



## Engine of Consciousness in Brain - A Review

Aldrin Joshua A<sup>1</sup>, Yuvaraj Babu K<sup>\*1</sup>, Gifrina Jayaraj<sup>2</sup>

<sup>1</sup>Department of Anatomy, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai - 77, Tamil Nadu, India

<sup>2</sup>Department of Oral Pathology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai - 77, Tamil Nadu, India

### Article History:

Received on: 23 Jul 2020  
Revised on: 10 Aug 2020  
Accepted on: 25 Aug 2020

### Keywords:

Consciousness,  
Anaesthetic drugs,  
Psychedelic drugs,  
Alzheimer's disease

### ABSTRACT

Consciousness is the cognitive faculty which is evolved by natural selection and it has designed a sense of ourselves and our surroundings. The cerebral cortex is 'the seat of consciousness' in humans and mammals. The salient features of consciousness, they are human consciousness exists, involves short term memory, it occurs independently of sensory inputs, it displays steerable attentions, has capacity for attentive interpretations of complex or ambiguous data, consciousness disappears in a deep sleep and finally, it harbours the contents of several basic modalities within a single unified experience. The consciousness depends on the ascending projections from the dorsal brainstem that form the ascending reticular activating system. The engine of consciousness depends mainly on the brain's activity of sustaining rich dynamics in neural activity. The aim of the present review is to study the neuroscientific aspects of consciousness and thereby, the present scope of retrieving people out of consciousness and to consciousness disorders. This research was conceived as a scoping literature review. This review has accessed existing reviews and researches in the last decade mostly, through PMC database, MeSH, Google Scholar, Pubmed, Medline, CrossRef. Considered research was limited to manuscripts related to English, to consciousness, anaesthetic drugs relations, and Alzheimer's disease. This review excluded non-english researches, other neurological disorders not related to consciousness, physiological impairment of consciousness. Quality of articles used was assessed using Quality assessment tools and graded as strong, moderate and weak. The description of the included studies for the review is tabulated.



### \*Corresponding Author

Name: Yuvaraj Babu K  
Phone:  
Email: [yuvarajbabu@saveetha.com](mailto:yuvarajbabu@saveetha.com)

ISSN: 0975-7538

DOI: <https://doi.org/10.26452/ijrps.v11iSPL3.2998>

Production and Hosted by

IJRPS | <https://ijrps.com>

© 2020 | All rights reserved.

### INTRODUCTION

Consciousness is the cognitive division of the brain which is evolved by natural selection and it has designed a sense of ourselves and our surroundings. The cerebral cortex is 'the seat of consciousness' in humans and mammals. There are seven salient features of consciousness. They are human consciousness exists, involves short term memory, it occurs independently of sensory inputs, it displays steerable attentions, has capacity for attentive interpretations of complex or ambiguous data, consciousness disappears in deep sleep which reappears in dreaming state when at-least in muted

or disjointed form and finally it harbours the contents of several basic modalities within single unified experience (Churchland, 1996). The consciousness depends on the ascending projections from the dorsal brainstem that form the ascending reticular activating system (Snider, 2020). The engine of consciousness depends mainly on the brain's activity of sustaining rich dynamics in neural activity (Demertzi, 2019).

Previous research models for consciousness was studied by Kaufman (2004). The study divided consciousness as brain-based and organism-based models. The neuroscientists claim that consciousness can also be reduced to the electrical pattern in specific brain modules. It helps in recording the responses of neurons to stimuli. Another recent study by Redinbaugh *et al.* (2020), conducted on monkeys, found that electrically stimulating a certain part of forebrain's central lateral thalamus which wakes the monkeys from anaesthesia with minimum mechanisms that will be necessary for consciousness. The study concluded that these findings might someday be used to bring people out of coma, treat consciousness disorders and will ensure patients to stay anaesthetised during intensive procedures. If these researchers hope to find a network of neurons that satisfy the conditions for a neural correlate of consciousness and need convenient terms, it has a multitude of characteristics with specificity which will be a significant advantage.

