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ORIGINAL PAPERS

The Frontal lobe and Criminal behaviour

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Abstract

The frontal lobe comprises a third of the surface of each hemisphere in human brain, and is responsible for movement, speech production, emotional expression, reward, attention, short-term memory tasks, future planning, and motivation. It is also involved in internal, purposeful mental action, and reasoning, and in socially acceptable responses. Many neuropsychological, volumetric and functional imaging studies, and case reports have shown certain changes in the frontal lobes of subjects who exhibited criminal or violent behaviour.
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Frontal lobe anatomy

The frontal lobe is the largest of the four lobes of the brain in the mammalian brain, comprising about a third of the surface of each hemisphere. It is located at the front of the brain and it is separated from the parietal lobe by the central sulcus, and the temporal lobe by the Sylvian fissure. The frontal lobe is functionally related to movement, speech production, emotional expression, reward, attention, short-term memory tasks, future planning, and motivation. The prefrontal cortex, which represents the anterior most portion of the frontal lobe and the largest part of the frontal lobe, is linked to internal, purposeful mental action, and reasoning. The Prefrontal cortex (PFC) is involved in predictions of future consequences that result from current actions, and includes override and suppression of socially unacceptable responses and task differentiation. The prefrontal cortex is one of the last cortical regions to undergo full myelination during adolescence in human [1].

The PFC is connected to distant and broadly dispersed parts of the limbic system and association cortex. It is connected with the amygdala, hypothalamus, midbrain, and pons, connections which are likely to integrate higher-order brain functions mediated by the PFC with more developmentally fundamental brain activities such as emotion and visceral, or autonomic functions [2]. The vast majority of the prefrontal connections is reciprocal, with the exception of the connections with the basal ganglia, to which the PFC sends unreciprocated direct efferents [3]. The PFC is the only neocortical region that projects directly to the hypothalamus and the septal region [4]. The orbital region of the PFC is primarily connected to the medial thalamus, hypothalamus, ventromedial caudate, and amygdala, while the dorsolateral PFC is connected to the lateral thalamus, the dorsal caudate nucleus, the hippocampus, and the neocortex [5].

Functional Organization of the PFC

The PFC is classified as a multimodal association cortex because processed information from various sensory modalities is integrated here in a precise fashion to form the physiologic constructs of memory, perception and intricate action [6].

The PFC plays an important role in executive functions. It is involved in the initiation of goal-directed patterns of behaviour, sustained attention [7], motor attention [8], short-term memory tasks, inhibitory control of interference, filtering or gating mechanism for information processing [9, 10], working memory, stimulus detection and sequencing tasks, planning, set shifting, flexibility, delayed responding, and active problem solving [11 - 13]. PFC is also involved in encoding and retrieval of memory. The right PFC is activated during retrieval of episodic memory, while the left is activated with memory encoding [13]. Certain aspects of intelligence are known to be mediated by PFC. Prominent among these are verbal expressions, memory, abstraction and the ability to formulate behavioural plans and to pursue them to their goal [14]. Furthermore, the PFC plays a role in the regulation of spontaneous speech, narrative expression, and verbal fluency, and in the analysis of pictorial detail, and the integrative scanning of all the pertinent details, through visual search and gaze control.

Symptoms on frontal lobe damage

Damage to the frontal lobe can cause inappropriate responses, impairment of executive functions such as future planning, judgement, decision-making skills, attention span and inhibition. The most known example of a person with frontal lobe damage is that of Phineas Cage, who was an American railroad construction foreman, and survived an accident in which a large iron rod was driven through his head, destroying much of his left frontal lobe. After the accident he showed lack of forethought and concern for the future, or capacity for embarrassment, inappropriate sexual behaviour, promiscuity, gambling, irresponsibility, aggressiveness, violence, vagrancy, begging, drifting, drinking, bullying, loss of respect for social conventions, and inability to make ethical decisions. Another less frequent effect of frontal lobe damage is the reduplicative paramnesia, in which patients believe that the location in which they reside is a replica of one located somewhere else.

