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Original Review Article

Future and Scope of Forensic Neurosciences in Criminal Investigation System towards Justice.

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Abstract

All crimes do not have their basis only in neuropsychology, but they may have organic neurological diseases like brain tumours, psychoses, sociopathy, sleep walking, etc. Our brain is a time clocked bomb, because, it is difficult to predict when a crime will be strategized and executed. Neuropsychology proposes that various theories of mind and childhood experiences bear an impact on adult behaviour being civic or criminal. The application of Neurology in crime investigation facilitates the understanding of criminal behaviour. The derived concepts and evidence from neuroscience helps to flesh out specific components of a larger psychological-level etiological model. Forensic neuroscience may play a pivotal role to develop and refine etiological models of crime-related behaviours.

1. Introduction

The human brain is the main commander of actions performed by the body. To understand any crime, the crime suspect's brain must be studied in and out. All crimes do not have their basis only in neuropsychology, but they may have organic neurological diseases like brain tumours, psychoses, sociopathy, sleep walking, etc. That's where the role of forensic neuroscience emerges. Forensic Neuroscience is a growing field in which the regulation of certain behaviours, including criminal, antisocial, sociopathic, and psychopathic, are viewed in light of neural mechanisms that determine such behaviours.[1]

2. Background/Need

Our brain is a time clocked bomb, because, it is difficult to predict when a crime will be strategized and executed. Both physiological and/or pathological states of the brain can lead to crime formation, which, with the help of neuroscience, we must aim to decipher.

Neuropsychology proposes that various theories of mind and childhood experiences bear an impact on adult behaviour being civic or criminal. Now, there is a huge wealth of data to suggest aetiologies of the crime lying in neurological aetiologies, pertaining to specific brain areas or structural idiosyncrasies. Hence, a comprehensive approach involving multiple disciplines of science like psychology, psychiatry as well as neurology is a better way to approach a crime. Causation of crime has been theorised of being due to a person's innate neural structure and its functioning. It is classified into two theories: crime aetiology and crime composition.

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The etiological causation includes the causative processes leading to the incidence of crime. This can be a bitter experience or a personality trait possessed by the individual including failure to regulate emotions, acquisition of cognitive biases, empathy failures, the guilt associated with it, aggressive inclinations, deviant sexual desires, emotional isolation, unrestrained impulsive behaviours, substance dependence, abuse, etc. For instance, some researchers have explored the connection between alterations in brain structure and deviant sexual preferences in males diagnosed with paedophilia.[1]

On the other hand, *Compositional* explanations for crime involves the persons' own constituents, experiences, behaviour and mindset, i.e., what actually makes the person. For instance, a fruit salad is composed of apples, oranges, peaches, and so on. The fruits do not cause the salad, but in fact, they are themselves, a part of the fruit salad. These theories need to be supported by the identification and outline of psychological and social mechanisms that underlie problems related to crime. Neurological evidence would build the case in order to support this. Such conclusions invite the knowledge of the neurology to work along with forensics in order to wholly understand a criminal event or behaviour.[2] A few other aspects in this discipline include:

- Lie Detection.
- Memory analysis
- Detection of malingers
- Attribution of crime to specific brain areas
- Bedside neurological examination

Lying is second nature to man, and the best liar is the one who has complete conviction in his lie, because he doesn't think it's a lie. This counter measure I.e., a strong conviction, easily can manipulate the tests for lie detection available today. Therefore, they are difficult to accept in the court of Law. A more detailed research and study into the science of lying, is the need of the hour.

Memory tests have multiple implications. For the onlookers, they are important in order to recreate crime scenes during interrogation, as a part of the crime investigation. For the criminals, it is memory which is relied upon when asked regarding trivial details to corroborate their testimony with situational evidence. This is a raw area in forensics & can be explored in great detail, especially when clubbed with investigative technologies like functional MRI so as to have increased admissibility value in legal matters.

One more requirement for this science to flourish is to detect malingering and at the same time, assess the suspect, unbiasedly, so as to not criminalize genuine mental insanity. Last, but not at all the least, is the role of bedside neurological examination in confirmation of suspicion or other supplementary evidence. For example, a thorough neurologist can pick up chronic arsenic toxicity by the presence of tiny horizontal whitish lines in the nails of the person being poisoned or exposed to arsenic in any form.[3] Another example is the case of a 23-year-old engineer, who presented with acute onset of mildly dilated pupils, sluggishly reacting to light with extrapyramidal features. Thoroughly investigated neurologically with no positive test results, this clinical picture was foxing for all the clinicians, until the relatives revealed how he recently had installed a gas geyser in his bathroom, with limited ventilation. This led to chronic carbon monoxide emission, which he inhaled and poisoned himself. This was picked up clinically and then the diagnosis was confirmed in the neuroimaging. He removed the causative factor and was treated with hyperbaric oxygen and supportive therapy, which helped him recover.[4]