Over the past years various research done by our team was on osteology (Choudhari and Thenmozhi, 2016), foramens in middle cranial fossa (Hafeez and Thenmozhi, 2016), styloid process (Kannan and Thenmozhi, 2016), foramen of Huschke (Keerthana and Thenmozhi, 2016), foramen meningo-orbitale (Pratha and Thenmozhi, 2016), giridy's tubercle (Nandhini, 2018), Occipital emissary foramen (Subashri and Thenmozhi, 2016), stature estimation (Krishna and Babu, 2016), radiation effects of mobile phone (Sriram *et al.*, 2015), use of i-pads in education (Thejeswar and Thenmozhi, 2015), on micro RNA (Johnson, 2020), microRNA especially on preeclampsia patients (Sekar, 2019), animal studies (Seppan *et al.*, 2018), and in few other fields like thyroid function (Menon and Thenmozhi, 2016), and amblyopia (Samuel and Thenmozhi, 2015). There was not much work done on neurosciences hence the aim of the present review is to study the neuroscientific aspects of consciousness and updates on the latest research in it thereby presenting the scope of retrieving people out of unconsciousness and other related consciousness disorders.

## MATERIALS AND METHODS

This research was conceived as a scoping literature review. This review has accessed existing reviews and researches in the last decade mostly, through PMC database, MeSH, Google Scholar, Pubmed, Medline, CrossRef and the search terms included were, 'consciousness', 'engine of consciousness', 'anaesthetic drugs', 'Alzheimer's disease', 'seat of consciousness'. Considered research was limited to manuscripts related to English, to consciousness, anaesthetic drugs relations, and Alzheimer's disease. This review excluded non-English researches, other neurological disorders not related to consciousness, physiological impairment of consciousness. The period of duration considered is 1909 to 2020. The total number of articles found on typing the topic is 6,840 and the number of articles actually relevant to the topic is 56 found by searching using keywords. The number of research articles that are used in writing the review is 35. Quality of articles used was assessed using Quality assessment tools and graded as strong, moderate and weak. The level of evidence of the reviewed articles was categorised according to the criteria of Centre for Evidence-Based Medicine, Oxford, UK and graded as strong, moderate and weak (Table 1).

### Consciousness

#### Definition of consciousness

Consciousness is the cognitive faculty that is evolved during natural selection which has designed a sense of ourselves and our surrounding (Churchland, 1996). Consciousness is the awareness by the sentience of external or internal existence. There are many definitions of consciousness in both scientific and psychological field. The real definition is still a mystery, but we can accept a few definitions (Lagercrantz and Changeux, 2010).

#### Region of the brain concerned with Consciousness

Consciousness mainly depends on ascending projections of the dorsal brainstem as ascending reticular activating system (Snider, 2020). Consciousness has a dependency on deep layer neurons which gives feedback to superficial layers. The neurons in the thalamus in deep cortical layers are more sensitive to the changes in consciousness level. So, for every change in consciousness level, it is due to neurons in the thalamus (Redinbaugh *et al.*, 2020). The consciousness has the ability to retrieve information of attributes that are present in the multimodal sensory environment of relevant elements of the past (John, 2002).

**Table 1: Description and Quality of included studies**

No.	Author	Year	Type of study	Key Points	Quality of study
1	Churchland (1996)	1996	Systematic review	Consciousness is cognitive faculty that is evolved during natural selection.	Moderate
2	Lagercrantz and Changeux (2010)	2010	Systematic review	Consciousness is awareness by sentience by external or internal existence.	Moderate
3	Snider (2020)	2020	Randomised controlled trial	Consciousness depends on ascending projections of dorsal brainstem.	Strong
4	Redinbaugh <i>et al.</i> (2020)	2020	Randomised controlled trial	Certain part of the brain wakes monkeys from anaesthesia which is the central lateral thalamus of the forebrain	Moderate
5	Johnson (2020)	2002	Systematic review	Consciousness has the ability to retrieve information of attributes that are present in the multimodal sensory environment of relevant elements of the past.	Moderate
6	Newman (1995)	1995	Case controlled study	High frequency by EEG activation causes alert state of intactness which is from reticular formation of the brainstem.	Moderate
7	Peterson (1908)	1908	Systematic review	Basal ganglia have the level of consciousness.	Moderate
8	Earl (2014)	2014	Expert opinion	The consciousness will have direct influence on our behaviour; it moulds the behaviour.	Weak
9	Tononi (2016)	2016	Systematic review	Consciousness has dissociation from other brain functions.	Moderate
10	Kaufman (2004)	2004	Systematic review	The consciousness is divided into brain based and organism based models. The neuroscientist claims that consciousness can be reduced to the electrical patterns in specific brain modules.	Moderate

