Journal of
Alcoholism & Drug Dependence
ISSN: 2329-6488

Ray, J Alcohol Drug Depend 2016, 4:5
DOI: 10.4172/2329-6488.1000e134

Editorial OMICS International

Brain Structural and Functional Changes in Cocaine Users during Abstinence

Suchismita Ray Ph.D*

Center of Alcohol Studies, Rutgers, The State University of New Jersey, USA

***Corresponding author:** Suchismita Ray, Center of Alcohol Studies, Rutgers, The State University of New Jersey, 607 Allison Road, Piscataway, NJ 08854, USA, Tel: 848-445-9391; Fax: 732-445-3500; E-mail: shmita@rci.rutgers.edu

Received date: October 14, 2016; **Accepted date:** October 17, 2016; **Published date:** October 24, 2016

Editorial

Stimulant abuse, particularly cocaine abuse is an important public health concern, as according to 2013 National Survey on Drug Use and Health (SAMHSA, 2013) [1], there are 1.5 million current cocaine users in the United States and costs to the society for drug abuse including cocaine abuse are calculated to be $62 billion (NDCS, 1997) [2]. Utilizing brain imaging techniques and neuropsychological tests, earlier studies have shown reduced anterior and posterior cingulate activation, attenuated inferior frontal and dorsolateral prefrontal cortex activation and altered posterior parietal activation, and impaired learning, memory, attention, reaction time and cognitive executive function in chronic cocaine users [3-5]. Long-term stimulant abuse has been associated with brain's structural abnormalities [6,7], as well as functional abnormalities characterized in terms of an enhanced neural reactivity to appetitive drug cues [8-12] enhanced neural response during craving [10], and an impaired neural response in paradigms that measure cognitive control [13-16]. A continuing problem with cocaine dependence is that the majority of cocaine users will frequently resume drug use after a period of abstinence [17]. However, there is relatively little empirical research on how the brain's structural and functional abnormalities change while a stimulant user maintains drug abstinence.

Studies using Diffusion Tensor Imaging (DTI; Beaulieu, 2002) [18] technique have shown that current users of cocaine have reductions in white matter (WM) integrity compared to controls [19,20]. However a fundamental question is whether these white matter differences are present following abstinence from cocaine use. To address this question, a limited number of DTI studies have been conducted that utilized a cross sectional design [21-23]. For example, Bell et al. [21] examined WM integrity in cocaine-abstinent individuals and non-using controls. Cocaine-abstinent individuals showed lower fractional anisotropy (FA) in the left anterior callosal fibers, left genu of the corpus callosum, right superior longitudinal fasciculus, right callosal fibers and the superior corona radiata bilaterally compared to controls. Differences between the cocaine abstinent sub-groups were observed bilaterally in the inferior longitudinal fasciculus, right anterior thalamic radiation, and right ventral posterolateral nucleus of the thalamus, left superior corona radiata, superior longitudinal fasciculus bilaterally, right cingulum and the WM of the right precentral gyrus. Similarly, Xu et al. [23] found that the long-term abstinence group had significantly higher FA than the short-term abstinence group in corpus callosum, frontal, parietal, temporal, occipital and cerebellar regions. Using structural MRI analyzed with voxel based morphometry (VBM), Hanlon et al. [22] showed that the one-month abstinent cocaine users had significantly higher gray matter density than current cocaine users in neocortical areas including the frontal and temporal cortex. Using a VBM technique, a reduced gray matter volume in the prefrontal cortex, lateral and medial aspects of the orbitofrontal cortex and right cingulate gyrus in 20-day abstinent cocaine users compared to controls was reported by Matochik et al. [24]. Thus, although a limited number of cross sectional studies have examined structural changes in abstinent cocaine users, no longitudinal data exist on this topic. The cross sectional studies are limited in that they fail to reveal if the structural and functional brain changes in substance users during abstinence are due to dynamic intra-individual changes that characterize successful abstinence, or if they manifest pre-existing differences between substance users.

A more recent focus of neuroimaging studies is understanding not just which individual brain areas are activated by a cognitive task, but how individual brain regions are integrated, i.e., functional connectivity. Functional connectivity has been examined in current cocaine users in the resting state [25-28] as well as while they performed a finger-tapping and an attention task [22,29]. However, earlier studies on functional connectivity in individuals who have abstained from cocaine use are limited with only a handful of imaging studies examining this topic [30-32]. For example, Adinoff et al. [30] assessed alterations in regional cerebral blood flow (rCBF) and related resting state functional connectivity (rsFC) to prospectively predict relapse in cocaine users following treatment for cocaine use disorder. Results showed an enhanced rCBF only in the left posterior hippocampus in the group who relapsed compared with the early remission (Individuals who did not use cocaine within 30 days following discharge) and control groups. Also, the left posterior hippocampus had an increased rsFC strength with the posterior cingulate cortex/precuneus in the relapsed versus early remission subgroups. Differences in measures of intrinsic connectivity during functional magnetic resonance imaging (fMRI) stroop performance were examined by Mitchell et al. [32]. Results demonstrated a relatively greater intrinsic connectivity in the ventral striatum, putamen, inferior frontal gyrus, anterior insula, thalamus and substantia nigra for abstinent cocaine users compared to controls.

