THE INDIVIDUAL NEUROBIOLOGICAL EFFECTS OF SUBSTANCE ABUSE ON ADOLESCENTS:

A Comparative study of Marijuana and Oxycontin abuse and the development of Conduct Disorder related behaviors among rural adolescents

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Abstract

As the brain of an adolescent does not reach maturity until past the age of 20, an adolescent’s tendency to take on reckless behaviors may impede his neurological development. Antisocial adolescents in particular have impulsive stimulation seeking behaviors which gives rise to substance abuse. Several studies have supported the view that alcohol and tobacco abuse is associated with impaired neurological development which predisposes antisocial behavior. However, with the abuse of prescription and illicit drugs on the rise especially in rural areas, there is a potential risk of similar neurodevelopment deficiencies among these adolescents as well. This paper brings to attention these deficiencies stemming from Oxycodone and Marijuana abuse which could induce Conduct Disorder related behaviors among rural adolescents. Further, a comparison between these 2 types of abuse lead to the conclusion that rural Oxycodone abusers could potentially face a higher risk of developing conduct disorder related behaviors.
Introduction

Antisocial adolescents have been extensively studied to understand the biological markers which might indicate if a child is antisocial. Chronic or repetitive antisocial behaviors entailing aggression, deceit or theft among early adolescents are diagnosed as conduct disorder based on the Diagnostic and statistical manual of mental disorders (DSM-V) (Kazdin, 1995). A study conducted revealed that one such marker was low resting heart rate among antisocial adolescents (Oritz & Raine, 2004). As a low resting heart rate indicates that antisocial adolescents have lower arousal levels than normal and tend to be more impulsive stimulation seeking, these adolescents will seek out more extreme forms of stimulation such as substance abuse instead.

Substance abuse has been both directly and indirectly associated to conduct problems in an individual depending on the drug abused. For the case of alcohol, maternal alcohol abuse can give rise to fetal alcohol syndrome which is characterised by central nervous system dysfunction which contributes to mental retardation and conduct problems among these offsprings (Hillman, Pauly, & Kerstein, 1989; Streissguth et al., 1991). A more direct effect of alcohol abuse is seen in conduct disorder adolescents where alcohol abuse among this group of adolescents lead to the progression of their diagnosis to adult antisocial personality disorder or worsening of conduct misbehaviors (Finn, Mazas, Justus, & Steinmetz, 2002; Myers, Stewart, & Brown, 1998).

Similar results were obtained for smokers as well. Maternal smoking leads to a fourfold increased risk of conduct disorder among their offsprings (Weissman, Warner, Wickramaratne, & Kandel, 1999). Smoking by adolescents themselves have also been shown to result in an increase in conduct disorder related behaviors such as impulsivity, risk taking and novelty seeking characteristics (Turner, Mermelstein, &
Thus, these studies hint at the possibility of the reversible relationship between substance abuse and antisocial adolescents, where substance abuse predisposes antisocial behavior and vice versa (Mason & Windle, 2002).

In this paper, I would analyze two other forms of substance abuse, namely marijuana and oxycodone which are the next two most commonly abused drugs after alcohol and tobacco (Duffy's Napa Valley Rehab, 2012). In the United States alone, 19.8 million people aged 12 and above are marijuana abusers while 2.05 million people suffers from opioid abuse excluding heroine (National Institute of Drug Abuse, 2014). In particular, this paper would analyze the individual effects of marijuana and oxycodone on adolescents in terms of changes in their brain function and how their environment especially characteristics of rural environment might exacerbate substance abuse which could relate to an increase in conduct disorder related behaviors.