*Continued on next page*

Table 1 continued

11	Freo and Ori (2005)	2005	Prospective study	In animals, consciousness is present in subcortical nuclei, reticular formation in midbrain and thalamus.	Strong
12	Walling (2000)	2000	Expert opinion	Salient features of consciousness are explained.	Weak
13	Kotchoubey (2018)	2018	Systematic review	Consciousness is useful in making voluntary decisions.	Moderate
14	Gil et al. (2001)	2001	Prospective study	Alzheimer's disease induces heterogeneous impairment.	Strong
15	Demertzi (2019)	2019	Systematic review	Engine of consciousness depends mainly on the brain's activity of sustaining rich dynamics in neural activity.	Strong
16	Pinto (2017)	2017	Systematic review	Split brain does not cause the individual as two independent conscious perceivers.	Strong
17	Turk (2002)	2002	Systematic review	Split brain patient is epileptic patient whose corpus callosum is severed.	Moderate
18	Perry (1999)	1999	Case controlled study	The Cholinergic system has modulatory neurotransmitter systems which is an essential component of conscious awareness. Without this system, consciousness would be impaired.	Moderate
19	Stanciu (2020)	2020	Systematic review	Current pharmacotherapy concentrated on drugs which improves cerebral acetylcholine level by facilitation of cholinergic neurotransmission by inhibiting cholinesterase.	Moderate
20	Al-Ali (2020)	2020	Prospective study	Physiological monitoring determines the depth of consciousness through EEG sensors.	Strong

Continued on next page

Table 1 continued

21	Schartner (2017)	2017	Systematic review	State of consciousness is higher when psychedelic drugs are used.	Moderate
22	Varley (2020)	2020	Randomised controlled trial	Anaesthetic drugs like GABA ergic agonist propofol, it is the way to control and reversibly modulate the brain's state of consciousness.	Strong
23	Cascella et al. (2020)	2020	Systematic review	The stage of Anaesthesia, a type of anaesthesia, has a direct influence on EEG expression.	moderate
24	Rudas (2020)	2020	Systematic review	The consciousness disorder is due to damage to the brain cortex.	strong
25	Chennu (2017)	2017	Prospective study	Link between the sensor level connectivity and alpha bond of conscious states that will be indexed by behaviour.	Strong
26	Wilson (2007)	2007	Case controlled study	Increased consciousness will have lower risk of Alzheimer's disease.	Moderate
27	Zeki (2003)	2003	Case controlled study	Attempts to decode the natural correlate the single unified entity for the unity of consciousness.	Moderate
28	Alagiakrishnan (2020)	2020	Systematic review	The vasovagal syncope in fainting is due to impaired consciousness.	Moderate
29	Monti (2010)	2010	Systematic review	The brain activation consists of some awareness in cognition of vegetative or minimally conscious state.	Moderate
30	Docu-Axelerad and Docu-Axelerad (2017)	2017	Randomised controlled study	Sometimes, overdose of painkillers, tranquilizers cause impaired consciousness. So, use of painkillers should be monitored.	Strong

## Origin of consciousness

In the 19th century, the neocortex was considered as the 'seat of consciousness' and it is proven wrong. Recent studies state when high frequency by EEG activation causes an alert state of intactness which is from reticular formation of brainstem (Newman, 1995). The seat of consciousness is present in basal ganglia; having asleep, wake centres contribute to level of consciousness when there is no cerebral development due to damage of cerebral substance making consciousness unimpaired (Peterson, 1908).