To date, only two fMRI effective connectivity studies which reveal the influence that one brain region exerts over another have been conducted with cocaine users. Effective connectivity studies provide enhanced information on the consequences of chronic drug use on the brain compared to functional connectivity studies. My colleagues and I have assessed effective connectivity among brain regions while chronic cocaine users viewed cocaine-related picture cues (Ray et al. [33]). And Ma et al. [34] examined effective connectivity in cocaine users during an immediate and delayed working memory task. I am not aware of any effective connectivity study involving abstinent cocaine users. Thus, although a few studies have examined functional connectivity in cocaine-dependent individuals who are abstinent, no studies implemented a longitudinal design.

In order to move the field forward, I propose that a longitudinal fMRI study should be conducted to examine dynamic structural and functional changes in treatment-seeking abstinent cocaine dependent individuals by scanning them at multiple time points during abstinence. Structural and functional brain changes should be examined using structural, functional and effective connectivity analysis approaches. Specifically, the focus should be on the cognitive control network (CCN) [35] which has been associated with impulsive drug seeking behavior. This study may have implications to develop therapies that have potentials to change the neuroplasticity within the CCN which may promote abstinence from cocaine use.

Acknowledgement

This research was supported by a National Institute on Drug Abuse grant (K01DA029047) to Dr. Suchismita Ray.