Frontal lobe and violent behaviour

The relationship between frontal lobe injuries and antisocial personality traits is known since 1835 [16]. Typically damage to the orbitofrontal cortex is associated with poor impulse control, explosive aggressive outbursts, inappropriate verbal lewdness, jocularity, and lack of interpersonal sensitivity [17]. Furthermore persons with frontal lobe damage acquired before the age of 8 have been reported to exhibit adult histories of recurrent impulsive, aggressive, and antisocial behaviour, associated with primary deficits in tests of executive function, poor abstract conceptual thinking, inability to envision another person's subjective experience, and immature moral reasoning [18]. The Vietnam Head Injury Study showed that subjects with lesions limited to the frontal lobes, exhibited more aggressive and violent behaviours compared with patients with non-frontal head injury and controls without head injury [19].

Clinical findings in criminal and violent populations

Antisocial subjects show more anterior EEG abnormalities [20], and orbitofrontal spiking on EEG is linked to hallucinations and assaultive behavioural schemes [21]. A study on 333 prisoners convicted for violent crimes showed a positive relationship between habitual physical aggression or explosive rages and EEG frontal changes [21]. Another study on 31 subjects, who had been charged with murder, found that at least two thirds of them showed physical evidence of frontal dysfunction [22]. A frontal lobe lesion was found to be the best predictor of involvement in a violent episode among inpatients in a neuropsychiatric unit [23], and persistent violent patients, had significantly worse frontal lobe impairment than transiently violent patients, and their behaviour seemed less responsive to environmental factors. Frontal executive dysfunction can also be significantly associated with a history of community violence [24]. Morphometric and functional neuroimaging studies on aggressive behaviour and violent subjects have found frontal lobe abnormalities in comparison to controls. A volumetric study on an antisocial personality disorder group found a positive link between a history of violent crimes, psychopathic traits and reduced overall prefrontal grey matter volume [25]. Another study on 41 persons charged with murder or manslaughter, showed statistically significant bilateral prefrontal metabolic decreased during frontal activation tasks, compared to controls [26].

Moral responsibility

How much brain differences, and/or damage explain criminal behaviour? Not all patients with frontal lobe damage or impairment are criminals. There are many ingredients that need to come into play. Genes, upbringing, provocation, alcohol and drugs, and other factors that cause momentary emotions and lapses in control, are all going to act through the brain, but cannot easily mapped onto the brain. A premeditated crime and a murder committed in blind fury may have few psychological features in common, and are therefore different in many aspects, and heterogeneous to investigate.

Conclusions

There is cumulative evidence that frontal damage, or hypofrontality, can be related to violent behaviours and criminality. Numerous studies have shown evidence of volumetric and/or functional changes to frontal lobes in subjects that exhibited violent behaviours or were charged with violent crimes. Lesion studies of the frontal lobes result in impulsive aggressive behaviour and defects in social and moral reasoning. There is a significant amount of neuroimaging research (SPECT and PET) that demonstrates frontal lobe dysfunction correlates with violent and criminal behaviour. Low perfusion in the prefrontal cortex is related with impairment of managing inhibition, self-censorship, and planning, and giving limited thought to the future consequences of their poor behaviour. Not all patients with frontal lobe damage though, exhibit violent behaviour, and only a small percentage of them show criminal behaviour. We should keep in mind that criminal behaviour cannot be solely explained by brain damage, and that there are multiple external factors that contribute to these behavioural schemes.

References

[1] Fuster JM. The PFC: Anatomy, physiology and neuropsychology of the frontal lobe. New York: Lippincott-Raven; 1997.

[2] Roberts RJ, Hager L, Heron C. Prefrontal cognitive processes, working memory and inhibition of antisaccade task 1994. In: Krasnegor NA, Lyon GR, Goldman-Rakic, editors. Development of PFC: Evolution, neurobiology and behaviour. London: Paul H. Brooks Publishing Co; 1997. pp. 265–82. as cited in: Pennington BF. Dimensions of executive function in normal and abnormal development.