## Function of consciousness

Consciousness has a high biological value that benefits the organism, by changing its behaviour, in adaptation, to single representation parts of the brain. Consciousness will have a direct influence on our behaviour. It moulds the behaviour. If a person has a high consciousness level of himself, then the behaviour would be of a high standard (Earl, 2014). Consciousness has dissociation from other brain functions, including the language, memory, attention, language of the body and the self (Tononi, 2016).

## Previous Researches

### Division of consciousness

The consciousness is divided into brain-based and organism-based models. The neuroscientist claims that consciousness can be reduced to the electrical patterns in specific brain modules. It helps in recording the responses to stimuli of neurons. This type of division of consciousness would be helpful to treat certain brain problems like progressive brain damage, traumatic and non-traumatic brain damage (Kaufman, 2004).

### Can it make patients come out of a coma?

It has been proven that on electrically stimulating a certain part of the brain in monkeys, wakes them from anaesthesia. Similarly, stimulating a certain part of the central lateral thalamus of the forebrain in humans can retrieve patients from coma or consciousness disorders during intensive procedures. There is no research done on humans to verify the retrieval of coma of patients (Redinbaugh et al., 2020). These studies need to progress forward for the benefit of humans.

### Salient features of consciousness

The salient features of consciousness involve short term memory by consciousness. It gives steerable attention, disappears in a deep sleep, it harbours the contents of basic sensory modalities within a single unified experience; it occurs independently

of sensory inputs (Walling, 2000). Consciousness will be useful for voluntary decision making. So, the consciousness level should be high for making better voluntary decisions (Kotchoubey, 2018). Consciousness has many features to explore and to study.

## Engine of Consciousness

### Depends on

Consciousness depends on the interactions of thalamocortical and corticocortical tracts. So, the tracts from the thalamus to brain cortex and between fibres of brain cortex have a greater dependence on consciousness (Redinbaugh et al., 2020). Consciousness also depends on brain's ability to sustain rich dynamics on neural activity (Demertzi, 2019).

### Split-brain

There are many theories behind the split-brain but does not cause the individual as two independent conscious perceivers (Pinto, 2017). The split-brain patient is the epileptic patient (individual) whose corpus callosum is severed in order to minimise the spread of seizure activity. This is the most accepted theory behind the split-brain (Turk, 2002).

### Cholinergic systems

The Cholinergic system has modulatory neurotransmitter systems which are an essential component of consciousness, without which, consciousness would be impaired (Perry, 1999). Current pharmacotherapy concentrated on drugs which improve cerebral acetylcholine level by facilitation of cholinergic neurotransmissions by inhibiting cholinesterase which is recognised as cholinesterase inhibitors which have a modest influence on the improvement of Alzheimer's disease (Stanciu, 2020).

## Current Advances

### Depth of consciousness

Physiological monitoring of the depth of consciousness through EEG sensors gives the treatment data (Al-Ali, 2020). So, normal EEG is enough to measure the depth of consciousness. The depth of consciousness is needed to know the level of consciousness and the treatment procedure.

### Psychedelic drugs involvement

State of consciousness is higher when psychedelic drugs are used. So, the use of these drugs will definitely increase the consciousness level (Schartner, 2017). These drugs will be useful in treating consciousness disorders.

### Anaesthetic drugs

Anaesthetic drugs like GABAergic agonist propofol is the way to control and reversibly modulate the

brain's state of consciousness (Varley, 2020). EEG expression is based on the type of anaesthesia and the stage at which anaesthesia is given. The anaesthetic drugs have a greater impact on consciousness (Casella *et al.*, 2020).

### Disorders

Disorders of consciousness is a set of clinical conditions where consciousness is affected by brain damage to the cerebral cortex (Rudas, 2020). The brain activation consists of some awareness in the cognition of vegetative or minimally conscious state (Monti, 2010). Leaves of *Mucuna pruriens* contain dopamine used for the treatment of epilepsy which is a group of CNS disorders (Seppan *et al.*, 2018).

### Behavioural consciousness

The link between the sensor level connectivity and alpha bond of conscious states that will be indexed by behaviour. So, behavioural consciousness is necessary for us in every part of life (Chennu, 2017).

