Academic Journal of Humanities & Social Sciences
ISSN 2616-5783 Vol.5, Issue 9: 76-83, DOI: 10.25236/AJHSS.2022.050912

Can Empathy Training Prevent Crime?

Liu Ding

Guangdong Lingnan Institute of Technology, School of Philanthropy, 492 Daguan Middle Rd, Tianhe District, Guangzhoui, Guangdong, China
oned@163.com

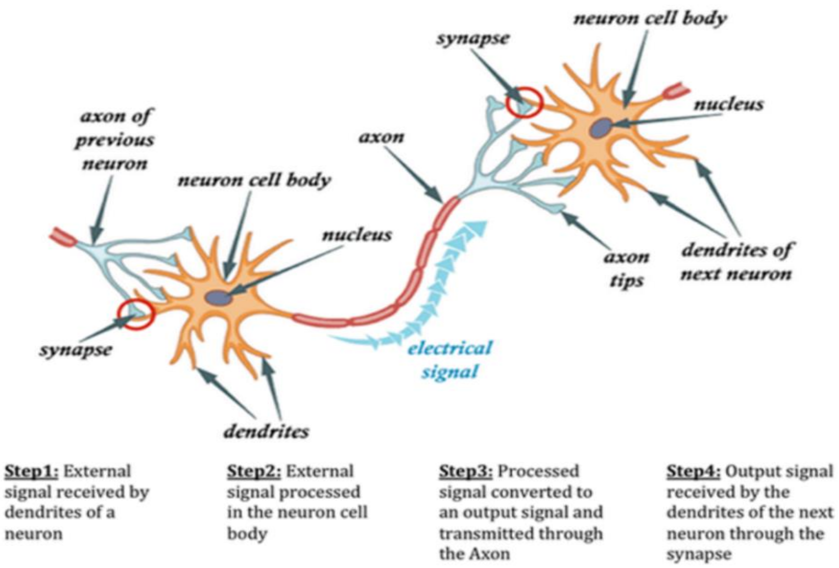
Abstract: *Base on biosocial theories, this study discusses the possibility that with neurobiological perspective, offenders could change their criminal behavior by empathy training. This study divides to four main parts and each part reviews the previous studies according to each topic. The four topics are 1) the specific areas of the brain relates to aggressive and violent behavior; 2) violent and criminal behavior is due to the impairment of empathy; 3) empathy training could change the brain function; 4) the new findings of the relationship between the brain functioning and intervention programs in criminology. Thus, crime→dysfunction of the brain→lacks empathy→empathy training→changes in brain functioning→changes in criminal behavior.*

Keywords: *crime, violence, aggressive, biology, brain, neuron, treatment, empathy, biosocial theories*

1. Introduction

1.1. Background

Biosocial Criminology and biosocial theories believe that the cause of crime is due to the interplay of the environmental factors and biological factors. According to a literature review (Barnes et al, 2012) which covers the contemporary biosocial criminology studies from 2000 to 2012, Barnes and his colleagues summarized the five major domains of biosocial criminology[1]. Among them, neurocriminology is of particular importance that most of the evolutionary, genetic, and biological risk factors manifest its impact on either the structure or the functioning of the brain (Barnes et al, 2012). How to explain the interaction between environment and neuro?



Source: Advantages and Applications of Neural Network Algorithms
http://dataunion.org/31528.html

Figure 1: Neural Plasticity

Now, we have evidence that brain is not a static organ. The organization of brain circuitry is constantly changing as a function of experience (Bryan et al, 2003), and these changes we call brain plasticity or

ISSN 2616-5783 Vol.5, Issue 9: 76-83, DOI: 10.25236/AJHSS.2022.050912

neural plasticity. It is widely known that each neuron includes synapses (axons & dendrites), neuron cell body and neurotransmitter. Let us imagine that every experience, thought, and feeling will leave a "mark" on the brain. This "mark", in terms of the study(Bryan et al, 2003), is to add or lost synapses in a particular region of the brain. The neuronal cells code the experience, thought or feeling as a form of electrical signals, which is received by the synapses of the neurons, and converses to output and passed through the axons to the next neuron. The next neuron can accept or reject through a type of chemical messenger, neurotransmitter (see Figure 1).

