahensha[3], Venu Simham[3], N.Sai Bhavana[4]

[1]Professor, Dept. of Pharmaceutics, Mother Theresa Institute of Pharmaceutical Education & Research, Kurnool, India.
[2] Professor, Dept. of Pharmacognosy, Mother Theresa Institute of Pharmaceutical Education & Research, Kurnool, India.
[3]Professor, Dept. of Pharma. Chemistry, Mother Theresa Institute of Pharmaceutical Education & Research, Kurnool, India.
[3]Associate Professor, Dept. of Pharma. Chemistry, Mother Theresa Institute of Pharmaceutical Education & Research, Kurnool, India.
[2]Assistant Professor, Dept. of Pharmacology, Mother Theresa Institute of Pharmaceutical Education & Research, Kurnool, India.

Article History

Received: 01/12/2023
Accepted: 30/12/2023
Published: 02/01/2024

Vol – 2 Issue – 1

PP: -01-08

Abstract

Objectives: *This article comprises the definition of attention and provides some measures for it, then discuss its development, particularly in infancy and early childhood as incredible changes in behaviour which we are all very familiar with, are mirrored by changing neural networks underlying control systems. The article also covers training attentional control, training self-regulation and control in children and adults, and finally the application of this work to mental health.*

Methods: *The article reviewed the research work done by neuroscientists over the past two decades including Mary Rothbart and Michael I. Posner the brain and behavioural mechanisms that underlie attentional networks and the developing control system of the human infant and child.*

Findings: *Studies found that all of the white matter tracks surrounding the anterior cingulate were increased in a statistic called fractional anisotropy which is the degree to which water molecules diffuse in a single direction which may traces arguably the efficiency of the white matter pathway.*

Novelty: *Because of the attention network test, there has been a whole cottage industry of studies running people with different kinds of mental health or normal aging or neurological disorders or mental health disorders like Alzheimer's and Schizophrenia and so on in trying to find out which attention networks are affected.*

Keywords: *Science of Attention, Meditation, NeuroScience, Mental Health*

1. Introduction

The theme of using effort to control mental processes is an old one in the Hindu Chinese and Hebrew traditions. However, it's taken the 2500 years that have elapsed between the Bhagavad Gita and the present time to develop a scientific approach to the mechanisms of this control.

This article provides a definition of attention and shows remarkable changes that occur in early development between the control network so early life and those adults and then show that there is a toolkit of training methods based on different ideas either exercising the network to increase its imprint efficiency or changing brain state in a way which will increase a broad range of changes the temptations and then finally how it could be related to mental health.

*Corresponding Author: **Juturi Ravi Kumar Reddy**

2. Attention

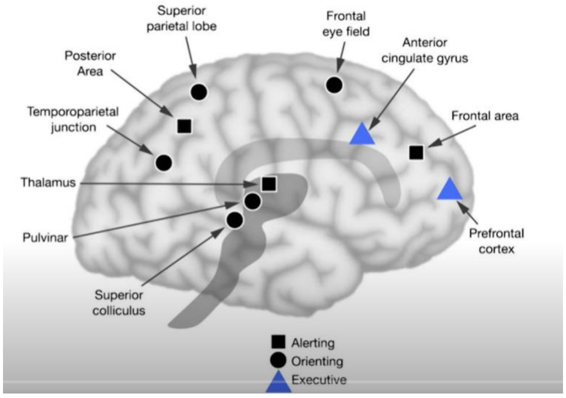

Fig 1: Altering, orienting, and executive regions in brain

In terms that have arisen since the development of neuroimaging, we were able to examine different neural networks. Looking primarily at two neural networks, the orienting network which is used to orient to external stimuli including areas in the frontal eye field, superior and inferior parietal lobe as well as some subcortical areas, and the executive network which in adults is primarily responsible for us being able to resolve conflicts and carry out particular goals [1,2].

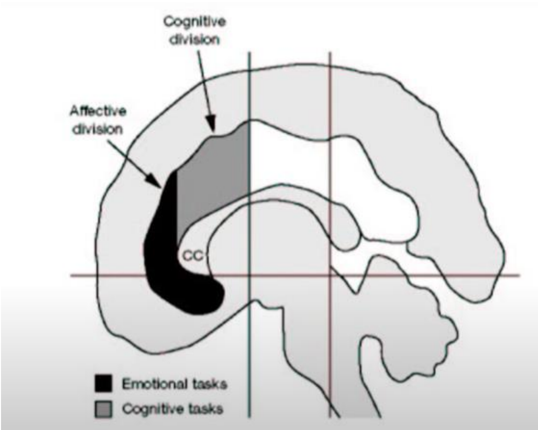

Fig 2: Cognitive and Affective division of brain

One area that is very important in the executive network is the anterior cingulate gyrus which provides strong control in its more dorsal part to cognitive processes and its more ventral part to emotional processes for example it has a close connection to the amygdale in the more ventral part of the anterior cingulate and it has close connections to frontal and parietal attentional areas in the more dorsal part [3]. The anterior cingulate of course is much more complicated than this division into just cognitive and emotional, some scientists pointed out, but nonetheless, a rough division between these two parts of the anterior cingulate and their connectivity is important.