**Marijuana and brain function**

Chronic marijuana abuse have been shown to result in an increased risk of neurocognitive impairment. For adolescents who abused marijuana before the age of 17, records have shown that they have smaller whole brain size and reduction in grey matter when compared to non-abusers (Jacobus, Bava, Cohen-Zion, Mahmood, & Tapert, 2009). Specifically, in marijuana abusers, there is significant volume reduction in the amygdala in response to heavy marijuana use. (Cousijn et al., 2012). Reduction of grey matter in these areas are closely related to a lack of empathy which is a characteristic of adolescents diagnosed with conduct disorder (Sterzer, Stadler, Poustka, & Kleinschmidt, 2007). Thus, Marijuana abuse can result in the reduction of such areas leading to an increase in lack of empathy.
Moreover, marijuana abuse is linked to the increase of white matter volume as well especially in the prefrontal region (Jacobus et al., 2009; Medina, Nagel, Park, McQueeny, & Tapert, 2007). This increase in white matter is proven to be a neurobiological basis of lying where liars have a 22 to 26% increase in their prefrontal white matter as compared to non-liars (Yang, 2005). Therefore, Marijuana abuse can also lead to increased pathological lying which is another key characteristic of Conduct Disorder listed under the DSM-V Conduct Disorder.

The prefrontal cortex itself can undergo various alteration during marijuana abuse (Jacobus et al., 2009). Such alterations is linked to deficits in planning, emotional regulation and inhibition of actions. Evidence shows that female adolescent abusers have a 4% increase in prefrontal cortex volume as compared to controls. In addition, when the go/no-go task of response inhibition was conducted, Marijuana abusers showed greater response in the no-go trials which indicated poorer neuropsychological performance (Squeglia, Jacobus, & Tapert, 2009). This shows increased impulsivity and lack of emotional management which could lead to greater aggressive behaviour among adolescent abusers.

Another key brain functioning deficit among marijuana abusers is a volume reduction in the right posterior cingulate cortex (Jacobus et al., 2009). This region of the brain is closely linked to moral reasoning and so a reduction in volume indicates that there is a decrease in moral reasoning capabilities among abusers (De Brito et al., 2008). Moreover, the posterior cingulate cortex is also essential in allowing an individual to assess his or her environment (Vogt, Finch, & Olson, 1992). A decrease in volume in this region might in turn contribute to an increase in recklessness among these individuals. This under-activation in the posterior cingulate gyrus is also observed in conduct
disorder adolescents which further supports the importance of this region of the brain in mediating conduct disorder (Rubia et al., 2008). Therefore, it is more likely for adolescent marijuana abusers to behave impulsively and to commit immoral acts such as theft more easily.

**Oxycodone and brain function**

Oxycodone, on the other hand, exhibit its effects mainly in the reward centre of the brain through the reward potentiating effects of consuming this drug (Wise, 1996). Such a drug is able to increase the activation of dopaminergic neurons that are responsible for eliciting a euphoric response in Oxycodone abusers (Hays, 2004). Oxycodone is likely to exacerbate the abuse of this drug among adolescents as chronic abuse of this drug will result in brain adaptation. Due to the overwhelming stimulation of neurons by dopamine, the brain responses and adapts to this chronic stimuli by reducing the number of dopaminergic receptors. Thus, decreasing the sensitivity of these neurons to dopamine which indicates that among these abusers, there is a constant need for large amounts of dopamine to achieve the required basal levels of these transmitters in the brain (Griffin, 2012). This ultimately enhances the stimulation seeking behaviors among antisocial adolescents.

Apart from increased stimulation of dopaminergic neurons, the amygdala plays a crucial role as well in stimulating reward sensations among individuals. The central nucleus of the amygdala contains a numerous amount of endogenous opioid receptors which is able to interact with Oxycodone and so increases the reward cue to the brain. This might enhance reward seeking behaviors among antisocial adolescents as well. This is exemplified through a study carried out on rats that underwent opioid stimulation in the central nucleus of the Amygdala. Under such a stimulation, the authors observed an
increased sensitivity and attractiveness of the rats to a particular reward cue. As a result, the rats were more aggressive and vigorous in their approach in obtaining their rewards (Mahler & Berridge, 2009). Similarly, antisocial adolescents with conduct disorder have been shown to make riskier choices after obtaining small rewards. This indicates that among these adolescents, there exists a shift in their sensitivity for rewards regardless of the presence of any form of substance abuse (Fairchild et al., 2009). If these individuals were to be coupled with the abuse of Oxycodone, they may experience enhanced decision making with little to no consideration of the risks involved when obtaining the rewards. Thus, possibly making them more impulsive and aggressive than they already are in terms of seeking out rewards. As a result, the amygdala is an essential brain structure in promoting motivational salience among antisocial Oxycodone abusers.