By this way, our brains could code our behavior and when we think about to reappear the behavior, they release information by neuron to provoke the behavior. Behavior is provoked by neuron which have been found by scientists, who used a particular light to induced behaviors by activating Zebrafish's specific neurons (Yizhar et al, 2011; Douglass et al, 2008).

After the mechanism of neurocriminology mentioned above, we come back to talk about the awkward situation of prevention in criminology. With the tons of life-course prevention or intervention programs and evaluations of crime prevention programs(Vaske et al,2011; Rocque ert al, 2012; Vaske, 2017), two misty still hung over criminologist. First of all, how effective the prevention is? James Q. Wilson asserted that "most rehabilitative efforts failed" and "Crime is also reduced when a nation increases its use of prisons" (Welsh, 2013). After then, why the prevention or intervention works? Even we know some prevention or intervention is effective, e.g. cognitive-behavioral therapy (CBT) is the most successful treatment choice when working with offenders, we still do not know the reasons why and why they are effective for only a subset of participants(Vaske et al, 2011).

Therefore, the ultimate cause of crime might underlay the biosocial factors, the neuron of our brains.

1.2. Significance of the study

This study has a significant meaning to intervention. First, how or whether treatment interventions affect neuropsychological processes may play a salient role in shaping their effectiveness (Vaske et al, 2011). Second, in addition to knowing why treatment is effective, it is important to understand who does not benefit from treatment, so that adjustments to treatment can be made for individuals who need additional support (Vaske, 2017). Accordingly, moving toward a biosocial theory of offender rehabilitation is an avenue worthy of serious consideration (Vaske et al, 2011). Therefore, this study is also essential to prevention and policy making as well.

Afterward, to understand how a behavior accrued offers us an ultimate theory to explain criminal behavior. When we look at the development of criminology theory, from classical theory to situational theory, some theories could only respectively explain some type of crime or explains limit criminal behaviors, and it always has an exception. Take disorganized theory for example, not all people tend to commit crime in disorganized communities. Some theories could barely tackle the problem surface or the correlated factors, which they hope that the underlying causes might be randomly worked out together, too. In biosocial theory, we aware that the different environment has impact on the change of individual neural plasticity. This theory directly reveals the underlying cause to us. Biosocial criminology wants to strengthen traditional criminological theories by adding relevant concepts and methodologies to them; it does not seek to replace them(Kenvin, 2010).

1.3. Purpose of the study

This study narrows down the topic to neural factors of empathy and criminal behavior, to find the possible biosiocal explanation of reducing crime.The key to this study is examining the brain functioning after empathy training.

In criminology, few studies discuss the cognitive-behavioral therapy (Vaske et al, 2011; Cornet et al, 2015; Cornet et al, 2016) and evidence-based treatment(Vaske et al, 2017) with biosocial perspective. However, each program has multiple neural correlates, including the neural correlates of cognitive empathy, emotional empathy, moral feelings, moral reasoning, and self-awareness (Vaske et al, 2011) .With all those neural correlates, it is a daunting task to determine if synapses have been added or lost in a particular region (Bryan et al, 2013). As we could not observe all change of those synapses, it is practical that we identified a smaller region. As a result, we focus on the neural correlates of empathy.

ISSN 2616-5783 Vol.5, Issue 9: 76-83, DOI: 10.25236/AJHSS.2022.050912

2. Literature review

2.1. Theoretical framework

This study is based on contemporary biosocial theory, which emphasizes the interplay between biological and environmental risk factors in the production of antisocial behaviours (Kenvin, 2010).

At the outset, criminologists ignored and rejected the biological factors on crime, due to the unscientific findings from early "biological criminology" studies (Diana, 2004) and the ethical issues along those findings. However, with the development of human science and many new evidence, criminology return to contemporary biosocial theory in 20^{th}-century, stated by Nicole (2006). It is distinct from tradition "biological criminology"(Diana, 2004; Matt, 2013) in three main ways: 1) biological and social constructs are complementary players; 2) biological factors increase the risk, but not determine, to be criminal. It could be changed; 3) most important of all, it is scientific (Matt, 2013).