### The relation between consciousness and Alzheimer's disease

Increased consciousness will have a lower risk of Alzheimer's disease. So, the consciousness if increased by any treatment of drugs, especially psychedelic drugs, will lower the risk of Alzheimer's disease (Wilson, 2007). Pulmonary arterial hypertension has been implicated in the pathogenesis of Alzheimer's disease (Johnson, 2020) and due to high blood pressure, the blood supply to the brain can be blocked causing preeclampsia which causes fainting of the individual (Sekar, 2019).

### Decoding

Attempts have been made to decode the neural correlate of consciousness, acknowledging the fact that consciousness is not a single entity and that there are instead many consciousnesses that are distributed in time and space. These multiple consciousnesses are called the 'synthetic, transcend' unified consciousness which constitutes a hierarchy. Thus the process of decoding will be helpful to access the part of the brain for retrieval of any information (Zeki, 2003).

### Factors affecting consciousness

The vasovagal syncope in fainting is due to impaired consciousness (Alagiakrishnan, 2020). Sometimes, overdose of painkillers, tranquilizers cause impaired consciousness. So, the use of painkillers should be monitored (Docu-Axelerad and Docu-Axelerad, 2017). Limitations of most previous researches are they only review articles. Most studies have been targeted in animals; such studies

have not been studied on humans. These previous researches also did not find out the correct location of consciousness in the brain.

## RESULTS AND DISCUSSION

The engine of consciousness mainly depends on interactions between thalamocortical and cortico-cortical nerve tracts (Redinbaugh *et al.*, 2020) and depends on the brain's ability of dynamics in neural activity (Demertzi, 2019). The seat of consciousness is in the reticular formation (Newman, 1995); basal ganglia has a level of consciousness (Peterson, 1908). Alzheimer's disease has a lower risk due to increased consciousness (Wilson, 2007). It induces heterogeneous impairment, consciousness has a convergence of many neural networks, the neuronal alterations that are lacking or distributed by the sequential order of successive stimuli cannot be maintained by heteromodal association cortex. The supramodal associative cortex has neural, cognitive networks (Gil *et al.*, 2001). Anaesthetic drugs like GABAergic agonist propofol modulates the brain's state of consciousness. It is supported by cholinergic and GABAergics which affects sensory and associated cortical areas through altered arousal and cognition. In animals, consciousness is present in subcortical nuclei, reticular formation in midbrain and thalamus (Freo and Ori, 2005). The dexmedetomidine and propofol at equisedative doses have a greater impact on effects on visual stimulus induced GBR, has visual evoked responses and PMBR has effects on human consciousness (Saxena *et al.*, 2020). Cholinergic systems have modulatory neurotransmitter systems that are an essential component in conscious awareness (Perry, 1999) and are advanced by current pharmacotherapy, the level of cerebral acetylcholine improved by drugs that inhibit cholinesterase (Stanciu, 2020). A certain part of the brain wakes monkeys from anaesthesia which is the central lateral thalamus of the forebrain. It is used for coma retrieval during intensive procedures (Redinbaugh *et al.*, 2020). It is different from the midcingulate cortex, which has a critical role in the integrator of brain activity which vanishes in an altered state of consciousness (Rudas, 2020).

The limitations of the present review are that only recent studies have been included, mostly older studies have not been included. The study population of previous researches are different, like monkeys, rats, etc. The review should have larger, deeper research—more research needed in *in vivo* studies and more elaborative studies to be included.

Future scope of the review is future studies to be conducted on humans of consciousness which will

provide the practice of reviving from a coma during trauma.

## CONCLUSION

More research has to be extended in humans so that for knowing the exact location of seat consciousness, methods can be devised to arouse the consciousness in patients going to an unconsciousness state as a result of trauma, health issues, faulty medical procedures and treatments, thereby many lives can be saved.

## Funding Support

The authors declare no funding support for this study

## Conflict of Interest

The authors reported the conflict of interest while performing this study to be nil.

## REFERENCES

Al-Ali, A. 2020. Depth of consciousness monitor. *US Patent*, pages 31–31.