Another key area that links Oxycodone abuse to reward seeking behaviors is the hyperactivity of the striatum as marked by increased striatum dopamine levels. Oxycodone abuse has also been shown to increase hyperactivity of the striatum only in adolescents as compared to adult mice (Zhang et al., 2009). This translates into the possibility that adolescents who abuse Oxycodone are more likely to experience this brain function abnormality. Moreover, for the case of conduct disorder adolescents, they have been observed to have increased striatal activation regardless of the presence of a reward. This implies that these adolescents are constantly seeking for rewards without taking into consideration any negative consequence which might arise from their actions (Gatzke-Kopp et al., 2009). Thus, antisocial adolescents who are Oxycodone abusers will experience heightened stimulation seeking behaviors which predisposes conduct disorder.
**Impacts of Rural Areas**

In many aspects, adolescents living in the rural areas are less well off than their urban counterparts. For instance, it is known that rural adolescents have lower Intellectual Quota (IQ) due to the lack of psychosocial stimulation achieved through education in these areas (Walker, Grantham-McGregor, Powell, & Chang, 2000; Hawk, 2011). Moreover, due to the lower levels of education available in rural areas, adolescents in these areas will be less knowlegable about the use of illicit drugs and these families tend to have negative family relations which often results in parental neglect. These social factors would no doubt increase the number of rural adolescents abusing marijuana (Ramirez et al., 2004). Another disparity between rural and urban areas is income. On average urban households earn about 32% more than rural households in terms of their yearly income (Hawk, 2011). These factors contribute to the lack of awareness of rural adolescents to the dangers of substance abuse. Thus, it is not surprising for adolescent abusers of marijuana and Oxycodone to stem from rural areas (Havens, Young, & Havens, 2011; Lambert, Gale, & Hartley, 2008).

For the case of Oxycodone, the demographics of rural areas do play a vital role in mediating abuse of this drug as well. As about 70% of the poor living in rural areas rely heavily on agriculture as their source of income (World Bank, 2014), this labour intensive workload increases the demand for painkillers such as Oxycodone in these areas compared to urban areas. Thus, increasing the ease of access of rural antisocial adolescents to such drugs especially since a major source of Oxycodone for adolescents is the legitimate prescription of Oxycodone to their parents. This is supported by increased prescription and marketing of Oxycodone to rural people in areas such as Appalachian Kentucky (Keyes, Cerdá, Brady, Havens, & Galea, 2014). Furthermore, rural
areas have higher rates of conduct disorder compared to urban areas. In the Smoky Mountain Study conducted in Appalachia, about 20% of their sample met the DSM-V CD criteria (Costello, Farmer, Angold, Burns, & Erkanli, 1997). Compared to the U.S. baseline of 9.5% of adolescents diagnosed with conduct disorder, Appalachia has a baseline of 6.5% which is relatively high (Nock, et al., 2013). Therefore, the high rate of conduct disorder coupled with high rates of Oxycodone abuse may result in increased aggression and violence in rural areas.

Another key characteristic of the rural environment is that social networks among the people are stronger than those in the urban areas. This is due to the fact that a larger emphasis is placed on community within rural areas which result in these individuals to be more likely to engage socially with those living around them (Keyes et al., 2014). This close network might promote quicker diffusion of Oxycodone prescription among adolescents, leading to higher rates of Oxycodone abuse among rural areas which will in turn promote conduct disorder among these adolescents.

Higher stress levels in rural areas attributes to higher rates of conduct disorder as well. With reference to the neurological impact of Oxycodone on the central nucleus of the amygdala among abusers, stress increases corticotropin-releasing factors in the central nucleus of the amygdala which increases anxiety among substance abusers (Mahler & Berridge, 2009). The onset of stress can in turn increase the impulsiveness of adolescents and elicit Oxycodone or marijuana craving among them. One such source of this stress is financial stress due to the higher rates of unemployment in rural areas. Due to this, individuals living in the rural areas might feel more stressed than their urban counterparts. This translates into higher levels of stress among the adolescents.
which places them in a high risk group in terms of exposure to any form of substance abuse.