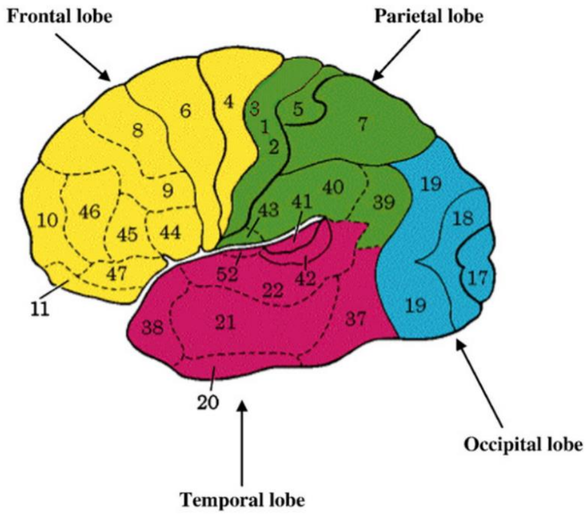
2.2. Previous studies

Early in 1998, a paper reviews studies on three specific biological risk factors for violence and crime. The risk factors contain physiological arousal, dysfunction of the brain and the birth complications, which they respectively made suggestions with, biofeedback training, cognitive remediation and prenatal, perinatal, and postnatal health care interventions.

As arousal is in part regulated by the frontal lobe and the empirical support for the link of the birth complications and violence is limited, we focus on the dysfunction of the brain. Raine and Liu(1998) describe that the findings of the dysfunction of the brain would give rise to the possibility that cognitive remediation of these neuropsychological deficits may be effective in reducing rates of violence(Raine *et al.*,1998). Two decades have passed since 1998, this chapter would combine several studies recently to explore this possibility.

2.2.1. Prefrontal cortex and the medial temporal, the regions of aggressive and violent behavior

Bufkin and Luttrell (2009) review 17 neuroimaging studies which link the aggressive, violent behaviors to brain. The 17 studies are summarized in their paper which are also attached after this review (see Appendix). The samples of the 17 studies derived from forensic settings, prisons, psychiatric hospitals, and on violent offenders who are noninstitutionalized. Different neuroimaging techniques were used in those studies, single-photon emission computed tomography (SPECT), positron emission tomography (PET)[2]; magnetic resonance imaging (MRI)[3]and functional MRI (fMRI)[4]. This new-found ability to view the brain "in action" has broadened our understanding of the neural circuitry that underlie emotional regulation and affiliated behaviors (Bufkin et al.,2009). They find prefrontal cortex and the medial temporal (particularly left-particular) associated with aggressive and violent behavior. The conclusion is consistent with Raine and Liu (1998) (see Figure 2).



Source: Toward a biosocial theory of offender rehabiltiation: Why does cognitive-behavioral therapy work? (Vaske et al, 2011).

Figure 2: Lateral/side view of the brain

ISSN 2616-5783 Vol.5, Issue 9: 76-83, DOI: 10.25236/AJHSS.2022.050912

However, differing from cognitive remediation, the intervention most consistently promoted is drug therapy, which has been successful in reducing aggressive behavior (Bufkin *et al.*,2009). How could we use the drug therapy in people without committing crime? This prediction without foolproof, dysfunction may be best viewed as a predisposition to violence rather than prefrontal dysfunction, in and of itself, causing violence (Raine *et al.*,1998). In this situation, cognitive remediation is the best choice. Many studies agree that the violation of social rules is related to difficulties in understanding other people's mental states and emotional sharing(Mariano *et al.*,2017), which are part of the empathic construct.

2.2.2. Criminal behavior, the impairment of empathy

According to Zaki and Ochsner (2012), empathic construct is divided into three dimensions, including pro-social concern, mentalizing and emotional sharing. A study investigates the role of empathy in subjects with social deficit which evaluates these competences of empathy construct in 74 criminal subjects. They find the criminal offenders group demonstrated a lower ability in empathy. The logistic regression results show that the higher the deficits in the mentalizing component are, the higher the probability of committing a crime against another person (Mariano *et al.*,2017).