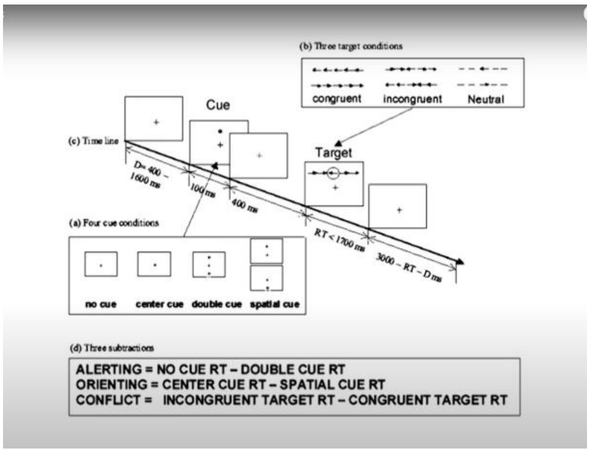

Fig 3: Target conditions of brain

Jin Fan and co. (2003) at Sackler Institute developed a method for measuring the activity in these different neural networks in a behaviour called the attention network test [3]. It's built around the flanker task originally developed by Ericsson where a person responds whether an arrow points to the left or right by pressing the left key if it points leftward and the right key if it points rightward and the central target can be surrounded by either congruent or incongruent flankers. The difference between congruent and incongruent is that simple reaction time provides an individual difference measure of the executive network, and surprisingly all through childhood into adulthood that very simple reaction time measure is related to the various measures that Dr. Rothbard and others have developed for effortful control that is for the self-reported or parental reported ability of the child or yourself to control their behavior in a variety of real-life situations.

Before the target occurs, there are cues given for when it will occur and where it will occur to measure the effectiveness or efficiency of the alerting and orienting networks. It is noticed that these measures seem to be uncorrelated. There are small correlations. It's not as if they were entirely separate brains but to a surprising degree, the three measures all derived from the same experiment are independent and furnished different individual difference measures of the efficiency in each of these networks.

Recently a report by Fjell (2012) [4] and about forty other authors, measured that 752 children from the age 4 to 21 who underwent magnetic resonance imaging carried out the task and were scanned and they found that from age 4 to 8 the best correlation of the difference between congruent and incongruent flankers is the size of the anterior cingulated gyrus. After the age of about 8 then noting is correlated with the conflict measure but overall reaction time continues to decline and that's related to effective connectivity. This fits with the findings from the attention network test where it's been shown that up until about 7 or 8 there is an improvement in the difference between congruent and incongruent flankers but after about age, that difference disappears, it is the same as in adults although reaction time continues to decline perhaps due to increased connectivity.

*Corresponding Author: **Juturi Ravi Kumar Reddy**

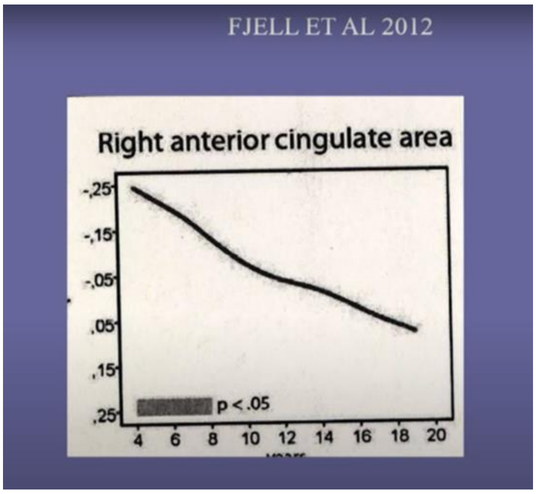

Fig 4: Cingulate area

Mary Rathbart (2011) [5] developed a series of tests beginning in infancy to measure so-called effortful control. These questions come from the adult temperament questionnaire. This is what one would fill out in order to get a measure of effortful control but of course, the questions are slightly different for infants and young children and the measure starts at about the age of four. Before that of course, control is usually provided by the parent, not by the child themselves. But after the age of four, parents can rate effortful control, and these various measures overall correlated with the difference between congruent and incongruent targets in the flanker's test which is a kind of measure of conflict. It is believed that the anterior cingulate is an important part of an intentional network which also concludes that anterior insula areas on the adjacent midline prefrontal cortex and the underlying striatum allow the control of behavior and part of this evidence is the correlation between the flanker task differences and this measure of effortful. Effortful control is not a trivial measure as it is reported by studies that showed that measuring effortful control from questions at about age four and showing that it could predict the success at age 35 in such things as health, the more effortful control the less sickness, or wealth, the more effortful control the higher your income, the more effortful control the less likely be a single parent, so social relations are better and less likely he/she will be involved in crime [6].

