How to Decrease Adolescent Smoking
Using Cognitive Neuroscience to Lower the Prevalence of Smoking among Young Adults

Cigarette smoking causes nearly one in five deaths in the United States (CDC, 2012). Its death toll is greater than that of the human immunodeficiency virus (HIV), illegal drug use, alcohol use, motor vehicle injuries, suicides, and murders combined (CDC, 2012). Furthermore, tobacco has been identified as an even more powerful gateway drug than alcohol in increasing the likelihood of subsequent use of illegal drugs such as cocaine, heroin, crack and marijuana (Johnson, Boles, & Kleber, 2008). Yet, it is also in many ways the single most preventable health concern (CDC, 2011). In 2010, about one in five adults aged eighteen or older were smokers (ALA, 2011). Of these people, nine out of ten began smoking before the age of eighteen (Rosenberg, 2012). Research has shown that smokers who began young are much more likely to develop into long-term users and have much greater difficulty quitting later as adults (Xiao et al., 2008). This finding suggests that adolescents remain a key segment of the population to target in order to decrease the prevalence of smoking as a whole.

In the past, efforts to curtail smoking have mainly focused on preventing adolescents from starting (Carpenter, 2001). Policymakers’ rationale for this has traditionally been based on the belief that getting adolescents who have already started smoking to quit is close to impossible given their propensity for risk taking (Carpenter, 2011). Recently, it has become apparent that while current efforts are working, the downward trend in adolescent smoking has slowed (Johnston, 2012). Since adolescence is a critical period before people progress into long-term smokers, policymakers should focus on helping adolescents quit smoking. Ignoring such an important segment of the population would greatly hinder ongoing efforts to decrease tobacco use. A close examination of the latest research in cognitive neuroscience suggests that there is hope for finding more effective ways to help adolescents quit smoking before they become regular, long-term smokers. Currently, policymakers have advocated for punishment-based approaches such as graphic warning labels or an increase in the legal age for purchasing tobacco in order to decrease smoking prevalence.

However, adolescents’ brains are still developing, particularly in the ventral medial prefrontal cortex (VmPFC) and ventral striatum regions which are important for successful integration of emotions and logic during decision-making and providing mental resistance to peer pressure, respectively. Consequently, adolescents often exhibit shortcomings in decision making in response to risk’s causal complexity, the allure of reward during decision-making, and social influences. Thus, such punishment based teaching methods should actually be
avoided. Instead, efforts should be aimed at developing a smoking cessation program that appeals to rewards based learning, augments their ability to resist negative social influences, and increases their ability to identify and understand the actual danger of risks with high causal complexity.

With brains that are still developing in many regions, adolescents have a particularly difficult time decision-making about risks and rewards, which involve the simultaneous application of prior beliefs, emotions, and logic (Evans & Feeney, 2004; Navqi, Shiv, & Bechara, 2006; Tversky and Kahneman, 1982). A common scenario that adolescent smokers might face is whether or not to accept a cigarette offered by a friend while surrounded by a group of friends who also smoke. In considering, they must decide whether the dangers of smoking or “punishment” are worth the possible “rewards” to be gained from accepting the cigarette. The rewards to be gained from accepting include a sense of peer acceptance and the neurochemical pleasure caused by the nicotine in tobacco. On the other hand, possible punishments include increased risks for lung cancer, heart disease, and respiratory diseases (CDC, 2012). Using this cigarette scenario as a starting point, further analysis of the neurocognitive features of the developing adolescent brain is necessary to reveal what exactly causes adolescent smokers to go wrong in their reasoning. In particular, we will examine three consequences of underdevelopment of the VmPFC and ventral striatum: distorted prior beliefs of the risks of smoking as a result of the combined effect of causal complexity and decreased loss aversion, unresponsiveness to punishment, and an inability to resist social pressure, each followed by some better strategies that harness adolescents’ cognitive tendencies to elicit the optimal results in smoking cessation.

Since adolescent smokers by definition have smoked before, the past experiences of smoking will most likely influence them to develop a set of their own perceptions of the risks of smoking. These perceptions make up their prior beliefs and will guide them throughout the decision making process. It is important to note that people’s perception of a risk may not always correspond to the actual magnitude or danger of the risk. This imbalance is due to risk’s causal complexity, or the intricacy of causes and effects. According to Grotzer, Miller, and Lincoln’s (2012) causal complexity taxonomy, there are six dimensions that define a risk’s causal complexity. They are: time period, reliability, obviousness, spatial proximity, agency-distribution, and agency-intentionality. Within each dimension, perceived salience of a risk varies inversely with complexity (Grotzer et al., 2012). Thus, risks that are perceived as having low salience have high complexity and tend to be probabilistic, non-obvious, distant, decentralized, non-intentional, and have a long time delays. The opposite holds true for risks with low complexity.