3. Indian And International Scenario

The future and scope of forensic neuroscience in our country depends on how we train our experts. National Forensic Sciences University, the erstwhile Gujarat Forensic Sciences University established in 2009 has accorded the status of Institution of National Importance and then also as a central university in October 2020. It has 69 subbranches and courses imparting knowledge about sub branches of forensics have also flourished therein. Ministry of Home Affairs, Government of India has already annexed the Delhi Centre, the erstwhile National Institute of Criminology and Forensic Sciences with this university.[5]

We have found a huge chunk of information since extensive research is ongoing on criminal neuroscience especially at Centres like NIH, USA; Institute of Criminology under Victoria University of Wellington; Keele University, Staffordshire, in the United Kingdom; Departments of Criminology, Psychiatry and Psychology at the University of Pennsylvania. These centres are conducting aggressive research in forensic neurosciences and the teaching programs for the same. A body of ongoing

research work called the NIH BRAIN (NIH Brain Research through Advancing Innovative Neurotechnologies) [6] is predominantly working on generating novel technology to change our understanding of the brain and its many connections internally, which manifest as our actions. Neuroethics is an important part of the research effort.

An investigative field which when clubbed with Neurology has multiple modalities of approach to a crime. Some forensic neuroscience investigations have been debated vastly in India.

3.1 Lie detection

In technical terms, known as Deception Detection Tests (DDT), lie detection methods have come a long way. It began as a primitive method, long back, when fists full of rice were stuffed into the mouths of all the suspects and they were vehemently accused of committing the crime or threatened of grave consequences. Intense stress leads to activation of the sympathetic fight or flight response, which leads to dryness of mouth. The spitting time of rice was clocked for each of the suspects and the one taking maximum time would be thought of as the culprit. After this extremely crude method, today technology has brought us to much refinement in reaching the conventional polygraph test which records respiration, heart rate, blood pressure, and galvanic skin response or moisture in the fingertips. This procedure via the polygraph test can be used on the accused in India, only after the accused has consented for it. The silence of the accused shouldn't be mistaken for consent. Its admissibility in the court of law is still questionable. Since according to the Article 21(3) of constitution of India, a person cannot be a witness against his/her own crime.[7]

3.2 Functional MRI

fMRI is a developing science now more commonly available at radiology centres in major metro cities in India. Some studies trying to understand the rich connections between the amygdala and the prefrontal cortex, have analysed a wealth of data. The entire prefrontal cortex is a region, whose deficits have usually been associated with crime, aggression and disinhibited behaviour.[8] The right temporoparietal junction (rTPJ) plays special roles in processing criminal offenders' state of mind and that the right dorsal lateral prefrontal cortex (rDLPFC) plays roles in resolving moral conflicts involved in legal judgments.[9] The ventromedial PFC (vmPFC) has been implicated as a critical neural substrate mediating the influence, rather overpowering of emotion on moral reasoning. There have been instances where people with damaged prefrontal cortex have harmed kin to save strangers.[10] The major problem with fMRI is that the areas of the brain that light up during visualizing and lying about performing the crime, also light up while imagining the crime. It detects mental familiarity of the images shown with approximately 70% accuracy[11]. While interpreting functional MRI – The region of interest (ROI) may show a highlight when we do a task, and similar highlight may be seen in multiple tasks, because each region might cater to multiple functions – deception, desire, etc. Some artefactual differences might also appear. Another aspect that revolves around conducting fMRI's on populations is that there are no constitutional or legal protections for the crime suspect to safeguard themselves from the police or the investigating agency so as to prevent them from performing the scans on patients. Functional MRI violates multiple themes including privacy, expression of self-thought, and fundamental cognitive liberty.