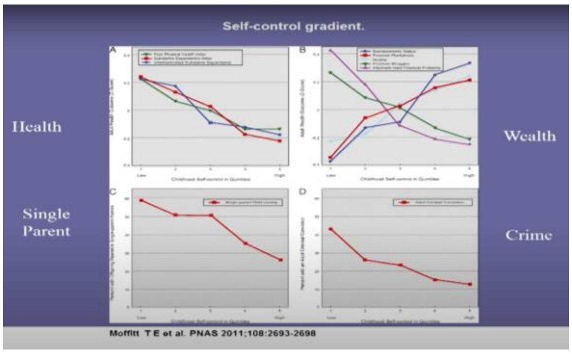

Fig 5: Self-control gradient

Now, it raises the question if we can train this function then perhaps, we can improve the human condition.

2.1. Development of Attention:

How does attention develop? We all know that there's a great difference between a child infant of a few months and one that's reached childhood. Every parent knows that the controls are changing. But the remarkable is that we now know that there is a shift in the underlying neural networks that allow this control to occur.

3. Developing Networks:

It's common in psychology and certainly, it was true that if you can't measure something you just decide it doesn't exist. Because we couldn't measure effortful control parents refuse to measure it, they provided control and of course, we can't ask an infant or even a 1 or 2-year-old to press a key when the arrow points to the left or right. The difficulty of measuring made us think that perhaps there was no real executive network until about age seven when we can begin to make the measures but Andrea Berger & Co. [6] measured the response of infants at seven months, building on the work of Karen Wynn. If we show an infant of seven months two puppets and then a hand reaches in and places another puppet and the screen goes down and there's only one puppet the child looks longer because that's an error, then if there are three puppets. But the question is what are the mechanisms of looking longer to find this out Andrea Berger used 256 electrodes as you can see in the lower part of this figure and measured the event-related potentials. Now in adults their so-called error negativity now is not your own error, this is an error induced by the perceptual situation but you can see there is negativity [7]. It is noticed that the difference between around 250 milliseconds one can see the error trails are drawing more negative than the correct trials.

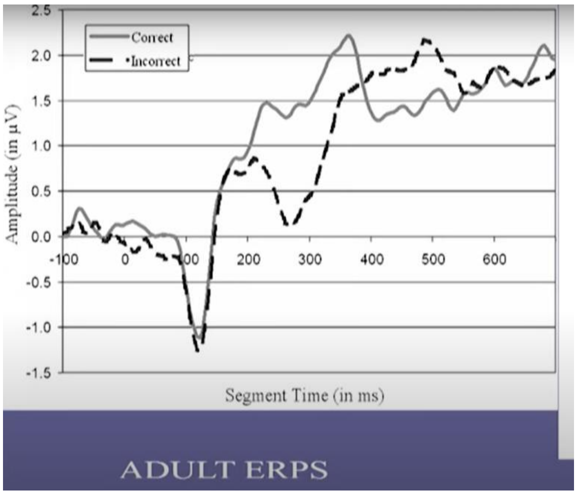

Fig 6: Adult ERPS

In children, about 50 milliseconds later notices the ERPs are a lot larger than they usually are in infants at this age but only about 50 milliseconds later and over exactly the same midline electrodes that we have been able to show come from the anterior cingulate gyrus, and it is found the exact same result in the infants suggesting that at least for the purposes of error detection one of the most important functions that had been found in the study of executive attention that infants as young as seven months can detect errors and use the same part of the

*Corresponding Author: **Juturi Ravi Kumar Reddy**

brain but Mary Rothbart and Michael I. Posner showed that they don't correct their error by slowing down after the trial in which they make the error until about 3 to 4 years of age. They looked at one screen and a very interesting stimulus came up and then when the stimulus shifted to the next screen over, they looked there but the order was fixed so infants at this learn to look in anticipation [8].

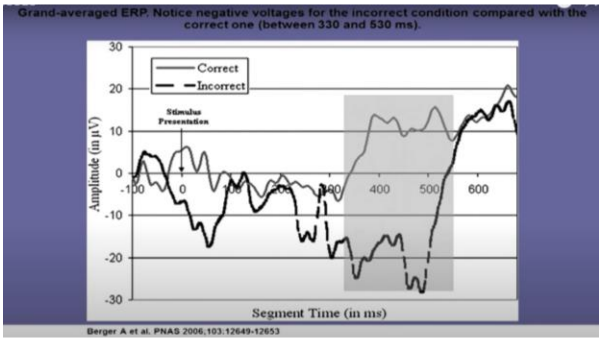

Fig 7: Grand averaged ERP

Correlations - IBQ at Time 1 and ECBQ at Time 2

	1.	2.	3.
Time 1 - Infant Behavior Questionnaire (IBQ)			
1. Positive Affect - Higher Order	1.00		
2. Negative Affect - Higher Order	-.05	1.00	
3. Orienting - Higher Order	.46**	-.33*	1.00
Time 2 - Early Childhood Behavior Questionnaire (ECBQ)			
4. Positive Affect - Higher Order	.47**	-.11	.25
5. Negative Affect - Higher Order	.17	.37*	-.08
6. Efffortful Control - Higher Order	.10	-.06	.26

Note: Correlations were conducted partialling child's age at Time 1 and Time 2.