Alagiakrishnan, K. 2020. Vasovagal Syncope. *Hypotensive Syndromes in Geriatric Patients*, pages 35–44.

Cascella, M., Bimonte, S., Amruthraj, N. J. 2020. Awareness during emergence from anesthesia: Features and future research directions. *World Journal of Clinical Cases*, 8(2):245–254.

Chennu, S. 2017. Brain networks predict metabolism, diagnosis and prognosis at the bedside in disorders of consciousness. *Brain: a journal of neurology*, 140(8):2120–2132.

Choudhari, S., Thenmozhi, M. S. 2016. Occurrence and Importance of Posterior Condylar Foramen. *Research Journal of Pharmacy and Technology*, 9(8):1083–1083.

Churchland, P. M. 1996. *The Engine of Reason, the Seat of the Soul: A Philosophical Journey Into the Brain*. MIT Press. ISBN: 9780262032247.

Demertzi, A. 2019. Human consciousness is supported by dynamic complex patterns of brain signal coordination. *Science advances*, 5(2):7603–7603.

Docu-Axelerad, A., Docu-Axelerad, D. 2017. The Impaired Consciousness. *Dialogo*, (2):144–150.

Earl, B. 2014. The biological function of consciousness. *Frontiers in psychology*, 5:697–697.

Freo, U., Ori, C. 2005. Neuroimaging pharmacology of attention and memory. *Anaesthesia*, pages 217–225.

Gil, R., Arroyo-Anllo, E. M., Ingrand, P., Gil, M., Neau, J. P., Ornon, C., Bonnaud, V. 2001. Self-consciousness and Alzheimer's disease. *Acta Neurologica Scandinavica*, 104(5):296–300.

Hafeez, N., Thenmozhi 2016. Accessory foramen in the middle cranial fossa. *Research Journal of Pharmacy and Technology*, 9(11):1880–1880.

John, E. R. 2002. The neurophysics of consciousness. *Brain research reviews*, 39(1):1–28.

Johnson, J. 2020. Computational identification of MiRNA-7110 from pulmonary arterial hypertension (PAH) ESTs: a new microRNA that links diabetes and PAH. *Hypertension research: official journal of the Japanese Society of Hypertension*, 43(4):360–362.

Kannan, R., Thenmozhi, M. S. 2016. Morphometric Study of Styloid Process and its Clinical Importance on Eagle's Syndrome. *Research Journal of Pharmacy and Technology*, 9(8):1137–1137.

Kaufman, B. 2004. Pain perception as a model for the study of consciousness. *ReVision*, 27(1):38–49.

Keerthana, B., Thenmozhi, M. S. 2016. Occurrence of foramen of huschke and its clinical significance. *Research Journal of Pharmacy and Technology*, 9(11):1835–1835.

Kotchoubey, B. 2018. Human Consciousness: Where Is It From and What Is It for. *Frontiers in Psychology*, 9:567–567.

Krishna, R. N., Babu, K. Y. 2016. Estimation of stature from physiognomic facial length and morphological facial length. *Research Journal of Pharmacy and Technology*, 9(11):2071–2071.

Lagercrantz, H., Changeux, J.-P. 2010. Basic Consciousness of the Newborn. *Seminars in Perinatology*, 34(3):201–206.

Menon, A., Thenmozhi, M. S. 2016. Correlation between thyroid function and obesity. *Research Journal of Pharmacy and Technology*, 9(10):1568–1568.

Monti, M. M. 2010. Willful modulation of brain activity in disorders of consciousness. *The New England journal of medicine*, 362(7):579–589.

Nandhini, J. S. T. 2018. Size, Shape, Prominence and Localization of Gerdy's Tubercle in Dry Human Tibial Bones. *Research Journal of Pharmacy and Technology*, 11(8):3604–3604.

Newman, J. 1995. Thalamic Contributions to Attention and Consciousness. *Consciousness and cognition*, 4(2):172–193.

Perry, E. 1999. Acetylcholine in mind: a neurotransmitter correlate of consciousness? *Trends in neurosciences*, 22(6):273–280.