In the case of smoking, some of the hallmark negative effects include lung cancer, stroke, coronary heart disease, and emphysema, a respiratory based disease (CDC, 2012). In terms of time, all these diseases are slow developing in nature, involving long periods of delay between the cause—smoking—and the associated effect—these serious illnesses. Choosing to smoke a single cigarette on one occasion will likely not cause an immediate, noticeable difference in the overall health of an adolescent. Negative effects will typically become apparent only with long-term smoking. This long time delay corresponds to
high causal complexity according to Grotzer et al.’s (2012) causal complexity taxonomy and low perceived salience. Furthermore, the effects of smoking are mostly non-obvious in nature. While some of the negative effects of smoking such as stroke may be easily perceptible when it occurs, other diseases such as cancer, heart disease, and emphysema are difficult to perceive externally unless they have progressed beyond a certain point or threshold. Even then, the diseases are difficult to identify unless people are specifically looking for the signs. The non-obvious nature of smoking adds to its overall causal complexity and low salience. Finally, a third factor is the reliability of negative effects to the cause. When an adolescent smokes, the chances of experiencing the negative effects likely depend on a multitude of factors such as genetic disposition and lifestyle choices. Some adolescents may be predisposed towards getting certain diseases due to race or heredity. Others may be more likely to develop heart disease because of a diet consisting mainly of fast food and a lack of exercise. Thus, the risks are very probabilistic in nature, which means they are of high complexity and low perceived salience. The combination of three highly causally complex aspects of smoking will likely lead adolescents to perceive smoking as less dangerous of a behavior than it actually is. This low perceived salience form a fundamental part of adolescent prior beliefs about the risks of smoking.

In addition to low perceived salience, adolescents’ natural lack of loss aversion as compared to adults due to neurological immaturity forms a vital part of their prior beliefs as well (Blakemore & Robbins, 2012; Pfeifer, 2011). Loss aversion is defined as a decision-making bias where any change that may result in a loss is seen as not worthwhile despite the potential for gains (Sunstein, 2002). In other words, even though a change may bring potential rewards, people tend to focus on the loss it may incur. Adolescents have a still-developing ventral striatum and ventral medial prefrontal cortex (VmpFC), two regions activated when loss aversion reasoning occurs (Pfeifer, 2011; Tom et al., 2007). It has been discovered that adolescents exhibit less activation of those two regions than adults during decision-making (Pfeifer, 2011). This lack of activation in adolescents likely leads to a decreased sense of loss aversion, in which adolescents demonstrate a tendency to try or explore new things with less fear of loss or negative effects. While this attitude is generally beneficial during people’s adolescent years, a time for learning, when this phenomenon is coupled with an already low perceived salience, this may lead to prior beliefs that cause adolescents to seriously underestimate the risk of smoking and make dangerous choices.

The combined effect of causal complexity and loss aversion in distorting adolescents’ prior beliefs of risk can be seen in their current misunderstanding of the actual risk of smoking. Despite the best efforts of policymakers to educate adolescents, a study conducted by Romer and Jamieson (2001) has found that while adolescents generally understand and even overestimate the risks of getting diseases like lung cancer, they either do not know or underestimate the actual chances of dying from smoking-related diseases after getting it. They also tend to be overly optimistic when estimating their ability to quit when they would like to (Romer & Jamieson, 2001). This misjudgment of the extremely addictive nature of cigarettes further exemplifies how underdevelopment of the adolescent brain causes an imbalance
between adolescents’ perception of risk and the actual risk of smoking.

To address this tendency to underestimate the dangers of smoking and overestimate their degree of self-control, new efforts in helping adolescents quit should first help them realize the causally complex nature of smoking and everyone’s natural tendency to discount the danger as a result. This can be done through introducing the idea of Grotzer’s complex causality taxonomy and presenting case studies where adolescents are given a chance to first estimate a health risk and then assess it according to the six dimensions of the taxonomy. Additionally, policymakers should extend the curriculum to cover not only the chances of getting serious illnesses as a result of smoking, but also the chances of death and other negative outcomes of the illnesses themselves. This addition would fill in any gaps in adolescents’ current knowledge of the risks. To make up for the lack of loss aversion, the curriculum should also include an aspect that teaches adolescents to value and appreciate what they have in terms of family, love, happiness, etc. By promoting appreciation of their current lives, adolescents may develop a sense of greater attachment to it and exhibit more fear of losing what they have. This modification in the curriculum will hopefully increase adolescents’ sense of loss aversion in face of risks such as smoking. The three changes would address the specific shortcomings and barriers in educating teen smokers about the true risks of the behavior.