3.3 PET Scan

These show brain glucose activity, which might be increased or decreased in specific disease states, which may have behavioural repercussions. A case in the court of state of New York, USA, of a man murdering his wife and throwing her out of the window of their 12 storey building in a fit of rage, pleaded mercy against his sentence of life imprisonment. The defendants used PET scans in the courtroom proceeding where a cyst was found on the PET results of the accused. He had an arachnoid cyst in the left sylvian fissure compressing the left frontal, temporal and insular regions. These regions have been proven to lead to disinhibited behaviour. But the admissibility of PET scan and its consequence on the legal proceedings is still questionable. The man was given a reduced charge of manslaughter.[12]

3.4 Electroencephalogram

Electroencephalogram (EEG) is a regularly used procedure in Neurology for seizure detection, localization and lateralization in epilepsy patients. The use of electricity in the body to interpret bodily functions is an old concept, which is now being used to understand the human brain psyche. Research does show how criminal populations have more abnormalities in their EEG's as compared to the

normal general public. Most common pathologies include presence of excessive theta activity, focal temporal lobe pathology, instability of patterns, often epileptic in nature. The age of the person undergoing EEG, needs to be considered while analysing various EEG's across populations since the maturation of EEG with age is a topic of vast information and must be studied by a dedicated neurologist prior to analysing the EEG's done with a forensic purpose. Aggressive behaviour, whether paroxysmal or as a baseline perennial behaviour- idiosyncrasy is shown to be a common denominator in the fundamental structure of these populations.[13]

When pitted against other methods of crime investigation, nobody disputes that EEG can reflect brain states, including the presence of memory traces, and measuring brain activity is inherently more direct than measuring secondary effects such as skin conductance. The extremely short time period to response, i.e., the latency period of the EEG response is an advantage since it provides less time for response modification or suppression by the subject. This suggests how it is harder to cheat on an EEG than a conventional polygraph test, even when both are no different in principle from handwriting, fibre or DNA evidence. There is no reason to deny the stamp of authority to EEG as a standard of evidence, once a rich wealth of data is available on studies done on criminal populations as well as patients showing uninhibited anger, aggression, personality traits of violence and lack of empathy. Data mining in forensic neuroscience is another aspect of crime analysis.[14]

3.5 Mind Reading technology

Brain computer interfaces (BCI) and *neural decoding* is a new technology. The usual mental states include imagination, emotions, intentions, perception, decision making, and so on. Using the understanding of these in neurosciences, technology has now been able to highlight some correlations between mental states and cerebral activity. This can indirectly or directly, on some occasions be used to analyse criminal behaviour, of course in some context of neurobiology. Some branches like anthropometry, dactyloscopy, photography, DNA fingerprinting, biometrics also aid in neurological recognition. The basic principle behind these technologies is recording of the electrical brain waves using surface EEG, Magnetoencephalography or Scalp EEG or even more comprehensive techniques like Electrocorticography (ECoG).[13]

In 2013, an experiment conducted using neurointerface technology in the form of a game for the participants. The 'P300' wave showed its role in extracting confidential information stored in one's brain like PIN numbers, or personal beliefs which one might not wish to communicate externally. The consequences and implications of such investigations are like a double-edged sword and must be used within the boundaries of the legal framework.[15] The main problems in accepting these investigations as evidence in the legal system include a small number of subjects studied in the control as well as study groups, which affects statistically acceptable comparisons between the two groups; the inadequacy of randomization in those trials; sample selection criteria discrepancies; inadequate drug abuse history; incomplete disease and family history disclosed by crime suspects, all of which resulting in incorrect interpretations or spurious examination findings. There also might be an associated existence of psychiatric conditions, which confounds the diagnostic validity of the brain imaging results, etc.

4. Discussion

Neuroscience helps us in the procurement of information about the psychological aspects of crime-related behaviours. The derived concepts and evidence from neuroscience can help us flesh out specific components of a larger psychological-level etiological model, so that we can appreciate those particular components in a newer light [16] Such constitutive explanations can do more than simply redescribe key psychological phenomena; they can suggest new targets for intervention. For example, by identifying the physiological events that underpin sudden bursts of rage – for instance, dramatic surges in adrenaline, we may be able to develop interventions that operate directly upon such events (for example, exercise techniques). Such ideas may not be present themselves so readily if we restrict ourselves entirely to neuropsychological-level descriptions.

Perhaps the most important role that neuroscience explanations can play is in helping to develop and refine etiological models of crime-related behaviours. This includes integrative pluralism since it takes different levels of description into account while preserving the potential explanatory uniqueness of each level. When it comes to forensic psychology, our psychological models of behaviour can benefit from the knowledge of the

corresponding neural events, and also the broader biological changes that accompany these events.

The trick is ultimately to let neuroscience illuminate the culprit at hand and not end up muddying the water. fMRI and event-related potentials generate direct markers of the brain activity occurring during a particular task. There is no need of the participant to interpret that activity. They therefore provide a source of evidence that is complementary to that obtainable from first person methods. For example, one question that has interested forensic researchers for decades is whether people who commit harmful acts may do so because they lack empathy. It is difficult to study empathy using methods that rely on self-report as it involves subject-bias. Individuals may under- or over-report the degree of empathy they feel. However, by examining fMRI signatures that have previously been found to be associated with empathic responses in general – for example, activation of the amygdala – we may be able to tackle this question in a new way.