References

1. Substance Abuse and Mental Health Services Administration (2013) National Survey on Drug Use and Health: Summary of National Findings, NSDUH Series H-48, HHS Publication No. (SMA), 14-4863.
2. National Drug Control Strategy (1997) Office of National Drug Control Policy. Washington D.C.: US Government Printing Office.
3. Aron JL, Paulus MP (2007) Location, location: Using functional magnetic resonance imaging to pinpoint brain differences relevant to stimulant use. Addiction 102: 33-43.
4. Jovanovski D, Erb S, Zakzanis KK (2005) Neurocognitive deficits in cocaine users: A quantitative review of the evidence. J Clin Exp Neuropsychol 27: 189-204.
5. Lundqvist T (2005) Cognitive consequences of cannabis use: Comparison with abuse of stimulants and heroin with regard to attention, memory and executive functions. Pharmacol Biochem Behav 81: 319-330.
6. Ersche KD, Barnes A, Jones PS, Morein-Zamir S, Robbins TW, et al. (2011) Abnormal structure of frontostriatal brain systems is associated with aspects of impulsivity and compulsivity in cocaine dependence. Brain: A J Neurol 134: 2013-2024.
7. Ersche KD, Jones PS, Williams GB, Turton AJ, Robbins TW, et al. (2012) Abnormal brain structure implicated in stimulant drug addiction. Science 335: 601-604.
8. Childress AR, Ehrman RN, Wang Z, Li Y, Sciortino N, et al. (2008) Prelude to passion: Limbic activation by "unseen" drug and sexual cues. PloS One 3: e1506.
9. Childress AR, Mozley PD, McElgin W, Fitzgerald J, Reivich M, et al. (1999) Limbic activation during cue-induced cocaine craving. Am J Psychiat 156: 11-18.
10. Kilts CD, Schweitzer JB, Quinn CK, Gross RE, Faber TL, et al. (2001) Neural activity related to drug craving in cocaine addiction. Arch Gen Psychiatry 58: 334-341.
11. Ray S, Hanson C, Hanson S (2014) Enhanced cue reactivity to cocaine cues in non-treatment seeking cocaine smokers. J Alcohol Drug Dep 2: 2.
12. Volkow ND, Wang G, Telang F, Fowler JS, Logan J, et al. (2006) Cocaine cues and dopamine in dorsal striatum: Mechanism of craving in cocaine addiction. J Neurosci 26: 6583-6588.
13. de Wit H (2009) Impulsivity as a determinant and consequence of drug use: A review of underlying processes. Addiction Biol 14: 22-31.
14. Everitt BJ, Belin D, Economidou D, Pelloux Y, Dalley JW, et al. (2008) Neural mechanisms underlying the vulnerability to develop compulsive drug-seeking habits and addiction. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 363: 3125-3135.
15. Garavan H, Hester R (2007) The role of cognitive control in cocaine dependence. Neuropsychol Rev 17: 337-345.
16. Li CR, Huang C, Yan P, Bhagwagar Z, Milivojevic V (2008) Neural correlates of impulse control during stop signal inhibition in cocaine-dependent men. Neuropsychopharmacology 33: 1798-1806.
17. Bossert JM, Ghitza UE, Lu L, Epstein DH, Shaham Y (2005) Neurobiology of relapse to heroin and cocaine seeking: An update and clinical implications. Eur J Pharmacol 526: 36-50.
18. Beaulieu C (2002) The basis of anisotropic water diffusion in the nervous system - a technical review. NMR Biomed 15: 435-455.
19. Lim KO, Wozniak JR, Mueller BA, Franc DT, Specker SM, et al. (2008) Brain macrostructural and microstructural abnormalities in cocaine dependence. Drug Alcohol Depen 92: 164-172.
20. Romero MJ, Asensio S, Palau C, Sanchez A, Romero FJ (2010) Cocaine addiction: Diffusion tensor imaging study of the inferior frontal and anterior cingulate white matter. Psychiatry Res 18: 57-63.
21. Bell RP, Foxe JJ, Nierenberg J, Hoptman MJ, Garavan H (2011) Assessing white matter integrity as a function of abstinence duration in former cocaine-dependent individuals. Drug Alcohol Dep 114: 159-168.
22. Hanlon CA, Wesley MJ, Stapleton JR, Laurienti PJ, Porrino LJ (2011) The association between frontal-striatal connectivity and sensorimotor control in cocaine users. Drug Alcohol Dep 115: 240-243.
23. Xu J, DeVito EE, Worhunsky PD, Carroll KM, Rounsaville BJ, et al. (2010) White matter integrity is associated with treatment outcome measures in cocaine dependence. Neuropsychopharmacology 35: 1541-1549.
24. Matochik JA, London ED, Eldreth DA, Cadet JL, Bolla KI (2003) Frontal cortical tissue composition in abstinent cocaine abusers: A magnetic resonance imaging study. Neuroimage 19: 1095-1102.
25. Cisler JM, Elton A, Kennedy AP, Young J, Smitherman S, et al. (2013) Altered functional connectivity of the insular cortex across prefrontal networks in cocaine addiction. Psychiatry Res 213: 39-46.
26. Gu H, Salmeron BJ, Ross TJ, Geng X, Zhan W, et al. (2010) Mesocorticolimbic circuits are impaired in chronic cocaine users as demonstrated by resting-state functional connectivity. Neuroimage 53: 593-601.
27. Ray S, Gohel SR, Biswal BB (2015) Altered functional connectivity strength in abstinent chronic cocaine smokers compared to healthy controls. Brain Connectivity 5: 476-486.
28. Wilcox CE, Teshiba TM, Merideth F, Ling J, Mayer AR (2011) Enhanced cue reactivity and fronto-striatal functional connectivity in cocaine use disorders. Drug Alcohol Depend 115: 137-144.
29. Tomasi D, Volkow ND, Wang R, Carrillo JH, Maloney T, et al. (2010) Disrupted functional connectivity with dopaminergic midbrain in cocaine abusers. PloS One 5: e10815.
30. Adinoff B, Gu H, Merrick C, McHugh M, Jeon-Slaughter H, et al. (2015) Basal hippocampal activity and its functional connectivity predicts cocaine relapse. Biol Psychiatry 78: 496-504.
31. McHugh MJ, Demers CH, Salmeron BJ, Devous MDS, Stein EA (2014) Cortico-amygdala coupling as a marker of early relapse risk in cocaine-addicted individuals. Front. Psychiatry pp: 5-16.
32. Mitchell MR, Balodis IM, Devito EE, Lacadie CM, Yeston J, et al. (2013) A preliminary investigation of stroop-related intrinsic connectivity in cocaine dependence: Associations with treatment outcomes. Am J Drug Alcohol Abuse 39: 392-402.
33. Ray S, Haney M, Hanson C, Biswal B, Hanson SJ (2015) Modeling causal relationship between brain regions within the drug-cue processing network in chronic cocaine smokers. Neuropsychopharmacology 40: 2960-2968.
34. Ma L, Steinberg JL, Hasan KM, Narayana PA, Kramer LA, et al. (2012) Stochastic dynamic causal modeling of working memory connections in cocaine dependence. Human Brain Mapping 35: 760-778.
35. Alexopoulos GS, Hoptman MJ, Kanellopoulos D, Murphy CF, Lim KO, et al. (2012) Functional connectivity in the cognitive control network and the default mode network in late-life depression. J Affect Disord 139: 56-65.