Table no. 1: Correlations IBQ and ECBQ

So, what they believe is the executive attention network is there but it is not really carrying out control because of a lack of connectivity and they showed some other consequences. As a result of this study, they did start at seven months not saying the executive network might not be there even earlier than seven months but that's where they started at seven months. At seven months they performed a little cognitive task that infants at this age could perform. They assumed or thought that maybe the anticipatory looks would be related to later executive attention but it was found wrong.

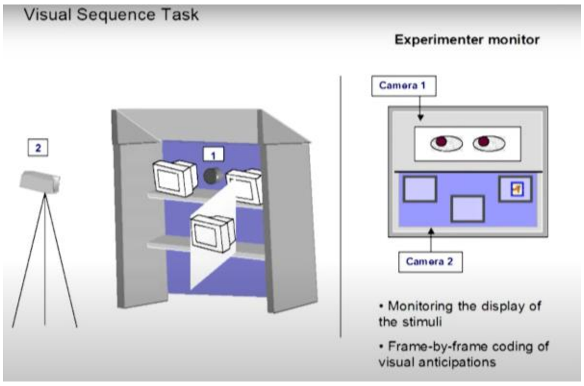

Fig 8: Visual sequence task

Since this was a longitudinal study eventually these children became old enough to press keys to instructions and found that; in fact, both the reactive and anticipatory look are related to the orienting network. Moreover, the control of motion also seems to depend primarily on the orienting network during early infancy. So, in infancy, there is one particular network, the orienting network, that produces most of the control functions, mostly self-regulation. [9] As they develop into childhood of course orienting is still can be some part of self-regulation but the executive network takes over the bulk of the self-regulation so hidden within the brain is a change in the basic networks of control that we think are responsible for at least partly responsible for the remarkable changes one finds in regulation between infancy and childhood. Moreover, they found that at seven months Dr. Rothbart's infant behavior questionnaire where parents were filling out aspects, particularly emotional aspects were related to each of the networks as measured at age four to seven [10]. For example, the alerting network depended upon the dimensions of perceptual sensitivity and duration of orienting. The orienting network on approach in suitability, the executive network on positive affect and vocal reactivity [11].

We think the heavy emphasis of these findings on temperamental emotional control shows that emotional control through the orienting network plays a dominant role in infancy and can be used to predict the later cognitive functions found in the attention network test.

The work they carried out in behavior has been confirmed and enlarged by remarkable development in MRI called resting state magnetic resonance imaging. [12] It's remarkable because everyone who studies development knows it's very hard to get a task that one age can do and is also appropriate for let's say adults or adolescents as well as infants or young children.

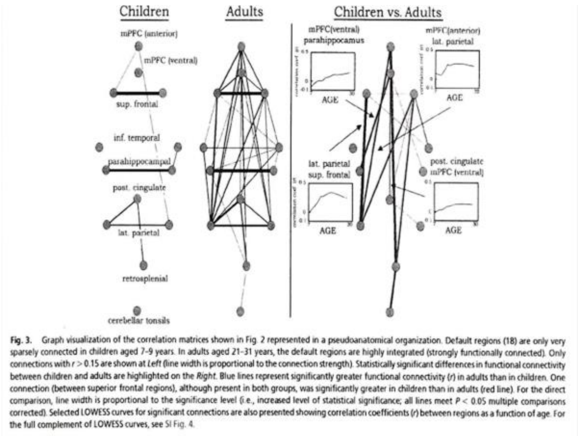

Fig 9: Graph visualisation of correlation of matrices

Task design is very difficult but this kind of MRI doesn't require a task and it reveals networks that are spontaneously active even during the rest two of those networks, the frontal-parietal network is essentially an identical orienting network. And the Cingular or opercular network involves two areas that are part of the executive attention network. [13] So, resting state MRI in this work reveals the same underlying networks and there is strong evidence from this work that these networks change in their connectivity over development, particularly early in development short-range connections are

*Corresponding Author: **Juturi Ravi Kumar Reddy**

more often present and the orienting network is much more connected than the executive network which remains almost in isolation until later childhood. This work has been brought down to infancy. In the picture, it is shown the actual development of the brain goes along with the changes in behaviour and the changes in brain networks that we're able to see through the attention network task.