2.2.3. Empathy Training

Providing remediation early in life may be critically important to success since it is likely that brain mechanisms are more plastic at an earlier age, allowing for a greater ability of undamaged areas to be "retrained" to take over the lost functions (Raine *et al.*,1998). Klimecki, Leiberg, Ricard, and Singer(2013) conducted a study to investigate functional neural plasticity underlying the augmentation of empathy. In their study, the experimental group of participants was first trained in empathic resonance and subsequently in compassion. They conducted a repeated measures multivariate analysis of variance (MANOVA) to determine how the different training regimes affected subjective experiences of empathy, positive affect and negative affect in response to the SoVT. After they analyzed imaging data using event-related statistics on the whole brain, they find that training empathy was associated with activations in a network spanning insula, aMCC, temporal gyrus, DLPFC, operculum and parts of basal ganglia (Klimecki *et al.*, 2013). Those brain areas involved in cross-sectional studies on empathy for pain, that means their involvement in self-experienced pain, and negative affect in general. In summary, the present findings reveal that already short-term affective intervention programs can induce reliable experiential and neural plasticity(Klimecki *et al.*, 2013).

2.2.4. New Findings

Table 1: Comparison of studies

study	subject	sample	Related variables	Neurobiological measurement	Findings
Lewis et al, 2008;	emotion regulation	Children	prefrontal brain activity	MRI	significant
Woltering et al, 2012;	self-regulation	Children	prefrontal brain activity	EGG	significant
Ross, 2012;	executive cognitive functions (ECFs)	Prisoners	12 variables	neuropsychological measures	Non-significant
Cornet et al, 2016	cognitive skills	Prisoners	14 variables	neurocognitive tasks	Non-significant

(Lewis et al, 2008; Woltering et al, 2012; E. H. Ross, 2012; Cornet et al, 2016)

What about aggressive/violent behaviors? With empathy training, will criminal offenders come to understand other people's feeling and stop their criminal behavior? Before we talk about the possibility, till now, only four studies(Lewis et al, 2008; Woltering et al, 2012; E. H. Ross, 2012; Cornet et al, 2016) exam the brain functioning after intervention programs aimed to reduce antisocial behavior. 1) The first study(Lewis et al, 2008) thinks that children aggressive behavior problems links to disorders of emotion regulation, which are embedded in neurobiological differences. They scanned the brain area by MRI[3] before and after an intervention combined PMT/CBT program. Through compare children who were improved with treatment and who were not, the study does find the change of the brain functioning. 2) The second study(Woltering et al, 2012) use Electroencephalogram(EGG)[5] to detect the electrical changes in the neural correlates of self-regulation (SR) after treatment. The study sample is 71 children aged 8-12 years old. 3) Ross's study(2012) focus on antisocial behaviours and deficits of prisoners in

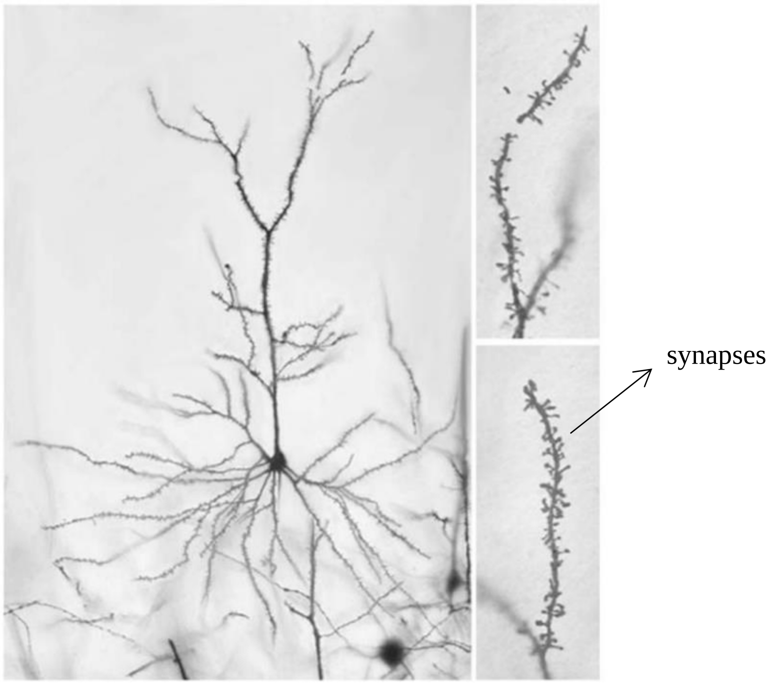
ISSN 2616-5783 Vol.5, Issue 9: 76-83, DOI: 10.25236/AJHSS.2022.050912