In addition to the influence of prior beliefs, adolescent decision-making in the cigarette scenario also involves the application of both logic and emotions. Since adolescents can not predict with certainty the likelihood of experiencing the negative effects of smoking, adolescents will likely have to resort to heuristics and biases as logical mental shortcuts to weigh the pros and cons (Tversky & Kahneman, 1982). Emotions form the other key aspect of the reasoning process, subconsciously influencing people to make choices that result in the maximum reward and minimum punishment such as in the cigarette scenario (Navqi et al., 2006). The VmPFC has been found to be important for successful integration of emotions and logic in the decision-making process (Sanfey, Hastie, Colvin, & Grafman, 2003). The Iowa Gambling Task (IGT) is a test often used to measure the functionality of people’s VmPFCs (Sanfey et al., 2003). Performance trends on the IGT have led researchers to propose that the VmPFC may be involved in predicting emotional consequences of potential punishments (Navqi et al., 2006). That is, it acts as a bridge connecting the logical and emotional components of decision-making. A lack of a functional VmPFC likely results in a disconnect where the person does not feel the emotions of dismay, anger, or loss normally experienced when one loses money such as during the IGT simulation. As a consequence, they are not able to respond to punishment based learning as well as reward based learning (Wheeler, 2006). Hence, they will likely continue to make disadvantageous decisions because their decisions are based on immediate rewards rather than long-term negative consequences (Bechara, Tranel, & Damasio, 2000).

Given the known relative underdevelopment of adolescents’ VmPFC region when compared to adults, several studies conducted on different populations of adolescents have confirmed that adolescent performance on the IGT to be worse
than that of normal adults (Hooper, Luciana, Conklin, & Yarger, 2004; Overman et al., 2004). An additional study demonstrated that 10th grade adolescent smokers who have smoked within the past week performed even worse on the IGT than normal adolescents who are nonsmokers or those who have smoked within the past 30 days rather than the past week (Xiao et al., 2008). This result suggests that adolescent smokers have even less mature or more dysfunctional VmPFCs than normal adolescents. Although the directionality of the relationship between smoking and a less functional VmPFC is unclear, one possibility is that this neurological difference plays an important role in predisposing adolescents to become smokers in the first place and choosing to continue to smoke once they begin. It is also possible that smoking may hinder development of the VmPFC in adolescents once they begin and works to perpetuate a continuous cycle of poor decision-making.

The especially immature VmPFCs of adolescent smokers likely compound normal adolescent tendencies to value immediate rewards in the cigarette scenario. A neuroanatomical explanation for this is that adolescents’ VmPFCs lack the network of white and gray matter seen in adults (Overman et al., 2004). From this, it is reasonable to hypothesize that the network of white and gray matter in the VmPFCs of adolescent smokers are even less developed than that of the average adolescent. Thus, adolescent smokers will likely be more neurocognitively predisposed to accepting the cigarette than normal adolescents or less frequent smokers in light of the tantalizing rewards of both peer approval and pleasure from nicotine. At the same time, they will likely be less responsive to punishment or potential negative long-term consequences such as heart disease, cancer, or respiratory diseases as well. The neurological immaturity of the VmPFC region may bias adolescent smokers in their logical consideration of the cigarette situation. It will likely lead adolescent smokers to see only the rewards as on-screen, or at the forefront of their minds, while the punishment or negative effects remain mainly off-screen (Sunstein, 2002).

The on-screen-off-screen bias associated with adolescent smokers suggests that recent initiatives to decrease smoking prevalence through a punishment-based approach may be misguided. These initiatives include efforts to initiate government mandated labeling of cigarette packets with large graphic images of the negative outcomes (Young, 2011). Policymakers have also suggested increasing the legal smoking age from 18 to 21 as a possibility (Steinberg, 2011). While both ideas seem promising at first glance, such methods do not take into account the cognitive neuroscience behind decision making by adolescent smokers. Since adolescent smokers have particularly underdeveloped VmPFCs, they react much better to reward based learning than punishment. Therefore, using punishment based methods such as negative images on cigarette packets, which may be emotionally disturbing, will most likely have little effect since their immature VmPFCs allow them to easily place negative future consequences off-screen. Similarly, increasing the smoking age would take the right to legally smoke away from adolescents, which is another punishment-based approach. This initiative will likely not be very effective because adolescent smokers are neurocognitively unable to integrate the negative emotions elicited by the punishment resulting from
breaking the law into future decisions. Currently, even with a legal smoking age of eighteen, nine out of ten smokers still began smoking before the age of eighteen (Rosenberg, 2012). The numbers indicate that increasing the age limit would have little overall effect in smoking cessation. Adolescents will likely continue to find ways to obtain cigarettes and smoke no matter the consequence. In both circumstances, the target audience, adolescent smokers, would be largely unreceptive. Thus, pursuing either of these initiatives would be a waste of time and resources.