- Peterson, F. 1908. The seat of consciousness. *The Journal of Abnormal Psychology*, 3(5):307-310.
- Pinto, Y. 2017. Split brain: divided perception but undivided consciousness. *Brain: a journal of neurology*, 140(5):1231-1237.
- Pratha, A. A., Thenmozhi, M. S. 2016. A Study of Occurrence and Morphometric Analysis on Meningo Orbital Foramen. *Research Journal of Pharmacy and Technology*, 9(7):880-880.
- Redinbaugh, M. J., Phillips, J. M., Kambi, N. A., Mohanta, S., Andryk, S., Dooley, G. L., Afrasiabi, M., Raz, A., Saalman, Y. B. 2020. Thalamus Modulates Consciousness via Layer-Specific Control of Cortex. *Neuron*, 106(1):66-75.e12.
- Rudas, J. F. 2020. Time-Delay Latency of Resting-State Blood Oxygen Level-Dependent Signal Related to the Level of Consciousness in Patients with Severe Consciousness Impairment. *Brain Connectivity*, 10(2):83-94.
- Samuel, A. R., Thenmozhi, M. S. 2015. Study of impaired vision due to Amblyopia. *Research Journal of Pharmacy and Technology*, 8(7):912-912.
- Saxena, N., Muthukumaraswamy, S. D., Richmond, L. 2020. A comparison of GABA-ergic (propofol) and non-GABA-ergic (dexmedetomidine) sedation on visual and motor cortical oscillations, using magnetoencephalography. *Neuroimage*, 245(118659).
- Schartner, M. M. 2017. *On the relation between complex brain activity and consciousness*. Doctoral, University of Sussex. ISNI: 0000 0004 6061 7969.
- Sekar, D. 2019. Methylation-dependent circulating microRNA 510 in preeclampsia patients. *Hypertension Research*, 42(10):1647-1648.
- Seppan, P., Muhammed, I., Mohanraj, K. G., Lakshmanan, G., Premavathy, D., Muthu, S. J., Shimray, K. W., Sathyanathan, S. B. 2018. Therapeutic potential of *Mucuna pruriens* (Linn.) on ageing induced damage in dorsal nerve of the penis and its implication on erectile function: an experimental study using albino rats. *The Aging Male*, pages 1-14.
- Snider, S. B. 2020. Cortical lesions causing loss of consciousness are anticorrelated with the dorsal brainstem. *Human Brain Mapping*, 41(6):1520-1531.
- Sriram, N., Thenmozhi, Yuvaraj, S. 2015. Effects of Mobile Phone Radiation on Brain: A questionnaire based study. *Research Journal of Pharmacy and Technology*, 8(7):867-867.
- Stanciu, G. D. 2020. Alzheimer's disease pharmacotherapy in relation to cholinergic system involvement. *Biomolecules*, 10(1):40-40.
- Subashri, A., Thenmozhi, M. S. 2016. Occipital Emissary Foramina in Human Adult Skull and Their Clinical Implications. *Research Journal of Pharmacy and Technology*, 9(6):716-716.
- Thejeswar, E. P., Thenmozhi, M. S. 2015. Educational Research-iPad System vs Textbook System. *Research Journal of Pharmacy and Technology*, 8(8):1158-1158.
- Tononi, G. 2016. The neurology of consciousness: an overview. *The Neurology of Consciousness*, pages 407-461.
- Turk, D. J. 2002. Mike or me? Self-recognition in a split-brain patient. *Nature neuroscience. nature.com*, 5(9):841-842.
- Varley, T. F. 2020. Consciousness & Brain Functional Complexity in Propofol Anaesthesia. *Scientific reports*, 10(1):1-13.
- Walling, P. T. 2000. Consciousness: A Brief Review of the Riddle. *Baylor University Medical Center Proceedings*, 13(4):376-378.
- Wilson, R. S. 2007. Loneliness and risk of Alzheimer disease. *Archives of general psychiatry*, 64(2):234-240.
- Zeki, S. 2003. The disunity of consciousness. *Trends in Cognitive Sciences*, 7(5):214-218.