executive cognitive functions (ECFs). Without mind-scan measurement technique, it conducts neuropsychological measures of ECFs. 4) The last study(Cornet et al, 2016) targets at prisoners, too. They measure prisoners' neurocognitive functioning by neurocognitive tasks. Compare the groups who completed a cognitive skills training program and who were not. As same as study by Ross(2012), it did not scan the brain functioning directly. Both Woltering et al. (2012) and Lewis et al. (2008) found there was a reduction in ventral prefrontal brain activity among children, which indicates increased efficiency of self-regulatory and emotion-control mechanisms(Cornet et al, 2016). However, E. H. Ross (2012) and Cornet et al.(2016) did not find the same outcome, no change in neurocognitive functioning among adult prisoners after intervention programs(see table 1).

3. Discussion

Why are the findings not consistent? Though the number of the studies is too few to illustrate the issues, we still could discuss the possible answers by comparing the procedure of those studies.

First of all, one explanation is may due to the different age of the sample. It is said that the neural plasticity may be distinct by age. The formal two studies target at children, while the last two studies prisoners. Bryan et al.(2003) has made a test among animal and drawn a conclusion that "experience alters the brain, and it does so in an age-related manner"(see Figure 3). They believe that that neural plasticity has its own limit, but we are still not know the degree of age-related or what the principle of the limitation.



Source: Bryan Kolb, Gibb, R., & Robinson, T. E. (2003). Brain Plasticity and Behavior. American Psychological Society, 49, 43–64.

Figure 3: Photograph of a neuron

Then, the different measurement may play a significant role of those findings as well. The formal two studies directly observe the brain area, while the last two studies indirectly measure it. As four studies are short-term studies. The treatment or intervention might have altered the nerve already, but not enough to be realized by the human being. Meanwhile, the task requires a complex set of cognitive skills and involves executive control processes (Cornet et al, 2016).

Last but not least, it is the multiple variables problem, as the last two studies contain 12-14 variables. This review mentioned above that too much variables are hard to locate the area of brain functioning. In a similar or logical way, it is conceivable that the selected neurocognitive skills were not targeted during intervention and, therefore, may not have undergone change (Cornet et al, 2016).

ISSN 2616-5783 Vol.5, Issue 9: 76-83, DOI: 10.25236/AJHSS.2022.050912

3.1. The possibility

In conclusion, the question that can empathy training prevent crime with neurobiological prospective comes clear. It is worth to conduct a study based on this question. Our desire is not to reduce aggression and/or violence to brain functioning but to inform of advances in neurological analyses of emotion regulation and their importance to studies of that behavior (Bufkin *et al.*,2009). It is argued that biology is not a destiny for violence, that we can change biological risk factors using benign, noninvasive techniques, and that a new generation of biosocial health research is required to help develop new strategies for more successful violence management(Raine *et al*.,1998).

3.2. Suggestions for future research

We could conduct more studies with Electroencephalogram (EGG). This imaging methodology, compare to other imaging methodology, have many advantages: with higher temporal resolution, directly measures brain activity; low level of expertise needed; lower cost($25,000); full portable; and what's more, it is harmless to human being which could be tested repeatedly. The only drawback for EEG is the spatial resolution, which could be overcame by calculations.

Note:

Five major domains of biosocial criminology are evolutionary criminology, biological criminology, behavior genetics, molecular genetics, and neurocriminology.

Positron Emission Tomography (PET): It is a functional brain measurement technique. Nuclear imaging technique that uses a radioactive drug tracer to detect how tissues and organs are functioning, measuring low concentrations of molecules to detect cell-to-cell communication, and track a substances distribution within and movement into and out of the brain.