Since adolescent smokers have especially dysfunctional VmPFCs that make them unreceptive to punishment, as an alternative, policymakers should concentrate efforts on developing an adolescent smoking cessation program that appeals to rewards based learning. Rewards in the cessation program should be two fold, both material and psychological. Potential material incentives could include offering monetary or other concrete rewards during the cessation program. Psychological incentives might include teaching adolescents to find pride and satisfaction in maintaining self-control and not succumbing to the temptations of smoking. Both kinds of rewards should be simultaneously given over the course of the program because different adolescents may respond better to one over the other depending on their personal traits. However, after the cessation program ends, continuously providing material incentives to every adolescent ex-smoker seems rather impractical in light of the enormous cost. For this reason, continued abstinence from smoking after the end of the program would mainly have to depend on psychological rewards to encourage permanent cessation. While material rewards can be used up, psychological rewards such as satisfaction and pride remain since it originates from the mind. Thus, such rewards would be helpful in reinforcing continued cessation.

Of the rewards that are on-screen, social approval will likely hold particular importance for adolescent smokers. The weight placed on it is a third consequence of the underdeveloped adolescent brain—specifically in the ventral striatum region in comparison to adults. The ventral striatum has been, found to be an important reward-processing center responsible for providing mental resistance to peer pressure (Pfeifer et al., 2011). With weaker ventral striatums, adolescents will be less able to overcome the allure of peer approval. Since peer pressure is a prominent factor in the cigarette scenario, it is likely that the underdevelopment of the ventral striatum will augment the effects of a social cascade. A social cascade is a heuristic-like process where one person’s strong beliefs in something that others are unsure about initiates a chain reaction where other people come to agree with the belief because they think everyone else agrees (Sunstein, 2002). Researchers have found that whether one’s friend group smokes is a major factor in influencing smoking in adolescents (McLeod et al., 2008). According to the cigarette scenario, since everyone in the group is a smoker, the act of offering a cigarette will likely trigger an immediate social cascade in which there will be a transfer of opinion from the group to the adolescent being offered the cigarette. Since adolescents are particularly weak at resisting the allure of peer approval, they are more likely to give in and accept the cigarette than adults with normally functioning ventral striatums. Hence, an underdeveloped ventral striatum likely augments the effects of a social cascade, ultimately significantly
reducing any doubts or reservations the adolescents had about the risks of smoking or negative effects.

In order to enhance the ability of adolescent smokers to resist negative social influences, cessation programs should also include a component that trains adolescents to resist peer pressure and other negative social influences. The training would help counteract adolescents’ weakness and tendency to give in to peer pressure due to a lesser developed ventral striatum. This may be done through tasks that simulate situations where one is offered a cigarette and teach proper ways to react. These tasks would provide mental preparation for what to expect in such social circumstances. Another possibility would be to design tasks that boost adolescents’ self-esteem. With self-esteem, adolescents may feel less of a need to conform with their peers. This aspect of the cessation program will play a critical role in preventing adolescents from relapsing into smoking after quitting.

Smoking has been a devastating but preventable health concern for far too long in the U.S. With recent advances in cognitive neuroscience, we now have the knowledge to decrease smoking prevalence as a whole by focusing on helping adolescent smokers quit. Although many factors, including causal complexity, mental heuristics, social circumstances, and an underdeveloped brain especially in the VmPFC and ventral striatum regions likely cause adolescent smokers to choose to continue smoking, we can also use the neurocognitive shortcomings of the adolescent brain to our advantage in developing a better smoking cessation program. A close analysis of adolescent brain functions demonstrates that policymakers should work toward implementing a program that helps adolescents quit through teaching with reward-based approaches, honing resistance to social pressure, and correcting misperceptions of risk due to a lack of loss aversion by emphasizing a comprehensive view of the actual risks of negative outcomes. The implementation of such a program will likely provide the necessary impetus to rejuvenating the downward trend in the prevalence of smoking in the U.S. Although this program may not be a panacea to eliminating smoking completely in society, it is an important first step to saving numerous lives.
References