[3] Kanki T, Ban T. Cortical fugal connections of frontal lobe in man 1952. In: Fuster JM, editor. The PFC: Anatomy, physiology and neuropsychology of the frontal lobe. New York: Lippincott-Raven; 1997

[4] Efferent connections of the medial prefrontal cortex in the rabbit. Buchanan SL, Thompson RH, Maxwell BL, Powell DA Exp Brain Res. 1994; 100(3):469-83.

[5] Cummings JL. Frontal-subcortical circuits and human behavior. Arch Neurol. 1993 Aug; 50(8):873-80.

[6] Masterman DL, Cummings JL Frontal-subcortical circuits: the anatomic basis of executive, social and motivated behaviors. J Psychopharmacol. 1997; 11(2):107-14.
[7] Luria AR. Higher cortical functions in man. New York: Basic Books; 1966
[8] Stuss DT Biological and psychological development of executive functions. Brain Cogn. 1992 Sep; 20(1):8-23.
[9] Shimamura AP, Janowsky JS, Squire LR Memory for the temporal order of events in [4]patients with frontal lobe lesions and amnesic patients. Neuropsychologia. 1990; 28(8):803-13.
[10] Chao LL, Knight RT Contribution of human prefrontal cortex to delay performance. J Cogn Neurosci. 1998 Mar; 10(2):167-77
[11] Fuster JM, Bordner M, Kroger JK. Cross model and cross-temporal associations in neurons of frontal cortex. Nature. 2000;405:347–51.
[12] Denckla MB. Romine CS, Reynoth CR, editors. Measurement of executive functions 1994. Sequential memory: A developmental perspective on its relation to frontal lobe functioning. Neuropsychol Rev. 2004;14:43–64.
[13] Fletcher PC, Shallice T, Dolan RJ. The functional role of PFC on episodic memory. Brain. 1998;121:1239–48
[14] Drewe EA. The effect of type and area of brain lesion on Wisconsin card sorting test performance. Cortex. 1974;10:159–70.
[15] Tyler RH. Disorders of visual scanning with frontal lobe lesions 1969. In: Fuster JM, editor. The PFC: Anatomy, physiology and neuropsychology of the frontal lobe. New York: Lippincott-Raven; 1997.
[16] Benson DF, Blumer D Blumer D, Benson DF (1975) Personality changes with frontal and temporal lobe lesions. in Psychiatric aspects of neurological disease. eds Benson DF, Blumer D (Grune and Stratton, New York).
[17] Duffy JD, Campbell JJ, III (1994) The regional prefrontal syndromes: a theoretical and clinical overview. J Neuropsychiatry Clin Neurosci 6:379–387.
[18] Price BH, Daffner KR, Stowe RM et al. (1990) The comportmental learning disabilities of early frontal lobe damage. Brain 113:1383–1393.
[19] Grafman J, Schwab K, Warden D, et al. (1996) Frontal lobe injuries, violence and aggression: a report of the Vietnam head injury study. Neurology 46:1231–1238.
[20] Mednik SA, Volavka J, Gabrielli WF, et al. (1982) EEG as a predictor of antisocial behavior. Criminology 19:219–231.
[21] Williams D (1969) Neural factors related to habitual aggression: consideration of differences between those habitual aggressives and others who have committed crimes of violence. Brain 92:503–520.
[22] Blake PY, Pincus JH, Buckner C (1995) Neurologic abnormalities in murderers. Neurology 45:1641–1647
[23] Krakowski M, Czobor P (1997) Violence in psychiatric patients: the role of psychosis, frontal lobe impairment, and ward turmoil. Compr Psychiatry 38:230–236.
[24] Krakowski M, Czobor P, Carpenter MD, et al. (1997) Community violence and inpatient assaults: neurobiological deficits. J Neuropsychiatry Clin Neurosci 9:549–555
[25] Raine A, Lencz T, Bihrle S, et al. (2000) Reduced prefrontal gray matter volume and reduced autonomic activity in antisocial personality disorder. Arch Gen Psychiatry 57:119–127.
[26] Raine A, Buchsbaum M, LaCasse L (1997) Brain abnormalities in murderers indicated by positron emission tomography. Biol Psychiatry 42:495–508.