Magnetic resonance imaging (MRI): It is a structural brain measurement technique. Imaging technique that uses a magnetic field and radio waves to generate detailed images of water molecules in a cross section or area of the brain. Different types of tissue hold different amounts of water, generating maps or pictures of the brain that contrast and detect structural abnormalities such as size, density and volume of brain tissue such as white and grey matter.

Functional MRI (fMRI): It is a functional brain measurement technique. Also known as a functional MRI (fMRI), this imaging technique measures brain activity by detecting changes associated with blood flow and oxygenation. https://www.recoveryanswers.org/recovery-101/brain-in-recovery/

Electroencephalogram (EGG): It measures the electrical activity of our brain via electrodes that are placed on the scalp. https://imotions.com/blog/eeg-vs-mri-vs-fmri-differences/

References

[1] Barnes J.C. , Brian B. Boutwell, & Kevin M. Beaver.(2012) Contemporary Biosocial Criminology: A Systematic Review of the Literature, 2000–2012.The Handbook of Criminological Theory

[2] Bryan Kolb, Gibb, R., & Robinson, T. E. (2003). Brain Plasticity and Behavior. American Psychological Society, 49, 43–64.

[3] Bufkin, J. L., & Luttrell, V. R. (2009). Neuroimaging studies of aggressive and violent behavior. Acta Zoologica Academiae Scientiarum Hungaricae, 55(4), 395–407. https://doi.org/10.1177/152483800 5275089

[4] Cornet, L. J. M., van der Laan, P. H., Nijman, H. L. I., Tollenaar, N., & de Kogel, C. H. (2015). Neurobiological Factors as Predictors of Prisoners' Response to a Cognitive Skills Training. Journal of Criminal Justice, 43(2), 122–132. https://doi.org/10.1016/j.jcrimjus.2015.02.003

[5] Cornet, L. J. M., van der Laan, P. H., Nijman, H. L. I., Tollenaar, N., & de Kogel, C. H. (2016). Does a Cognitive Skills Training Program for Prisoners Affect Neurocognitive Functioning and Heart Rate Activity? Criminal Justice and Behavior, 43(11), 1481–1504. https:// doi.org/ 10.1177/ 0093854816643732

[6] Diana H. Fishbein. (1990), Biological Perspectives in Criminology, Biosocial Theories of Crime

[7] Douglass A.D., S. Kraves, K. Deisseroth, A.F. Schier,& F. Engert (2008). Escape behavior elicited by single, Channelrhodopsin-2-evoked spikes in zebrafish somatosensory neurons.Curr. Biol., 18, pp. 1133-1137

[8] Goldfried, M. R. and Davison, G. C. (1976). Clinical behaviour therapy. Chicago: Holt, Rinehart

