

# Substance-use in Childhood and Adolescence: A Brief Overview of Developmental Processes and their Clinical Implications

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## Abstract

**Objective:** The current paper aims to review findings from developmental research that are related to adolescent substance-use and are considered key for improving theory and developing effective prevention. **Method:** A selective literature review of relevant developmental studies on adolescent substance-use was conducted. **Results:** Studies in epidemiology and developmental science focusing on developmental onset, developmental transitions, comorbidity among disorders, and endophenotypes have identified important trends, risk-factors for and consequences of adolescent substance-use, which have informed theoretical models of addiction. Furthermore, they have informed clinical practice by identifying childhood disorders and personality characteristics that can be targeted preventatively before substance-use problems have their onset. **Conclusions:** Developmental research has contributed significantly to the understanding of aetiology and treatment of substance-use disorders. By targeting early liability factors rather than substance-use problems later in adolescence, interventions could reduce the adverse impact substance-use has on the developing brain as well as other associated harms.

**Key Words:** *substance-use, adolescence, development, aetiology, prevention*

## Résumé

**Objectif:** Le présent article vise à examiner les résultats de la recherche développementale qui ont trait à l'utilisation de substances des adolescents, et qui sont considérés essentiels pour améliorer la théorie et mettre au point une prévention efficace. **Méthode:** Une revue sélective des études développementales pertinentes de la littérature sur l'utilisation de substances des adolescents a été menée. **Résultats:** Les études en épidémiologie et en science du développement portant sur le début développemental, les transitions développementales, la comorbidité parmi les troubles, et les endophénotypes ont identifié d'importantes tendances, les facteurs de risque et les conséquences de l'utilisation de substances des adolescents, et cette information a contribué aux modèles théoriques de la toxicomanie. En outre, ces études ont éclairé la pratique clinique en identifiant les troubles de l'enfance et les caractéristiques de la personnalité que la prévention peut cibler avant que n'apparaissent les problèmes d'utilisation de substances. **Conclusions:** La recherche développementale a significativement contribué à la compréhension de l'étiologie et du traitement des troubles liés à l'utilisation de substances. En ciblant tôt les facteurs de responsabilité plutôt que les problèmes d'utilisation de substances plus tard à l'adolescence, les interventions pourraient réduire l'effet nuisible de l'utilisation de substances sur le cerveau en développement ainsi que d'autres méfaits connexes.

**Mots clés:** *utilisation de substances, adolescence, développement, étiologie, prévention*

The transition from childhood to adolescence is characterised by important biological, cognitive, emotional and social changes. This period is heavily marked by the onset of and progression through puberty, greater autonomy and less self-regulation, and changes in parental and peer relationships. Despite these substantial changes, most young

people experience this transition positively. However, adolescence is also a time when risk-factors for substance-use and other psychiatric disorders begin to manifest themselves and, in interaction with rapidly changing social and biological contexts, can set off deviant trajectories which, if left untreated, can lead to severe and long-term disability

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Submitted: July 9, 2012; Accepted: November 19, 2012

later in life. The aim of this paper is to provide a brief overview of some of the developmental processes involved in adolescent substance use and how developmental studies can inform clinical practice. In no way should this review be considered a comprehensive review on adolescent substance use, but rather an introduction to developmental research on adolescent substance use. For more comprehensive reviews on different developmental aspects of and risk factors for substance use, see Hawkins, Catalano and Miller (1992), Sher, Grekin and Williams (2005), Casey and Jones (2010), and Gladwin, Figner, Crone and Wiers (2011). See also Salvo et al. (2012) for a systematic review of findings from preventative interventions for substance use behaviours in youths with, or at high-risk for, mental disorders.

## Epidemiological studies: prevalence of adolescent substance-use

Epidemiological studies across the lifespan have shown that adolescence is an important developmental period for the onset of substance-use and misuse, with some considering exploratory drug use as normative during this period. Canadian statistics show that more than 60% of illegal drug users are aged 15-24 years of age and that, depending on the province, 19-30% of 12-18 year olds report binge drinking in the past month, and 17-32% report using cannabis in the past year (Young et al., 2011). Trends across European countries are similar, with 39% of 15-16 year olds reporting binge drinking in the past month, and 17% having consumed cannabis in the past year (Hibell et al., 2012). While there is some evidence that drinking and binge drinking rates have declined in the last five years in the United States, marijuana and some illicit drug use (e.g., MDMA) have increased during this period (Johnston, O'Malley, Bachman, & Schulenberg, 2012). More troubling are results showing that the age of onset of alcohol-use has been decreasing over the last 35 years, with youth now initiating drinking at 12 years on average (Johnston, O'Malley, Bachman, & Schulenberg, 2011), and the median age of onset of substance-use disorders (SUDs) at around 15 years of age (Merikangas et al., 2010).

Epidemiological and developmental studies can not only inform on the trends in prevalence of normative and problem substance use, but can also inform on nosology, aetiology and how substance use disorders may manifest themselves later in adulthood. Developmental studies can also inform on how age of onset interacts with key developmental processes to affect the course of substance use disorders. Accordingly, the next sections will focus on some of the findings that have resulted from different developmental questions and methodologies, namely those attempting to understand developmental onset, developmental transitions, comorbidity among disorders, and understand developmental endophenotypes - i.e., characteristics or behaviours that

link specific genotypes with diseases or problem behaviours (Thatcher & Clark, 2008).