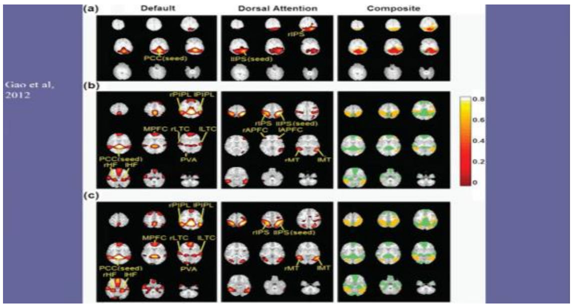

Fig 10: Images showing default, dorsal attention, and composite

4. Summary

In development, there seems to be both emotional and cognitive control and heavy involvement of the anterior cingulate in different areas. Emotional development seems to be a bit earlier than cognitive development but they develop in parallel and they influence each other reciprocally so one can predict later cognition in the attention network test from early emotion but the emotion itself is controlled via the orienting network and then there is a shift from the orienting network to the executive network. It is also found that there are very important gene-by-environment interactions. The environment is large but one of the most important of those environmental effects in data and those scientific reports is parenting. So, parenting quality interacts with many of the genetic paramorphism so both the genetic background, the temperament of the child, and the experience of the child are important. Well, if parents can influence the development of networks through training in the form of gene-by-environment interaction then it should also be possible for psychologists to influence through training. Two forms of training for influencing the development and efficiency of these networks. One of the forms is called attention training because it involves exercising the various attention networks and the other one is called attention state training because it involves changing the brain state which influences attention and other functions.

5. Improving Self Control:

5.1. Changing Executive Network by Training:

It involves developing a training mechanism in five days. On the first day and the seventh day, the children are assessed with the child version of the attention network test but in the interim they are trained to control, to use a joy structure to control movement, to work on working memory, and to resolve conflict. In five days of training, it is found by use of scalp electrodes it was possible to change the difference between congruent and incongruent trials in a child version of the flanker task in the direction of adults [15]. A very small effect is recorded. It is difficult to see in the adults because the child flanker test is so simple yet there is a difference between congruent and incongruent trials that occurs at about two hundred milliseconds after input. The trained children also show the same difference but not the untrained children.

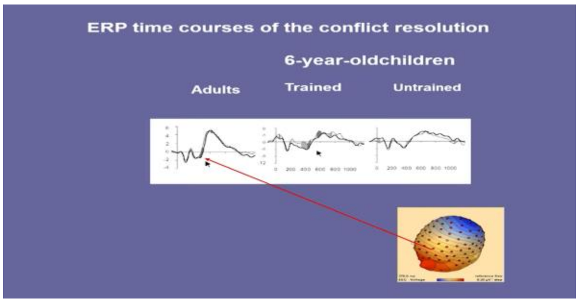

Fig 11: ERP time courses of the conflict resolution

So, this evidence is supporting that, it is possible to modify the network through training. And, the child also shows that both initially and two months later that produces an improvement in a delay of gratification, which is one of the marker tasks for self-regulation or self-control. [16]

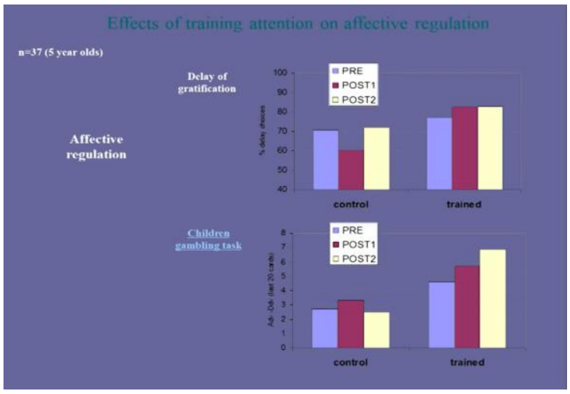

Fig 12: effects of training attention on affective regulation

Tang et al., (2013) developed a form of meditation that could show important changes within five days [17]. He was able to do scientific experiments which would allow this to be found, to be supported. He has done laboratory tests on undergraduate volunteers. Volunteers are assigned randomly either to the IBMT key or to relaxation training. When the subject is trying to relax each muscle group which is part of cognitive behavioural training. They carried out a series of experiments comparing IBMT within five days of training.

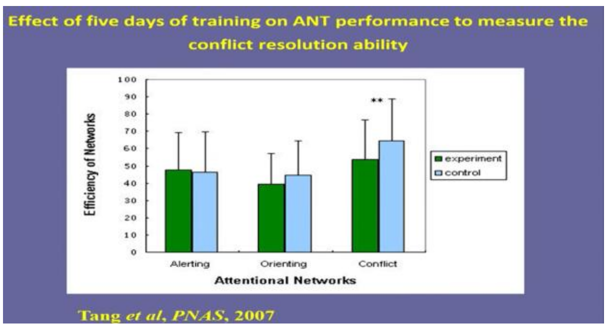

Fig 13: ANT Performance

Randomly assigned groups showed higher executive attention following IBMT than the following relaxation. They also showed greater positive mood and less negative mood.