With reference to Table 1, it is observed that rural Appalachia has higher unemployment rates as compared to the rest of the United States regardless of marital status which indicates higher levels of stress among rural areas. In these financially distressed families, studies have shown that there is increased parental hostility towards their children. As a result, these adolescents are more likely to be more rebellious and have behavioral problems which includes getting involved in substance abuse (Lichter & Campbell, 2005).

**Comparison of risk between marijuana and Oxycodone abusers**

Although the rates of marijuana and Oxycodone abuse are both high in rural areas, the risk in which adolescents may develop conduct disorder might differ between these two drugs.

Based on Table 2, it is observed that the mean age onset of marijuana and Oxycodone abuse differs by about 5 years. For the case of marijuana, the age onset is an average of 14 years while the mean for Oxycodone is 19 years. Based on this sole comparison of age of first use, marijuana adolescent abusers are seen to have a higher risk of developing conduct disorder. As the brain only becomes fully developed in the early 20s, the harmful neurobiological effects as aforementioned will be greater among marijuana abusers than those of Oxycodone (Health, 2011). Thus, the risk of developing conduct disorder seems to be higher among marijuana abusers in rural areas.

However, with Oxycodone being more legally recognised and easier to purchase as compared to marijuana, Oxycodone abusers do have a higher risk as compared to
marijuana abusers in rural areas in developing conduct disorder despite the later age onset of abuse (Warren, Smalley, & Barefoot, 2015). Furthermore, the purchase of illicit drugs off the street are more closely monitored by law enforcement officials and an increase rates of arrests is observed for abuse of illicit drugs than prescription drugs such as Oxycodone (Room, 2010). In another study, it is observed that adolescents’ perception of harm differs between these two drugs. Adolescents perceive marijuana to be more harmful than Oxycodone. This is coupled with the idea that Oxycodone is more socially acceptable since it is commonly used as a painkiller and its route of administration does not necessarily have to be through socially stigmatised routes such as snorting or injecting (Keyes et al., 2014). Therefore, in terms of ease of access and social perception of Oxycodone, adolescents are more likely to abuse Oxycodone in rural areas which increases their risk of developing conduct disorder as compared to marijuana.

**Conclusion**

Overall, marijuana and Oxycodone abuse are highly potent to adolescents neurologically as their brains are still in midst of development and are more sensitive towards the harmful effects of substance abuse. This would in turn promote conduct disorder related behaviors among these adolescents and the risk as discussed above is higher for oxycodone abusers living in the rural areas. However, with the increased awareness of health implications of Oxycodone abuse, governments are exhibiting greater control in the availability of Oxycodone. For instance, the Canadian government has banned the sale of Oxycodone in their health markets. However, this does not serve as an effective deterrent for opioid abuse as opioid consumption in Canada is found to be even higher than that of the U.S despite the ban (Paperny, 2013). This implies that people are
seeking alternative sources of opioids such as heroin instead (Cicero & Ellis, 2015).
Thus, it may be possible in future for heroin opioid abuse to takeover Oxycodone abuse
which could have detrimental implications on adolescents especially antisocial
adolescents and the risk of developing conduct disorder as well.

Future considerations involving alternative measures to reduce Oxycodone abuse aside
from prohibiting the sales of this drug should be conducted in order to effectively tackle
this issue. One such possibility would be the implementation of better monitoring
programmes such as the geographic information systems which can offer real time post-
marking surveillance on opioids prescribed (Ilhan et al., 2009). This could potentially
provide more accurate surveillance of opioid usage. Therefore, future studies should be
conducted on potential surveillance methods to be implemented in rural areas with a
more streamlined focus on antisocial adolescents who pose a larger risk of developing
conduct disorder in the presence of substance abuse.
References


http://www.nimh.nih.gov


Tables

Families in poverty, by family type and employment status of householder, Appalachia and non-Appalachian United States, 2000

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Source: U.S. Census Bureau, 2000 census.

Table 1. Comparison of rates of unemployment between rural Appalachia and Urban U.S. (Lichter & Campbell, 2005)
Table 2. Comparison of age onset of marijuana and Oxycodone abuse between rural and urban areas (Leukefeld et al., 2002)