and Winston.
[9] Cornet, L. J. M., van der Laan, P. H., Nijman, H. L. I., Tollenaar, N., & de Kogel, C. H. (2016). Does a Cognitive Skills Training Program for Prisoners Affect Neurocognitive Functioning and Heart Rate Activity? Criminal Justice and Behavior, 43(11), 1481–1504. https:// doi.org/ 10.1177/009385481 6643732
[10] Kevin M.B. (2010). Introduction. Biosocial theories of crime
[11] Klimecki, O. M., Leiberg, S., Ricard, M., & Singer, T. (2013). Differential pattern of functional brain plasticity after compassion and empathy training. Social Cognitive and Affective Neuroscience, 9(6), 873–879. https://doi.org/10.1093/scan/nst060
[12] Lewis, M. D., Granic, I., Lamm, C., Zelazo, P. D., Stieben, J., Todd, R. M., Pepler, D. (2008). Changes in the neural bases of emotion regulation associated with clinical improvement in children with behavior problems. Development and Psychopathology, 20(3), 913–939. https://doi.org/10.1017 /S0954579408000448
[13] Marshall, L. E., & Marshall, W. L. (2011). Empathy and antisocial behaviour. Journal of Forensic Psychiatry and Psychology, 22(5), 742–759. https://doi.org/10.1080/14789949.2011.617544
[14] Mariano, M., Pino, M. C., Peretti, S., Valenti, M., & Mazza, M. (2017). Understanding criminal behavior: Empathic impairment in criminal offenders. Social Neuroscience, 12(4), 379–385. https://doi.org/10.1080/17470919.2016.1179670
[15] Matt Delisi. (2013) Revisiting Lombroso. The Oxford Handbook of Criminological theory
[16] Nicole Hahn Rafter (2006), H.J. Eysenck in Fagin's Kitchen: The Return to Biological Theory in 20th-Century criminology. Biosocial theories of Crime
[17] Raine, A., & Liu, J. H. (1998). Biological predispositions to violence and their implications for biosocial treatment and prevention. Psychology, Crime and Law, 4(2), 107–125. https://doi.org /10.1080/10683169808401752
[18] Rocque, M., Welsh, B. C., & Raine, A. (2012). Biosocial criminology and modern crime prevention. Journal of Criminal Justice, 40(4), 306–312. https://doi.org/10.1016/j.jcrimjus.2012.05.003
[19] Ross, Erin H. (2012) "Are Offence-Focused Correctional Rehabilitation Programs Affecting Inmates' Executive Cognitive Functions?". Electronic Thesis and Dissertation Repository. 574.
[20] Vaske, J. C. (2017). Using Biosocial Criminology to Understand and Improve Treatment Outcomes. Criminal Justice and Behavior, 44(8), 1050–1072. https://doi.org/10.1177/0093854817716484
[21] Vaske, J., Galyean, K., & Cullen, F. T. (2011). Toward a biosocial theory of offender rehabiltiation: Why does cognitive-behavioral therapy work? Journal of Criminal Justice, 39(1), 90–102. https://doi.org/10.1016/j.jcrimjus.2010.12.006
[22] Welsh, B. C., & Farrington, D. P. (2013). Preventing crime is hard work: Early intervention, developmental criminology, and the enduring legacy of James Q. Wilson. Journal of Criminal Justice, 41(6), 448–451. https://doi.org/10.1016/j.jcrimjus.2013.08.003
[23] Woltering, S. (2012). Neural Changes Associated with Treatment Outcome in Children with Externalizing Problems.
[24] Yizhar. O, L.E. Fenno, T.J. Davidson, M. Mogri, & K. Deisseroth (2011). Optogenetics in neural systems. Neuron, 71, pp. 9-34.