When we run thousands of statistical tests on a big data set, there is an increased likelihood of finding significant, but essentially spurious, results. Even if statistical corrections are applied to reduce the number of such outcomes, this is unlikely to solve the problem. In this situation, researchers can be tempted to “cherry pick” results that support what they might have expected to see based on an existing theory or hypothesis, and gloss over those results that are awkward to explain.[16] The problem with this approach is that the data are no longer being used to challenge our understanding of the phenomenon, but rather to confirm our pre-existing beliefs. There is a loss of randomization. Many upcoming techniques include:

- Narcoanalysis
- Brain mapping
- Voice stress analyzers (This test detects miniscule/inaudible voice variations called laryngeal microtremors in neurology- they speed up during deception)
- thermal images of facial-skin temperature.

5. Conclusion and Recommendations

The derived concepts and evidence from neuroscience bring out specific components of a larger psychological-level etiological model. The forensic neuroscience may play a pivotal role to develop and refine etiological models of crime-related behaviours. Empathic responses may be studied with the help of fMRI signature examination. There is need of hour to work on the upcoming neurological investigational techniques in criminal investigations. In consideration with the ethical perspective, there should be appropriate legal provisions.

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References:

1. Poeppl TB, Eickhoff SB, Fox PT, Laird AR, Rupprecht R, Langguth B, Bzdok D. Connectivity and functional profiling of abnormal brain structures in pedophilia. Human brain mapping. 2015; 36(6): 2374-86.
2. Beech, A., Carter, A., Mann, R., & Rotshtein. Eds. The Wiley Blackwell Handbook of Forensic Neuroscience. Oxford, UK: Wiley-Blackwell; 2018.
3. Ratnaike RN. Acute and chronic arsenic toxicity. Postgrad Med J. 2003; 79(933): 391-396.
4. Correia P, Agrawal C, Ranjan R. Gas geyser syndrome: An important preventable cause of disabling neurological events. Ann Indian Acad Neurol. 2013; 16(2): 245-248.
5. "List of State Universities as on 06.08.2021". University Grants Commission.(Cited 25 August 2021).
6. Ramos KM, Grady C, Greely HT, Chiong W, Eberwine J, Farahany NA, Johnson LS, Hyman BT, Hyman SE, Rommelfanger KS, Serrano EE. The NIH BRAIN initiative: Integrating neuroethics and neuroscience. Neuron. 2019 ;101(3):394-8.
7. Polygraph test can only be conducted with consent of the accused: Karnataka HC. India News-Hindustan Times, 17 Mar 2021 (Cited 25 March 2022). Available from: https://www.hindustantimes.com/india-news/polygraph-test-can-only-be-conducted-with-consent-of-the-accused-karnataka-hc-101615972372932.html
8. Bannon SM, Salis KL, O'Leary KD. Structural brain abnormalities in aggression and violent behavior. Aggression and violent behavior. 2015; 25:323-31.
9. Yang Q, Shao R, Zhang Q, Li C, Li Y, Li H, Lee T. When morality opposes the law: an fMRI investigation into punishment judgments for crimes with good intentions. Neuropsychologia. 2019; 127:195-203.
10. Thomas BC, Croft KE, Tranel D. Harming kin to save strangers: further evidence for abnormally utilitarian moral judgments after ventromedial prefrontal damage. J Cogn Neurosci. 2011;23(9):2186-2196.

11. Kay KN, Naselaris T, Prenger RJ, Gallant JL. Identifying natural images from human brain activity. Nature. 2008;452(7185):352-355.
12. People v. Weinstein, 156 Misc. 2d 34, 591 N.Y.S.2d 715 (N.Y. Misc. 1992)
13. Bonkalo A. Electroencephalography in Criminology. Canadian Psychiatric Association Journal. 1967;12(3):281-286.
14. Critchley HD, Tang J, Glaser D, Butterworth B, Dolan RJ. Anterior cingulate activity during error and autonomic response. Neuroimage. 2005 ;27(4):885-95.
15. Rainey, S., Martin, S., Christen, A. et al. Brain Recording, Mind-Reading, and Neurotechnology: Ethical Issues from Consumer Devices to Brain-Based Speech Decoding.2020. Sci Eng Ethics;26: 2295–2311.
16. Ienca M, Ferretti A, Hurst S, Puhan M, Lovis C, Vayena E. Considerations for ethics review of big data health research: A scoping review. PloS one. 2018 ;13(10): e0204937.