*Corresponding Author: **Juturi Ravi Kumar Reddy**

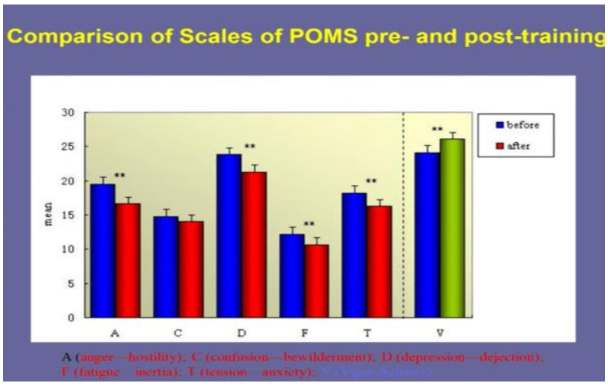

Fig 14: Comparison of scales of POMS

They also showed less secretion of the stress hormone cortisol following a cognitive challenge and even more impressive after a month of IBMT at baseline when subjects came in the laboratory, they showed a difference in cortisol suggesting that cortisol would be reduced by IBMT in regular life daily life activity [18]

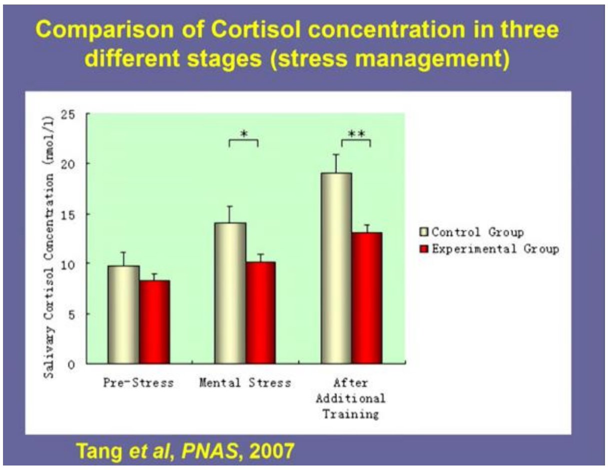

Fig 15: Comparison of cortisol concentration

These experiments were subsequently done using fMRI and showed one of the most important differences between the relaxation training and IBMT within the part of the anterior cingulate gyrus. [19] They used diffusion tensor analysis to look at the efficiency of white matter. They found that all of the white matter tracks surrounding the anterior cingulate were increased in a statistic called fractional anisotropy which is the degree to which water molecules diffuse in a single direction which may traces arguably the efficiency of the white matter pathway. [20] So white matter seems to change following two weeks to a month of IBMT, not in five days. Looking at axial and radial diffusivity arguably measures axon density and myelination.

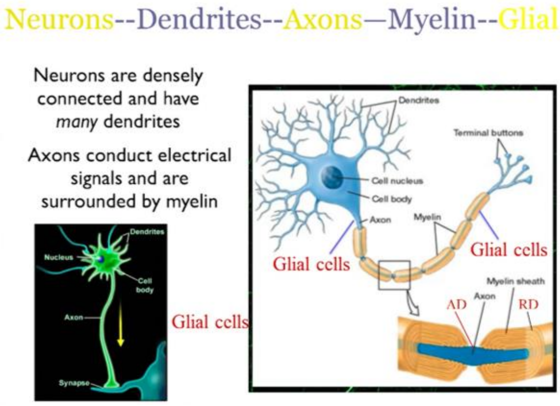

Fig 16: Neurons, dendrites, axons, Myelin, glial

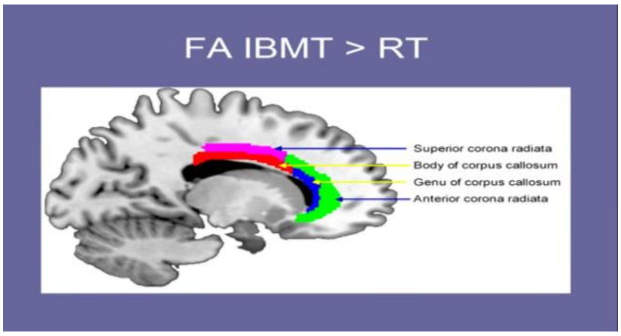

Fig 17: Different regions of brain

5.2 Changes in White Matter

After two weeks they find altered fractional anisotropy and more efficient white matter connections. [21] Those differences in two weeks are all due to axial diffusivity but by four weeks both axial diffusivity axon density and myelination are changed so white matter connectivity between critical aspects of the executive attention network is trained by a month of attention state training through IBMT. [22]

Meditation is a quiet mental exercise in which one keeps the mind centered not on any particular thing but in the moment and forces oneself not to allow it to wander, how could this change white matter? Studies of myelinating diseases like multiple sclerosis have shown there are rapid changes in which precursors can be converted to ordeal denticities which can produce changes in myelination.

Hypothesis: Meditation produces a strong frontal theta rhythm of 4 to 8 cycles per second. Theta rhythms can induce changes in produces which can and in some studies been shown to change the dormancy of orbital denticities. So, the hypothesis related to how meditation through this frontal theta might produce a physical change in the white matter within two to four weeks.