ISSN 2616-5783 Vol.5, Issue 9: 76-83, DOI: 10.25236/AJHSS.2022.050912

Appendix

17 Neuroimaging Studies Review by Bufkin and Luttrell (2009)

Table 2 Neuroimaging Studies in Aggressive , Violent, and/or Antisocial Patients

Reference	*Patients*	*Methods*	*Results*
Amen, Stubblefield, Carmichael, & Thisted (1996)	40 psychiatric patients with aggression and 40 matched psychiatric controls with nonaggression	SPECT	Aggressive patients more likely exhibited decreased activity in the prefontal cortex and increased activity in the anteromedial frontal cortex, left basal ganglia, and left temporal lobe.
Kuruoglu, Arikan, Vural, Karatas, Arac, & Isik (1996)	40 alcoholic patients, 15 with APD, and 10 matched controls	SPECT	Reduced frontal functioning in alcoholic patients. Pronounced dysfunction in the anterior frontal lobes, with some decrements in right parietal and left temporal lobes in alcoholics with APD.
Hirono, Mega, Divov, Mishkin, & Cummings (2000)	10 patients with dementia and aggression and 10 patients with dementia and no aggression	SPECT	No statistically significant differences in orbitofrontal functioning. Aggressive patients exhibited reduced functioning in the bilateral dorsolateral frontal cortex, left anterior temporal cortex, and right superior parietal cortex.
Volkow and Tancredi (1987)	4 psychiatric patients who were violent and 4 normal, matched controls	PET	50% of the patients who were violent had reduced frontal functioning. Left temporal lobe abnormalities in all patients who were violent.
Volkow et al. (1995)	8 psychiatric patients who were violent and 8 normal controls	PET	Patients who were violent had reduced functioning in the left and right prefrontal cortex, left frontal cortex, and left and right temporal medial cortex.
Goyer et al. (1994)	17 patients with personality disorders and 43 controls	PET	Reduced functioning in the orbitofrontal and anterior-medial frontal cortices was associated with higher self-reported aggression among patients.
Raine, Buchsbaum, Stanley, et al. (1994)	22 accused murderers pleading insanity or incompetence and 22 matched controls	PET	Murderers had reduced activity in the OFC, anterior medial cortex, and superior frontal cortex. Murderers showed reduced lateral prefrontal activity in the left but not right hemisphere.
Raine, Buchsbaum, & LaCasse (1997)	41 accused murderers pleading NGRI and 41 matched controls	PET	Murderers showed reduced activity in the lateral prefrontal cortex, medial prefrontal cortex (right orbitofrontal and bilateral medial frontal), and the posterior parietal cortex. Murderers showed reduced activity in the corpus callosum and left-sided reductions in the amygdala, thalamus, and medial-temporal areas.
Raine, Stoddard, Bihrle, & Buchsbaum (1998)	38 accused murderers pleading NGRI, 12 with significant psychosocial deprivation and 26 with minimal or no deprivation, and 41 matched controls	PET	Murderers without deprivation had reduced lateral and medial prefrontal functioning compared to controls. Murderers without deprivation had reduced medial prefrontal functioning compared to deprived murderers. Murderers without deprivation had reduced right orbitofrontal functioning compared to deprived murderers and controls.
Raine, Meloy, et al. (1998)	24 accused murderers pleading NGRI with 9 classified as affective murderers and 15 as predatory murderers, and 41 matched controls	PET	Lower bilateral prefrontal activity, higher right subcortical activity, and reduced right prefrontal and subcortical ratios in affective murderers. Increased right subcortical activity and reduced right prefrontal and subcortical ratios in predatory murderers.
Tonkonogy (1991)	23 patients with organic mental disorders (14 violent and 9 nonviolent)	MRI	Orbitofrontal lesions were found in only 1 of 14 violent patients. Violent patients were more likely to have tissue loss in the anterior-inferior temporal lobe, particularly in the amygdalo-hippocampal region or adjacent areas.
Sakuta & Fukushima (1998)	69 criminals (52 murderers and 17 nonmurderers)	MRI	Structural abnormalities were significantly higher in the murderer group and were likely to be found in the temporal lobes.
Elst, Woermann, Lemieux, Thompson, & Trimble (2000)	8 patients with TLE (24 violent and 24 nonviolent) and 20 age- and sex-matched healthy controls	MRI	44% of aggressive patients showed amygdalar pathology.
Woermann et al. (2000)	48 patients with TLE (24 violent and 24 nonviolent) and 20 age- and sex-matched healthy controls	MRI	Violent patients had reductions in frontal grey matter volume compared to nonviolent patients and controls. Aggression scores were inversely related to left frontal grey matter volume in violent patients. Violent patients had increases in left temporal lobe volume compared to controls.
Wong et al. (1997)	20 RVOs and 19 NRVOs with schizophrenic and schizoaffective disorders, with 14 normal controls	MRI	Compared to controls, violent offenders exhibited nonspecific white matter abnomalities and generalized cortical hypometabolism.
		PET	Asymmetric gyral patterns in the temporal-parietal region were more commonly found in RVOs than in NRVOs.
Aigner et al. (2000)	82 offenders with mental illness from a high-security prison categorized into high- or low-violence groups.	MRI	In the high-violence group, 65.5% showed MRI abnormalities compared to 16.6% in the low-violence group.
Raine, Lencz, Bihrle, LaCasse, & Colletti (2000)	21 patients with APD, 26 patients with substance dependence, 21 psychiatric controls, and 34 healthy controls	MRI	Compared to all other groups, patients with APD showed reductions in prefrontal grey matter volume. Patients with APD had lower autonomic activity during a social stressor compared to other groups.

NOTE: SPECT = single-photon emission computed tomography; APD = antisocial personality disorder; PET = positron emission tomography; NGRI = not guilty by reason of insanity; MRI = magnetic resonance imaging; TLE = temporal lobe epilepsy; RVOs = repeat violent offenders; NRVOs = nonrepeat violent offenders.