Cris Niell conducted experiments using optogenetics. One could take a virus that would allow the cells of the anterior cingulate, and the outflow of the anterior cingulate to be changed by an implanted light, and by turning that light on and off we can impose a theta rhythm. A variety of mice in Eugene Oregon are having their brains stimulated in the mouse box by theta rhythm. Likewise, after a month assay

*Corresponding Author: **Juturi Ravi Kumar Reddy**

will be performed on changes in the white matter that occur as a result of this meditation to test the hypothesis.

6. Conclusion & Application of work to mental health

Because of the attention network test, there has been a whole cottage industry of studies running people with different kinds of mental health or normal aging or neurological disorders or mental health disorders like Alzheimer's and Schizophrenia and so on in trying to find out which attention networks are affected.

In addition, it's quite remarkable and raises a very important principle that includes the anterior cingulate, and its connection to the striatum is also changed by meditation. If a particular addiction, smoking could be changed by IBMT after two weeks by BMP because the increase in activity in these areas shows changed flowing meditation. So, they recruited a number of smokers, and this is the work of Yi-Yuan at Texas Tech. Subjects were randomized and they were given either two weeks of IBMT or two weeks of relaxation training. They found first that there was a large reduction (60%) as measured by CO meters. There are objective measures in cigarette consumption following but not relaxation training. The green dots which are close between 0-5 would actually be called quitting smoking and this is of course immediately after two weeks of IBMT or relaxation training. Most of the subjects didn't realize that they quit smoking. They didn't actually intend to quit smoking. How important of a pathway is the intention and how important is the modification on the brain areas which showed or modify, increased in connectivity and activity following the IBMT training. So, there was complete discordance between the subjective opinion of whether they quit smoking, that is whether they actually knew they quit smoking.

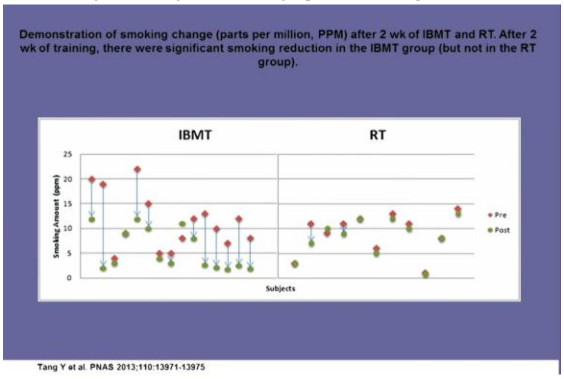

Fig 18: Demonstration of smoking change

Acknowledgment

The work was supported by Mother Theresa Institute of Pharmaceutical Education & Research, Kurnool, India. The authors are grateful to the Institute (MIPER) Director for providing all necessary support for publication of the work.

References

1. Fan J, Fossella J, Sommer T, Wu Y, Posner MI. Mapping the genetic variation of executive attention onto brain activity. Proc Natl Acad Sci U S A. 2003 Jun 10;100(12):7406-11. doi: 10.1073/pnas.0732088100. Epub 2003 May 28. PMID: 12773616; PMCID: PMC165888.
2. Rothbart MK, Sheese BE, Rueda MR, Posner MI. Developing Mechanisms of Self-Regulation in Early Life. Emot Rev. 2011 Apr;3(2):207-213. doi: 10.1177/1754073910387943. PMID: 21892360; PMCID: PMC3164871.
3. Rothbard, M. Ethics of Liberty, New York City, NY: New York University Press, 1998 [1982]
4. Berger A, Tzur G, Posner MI. Infant brains detect arithmetic errors. Proc Natl Acad Sci U S A. 2006 Aug 15;103(33):12649-53. doi: 10.1073/pnas.0605350103. Epub 2006 Aug 7. PMID: 16894149; PMCID: PMC1567933.
5. Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., Houts, R., Poulton, R., Roberts, B. W., Ross, S., Sears, M. R., Thomson, W. M., & Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. Proceedings of the National Academy of Sciences, 108(7), 2693–2698.
6. Landau, Rivka & Sadeh, Avi & Vassoly, Paz & Berger, Andrea & Atzaba-Poria, Naama & Auerbach, Judy. (2010). Sleep patterns of 7-week-old infants at familial risk for attention deficit hyperactivity disorder. Infant Mental Health Journal. 31. 630 - 646. 10.1002/imhj.20275.
7. Posner, Michael & Rothbart, Mary. (2007). Posner MI, Rothbart MK. Research on attention networks as a model for the integration of psychological science. Ann Rev Psychol 58: 1-23. Annual review of psychology. 58. 1-23. 10.1146/annurev.psych.58.110405.085516.
8. Bush G, Luu P, Posner MI. 2000. Cognitive and emotional influences in the anterior cingulate cortex. Trends Cogn. Sci. 4(6):215–22
9. Corbetta M, Shulman GL. 2002. Control of goal-directed and stimulus-driven attention in the brain. Nat. Neurosci. Rev. 3:201–15
10. Crottaz-Herbtte S, Menon V. 2006. Where and when the anterior cingulate cortex modulates attentional response: combined fMRI and ERP evidence. J. Cogn. Neurosci. 18:766–80
11. Boyden ES. A history of optogenetics: the development of tools for controlling brain circuits with light. F1000 Biol Rep. 2011;3:11. doi: 10.3410/B3-11. Epub 2011 May 3. PMID: 21876722; PMCID: PMC3155186.
12. Arenkiel BR, Peca J, Davison IG, Feliciano C, Deisseroth K, Augustine GJ, Ehlers MD, Feng G. In vivo light-induced activation of neural circuitry in transgenic mice expressing channelrhodopsin-2. Neuron. 2007;54:205–18. doi: 10.1016/j.neuron.2007.03.005
13. Zemelman BV, Nesnas N, Lee GA, Miesenbock G. Photochemical gating of heterologous ion channels: remote control over genetically designated

*Corresponding Author: **Juturi Ravi Kumar Reddy**

populations of neurons. Proc Natl Acad Sci U S A. 2003;100:1352–7. doi: 10.1073/pnas.242738899

14. Ma D, Zerangue N, Lin YF, Collins A, Yu M, Jan YN, Jan LY. Role of ER export signals in controlling surface potassium channel numbers. Science. 2001;291:316–9. doi: 10.1126/science.291.5502.316
15. Dehaene S, Artiges E, Naccache L, Martelli C, Viard A, et al. 2003. Conscious and subliminal conflicts in normal subjects and patients with schizophrenia: the role of the anterior cingulate. Proc. Natl. Acad. Sci. USA 100(23):13722–27.
16. Fan J, McCandliss BD, Fossella J, Flombaum JI, Posner MI. 2005. The activation of attentional networks. Neuroimage 26:471–79
17. Carey, S. (1991). Knowledge acquisition: Enrichment or conceptual change? In S. Carey, & R. Gelman (Eds), The epigenesis of mind. Hillsdale, NJ: Erlbaum.
18. Fan J, McCandliss BD, Sommer T, Raz M, Posner MI. 2002. Testing the efficiency and independence of attentional networks. J. Cogn. Neurosci. 3(14):340–47.
19. Fossella J, Posner MI. 2004. Genes and the development of neural networks underlying cognitive processes. The Cognitive Neurosciences III, ed. MS Gazzaniga, pp. 1255–66. Cambridge, MA: MIT Press. 3rd ed.
20. Gallagher HL, Frith CD. 2003. Functional imaging of "theory of mind." Trends Cogn. Sci. 7:77–83.
21. Harman C, Rothbart MK, Posner MI. 1997. Distress and attention interactions in early infancy. Motiv. Emot. 21:27–43
22. Baillargeon, R. (1993). The object concept revisited: New directions in the investigation of infants' physical knowledge. In C.E. Granrud (Ed.), Vixuzlperception wd cognition in infancy (pp. 265-316). Hillsdale, NJ: Erlbaum
23. Tang YY, Tang R, Posner MI. Brief meditation training induces smoking reduction. Proc Natl Acad Sci U S A. 2013 Aug 20;110(34):13971-5. doi: 10.1073/pnas.1311887110. Epub 2013 Aug 5. PMID: 23918376; PMCID: PMC3752264.
24. Westbrook C, Creswell JD, Tabibnia G, Julson E, Kober H, Tindle HA. Mindful attention reduces neural and self-reported cue-induced craving in smokers. Soc Cogn Affect Neurosci. 2013 Jan;8(1):73-84. doi: 10.1093/scan/nsr076. Epub 2011 Nov 22. PMID: 22114078; PMCID: PMC3541484.
25. Kral TRA, Imhoff-Smith T, Dean DC, Grupe D, Adluru N, Patsenko E, Mumford JA, Goldman R, Rosenkranz MA, Davidson RJ. Mindfulness-Based Stress Reduction-related changes in posterior cingulate resting brain connectivity. Soc Cogn Affect Neurosci. 2019 Jul 31;14(7):777-787. doi: 10.1093/scan/nsz050. PMID: 31269203; PMCID: PMC6778831.
26. Tang R, Friston KJ, Tang YY. Brief Mindfulness Meditation Induces Gray Matter Changes in a Brain Hub. Neural Plast. 2020 Nov 16;2020:8830005. doi: 10.1155/2020/8830005. PMID: 33299395; PMCID: PMC7704181.
27. Tang YY, Tang R, Posner MI. Mindfulness meditation improves emotion regulation and reduces drug abuse. Drug Alcohol Depend. 2016 Jun 1;163 Suppl 1:S13-8. doi: 10.1016/j.drugalcdep.2015.11.041. PMID: 27306725.

*Corresponding Author: **Juturi Ravi Kumar Reddy**