## Understanding developmental onset

Studies focusing on the developmental onset of substance-use have shown that alcohol and drug use before the age of 14 years is associated with a plethora of short- and long-term negative consequences. These include school dropout, higher risk for assault, suicide, alcohol poisoning, behavioural and mental-health problems, with all alcohol-use and its consequences accounting for almost 4% of the global burden of health (World Health Organization, 2011). With knowledge gained through developmental research, it is estimated that 40% of this early-onset group will be diagnosed with alcohol dependence later in adulthood (Grant & Dawson, 1998). Because of this, delaying onset could change the prevalence and nature of future adult-onset substance use disorders.

## Developmental processes in the transition from childhood to adolescence

Studies focusing on key developmental milestones show that puberty is a sensitive period associated with the onset and/or increase of emotional and behavioural problems, including substance-use. Early-maturing adolescents have been shown to initiate smoking and drinking earlier and to be more likely to experiment with other illegal substances than later-maturing adolescents.

Studies investigating key cognitive and neural changes occurring during this maturational period have contributed to the formulation of a "dual-systems" model of risk for addiction (Steinberg, 2008), which posits that heightened risky behaviours in adolescence, including substance-use, are a product of the interaction between the level of development of two distinct neurobiological systems: a socio-emotional system, localized primarily in limbic and paralimbic areas of the brain, and a cognitive-control system, mainly associated with lateral prefrontal and parietal cortices. According to this model, risky behaviours increase due to a relatively more rapid development of the socio-emotional system, which is hypothesized to lead to increases in dopaminergic activity and sensation-seeking. However, this happens before the cognitive control system, associated with self-regulation and impulse control, is fully developed, which is not until the end of adolescence or early adulthood. Vulnerability to risk-taking during adolescence would therefore be heightened when a fast-developing socio-emotional system combines with a slow-developing cognitive control system.

It is well established that, regardless of developmental period, chronic exposure to alcohol and drugs is associated with neural changes in the reward circuitry of the brain

(Robison & Nestler, 2011). However, developmental studies suggest that as the adolescent brain undergoes significant neuromaturation it is particularly susceptible to damage caused by acute and chronic effects of alcohol. This has been shown to be true in rodent models (Crews, He, & Hodge, 2007) and humans (McQueeney et al., 2009), where alcohol-neurodegeneration is more severe in adolescent than adult brains, particularly in the hippocampus and areas of the prefrontal cortex. In addition to this neurodegeneration, alcohol-related neuropsychological deficits have also been shown in adolescents, even in non-problematic, social drinking adolescents (Squeglia, Spadoni, Infante, Myers, & Tapert, 2009). This is compounded by the fact that animal studies show that adolescents are not only more sensitive to the cognition-impairing effects of alcohol, but that they are less sensitive than adults to the motor-impairing and sedative effects of alcohol. The reduced sensitivity to these aversive effects, typically associated with moderate alcohol consumption, may contribute to the high rates of binge drinking in adolescence. These and human neuroimaging studies have inspired a new area of research in the field of addiction treatment which attempts to enhance neurocognitive factors that may be impaired in adolescent and adult substance users (Houben, Wiers, & Jansen, 2011).

Studies focusing on social development have shown that in addition to the physical and biological changes described above, children's social environments also change dramatically during adolescence. Not only are there changes in school environment brought about with the entry to high-school, where peer groups widen, and supervision becomes more diffused among multiple teachers, but other important changes happen within the family and peer groups. As children move into adolescence, they spend less time with the family, favoring time and activities with peers where quality adult supervision is reduced. This does not mean, however, that family factors do not play an important role in children's development during this period. A positive relation with one's parents (i.e., feeling accepted, good communication, parental monitoring) has been shown to reduce future alcohol consumption (Nash, McQueen, & Bray, 2005). Conversely, parents of children who later go on to develop substance abuse problems tend to decrease family management in early- to mid-adolescence.

Although a number of positive outcomes have been identified as coming from greater autonomy and affiliation with peers, affiliation with deviant or substance-using peers is associated with a higher risk of engaging in substance-use, delinquency and risk-taking behaviours (Gardner & Steinberg 2005). Youth's perception of social norms around substance-use has been shown to impact on their behaviours, and many youth overestimate levels of substance-use among peers, and are consequently more likely to use substance themselves (Edwards et al., 2008). A number of studies have demonstrated that the effect of peers on risk-taking behaviours is at its strongest in early- to mid-adolescence,

and that peer acceptance activates the same brain regions as other non-social-based rewards (Guyer, Chaote, Pine, & Nelson, 2012), and may therefore facilitate substance-use in peer contexts.

## Studies of psychiatric comorbidity from a developmental perspective

Associations between substance-misuse and other mental-health disorders are reported in a number of large-scale epidemiological studies, and comorbidity between substance-misuse and internalising or externalising problems is common (Kandel et al., 1999; Hasin, Stinson, Ogburn, & Grant, 2007), both in adulthood and childhood and adolescence.

Studies examining the prospective link between childhood internalising problems and adolescent substance-use show that children with high negative-affect, depression or anxiety symptoms are more likely to initiate alcohol-use early (King, Iacono, & McGue, 2004), have higher marijuana use (Wittchen et al., 2007) and have alcohol use disorders (Mason, Hitchings, & Spoth, 2007) in adolescence and early adulthood.

Externalising problems in childhood have also been associated with substance-misuse in adolescence (van Lier, Huizink, & Crijnen, 2009), of which conduct disorder is the most consistent predictor of later substance-misuse (e.g., Fergusson, Horwood, & Ridder, 2007; White, Xie, Thompson, Loeber, & Stouthamer-Loeber, 2001). Attention deficit/hyperactivity disorder has also been associated with adolescent substance-use, although some suggest this is largely due to the co-occurrence of conduct disorder symptoms or executive function deficits (Dawes et al., 2000).

Many of these disorders have been shown to predate substance-misuse, and thus are considered risk-factors. However, some studies also show that substance misuse can predict higher internalising and externalising problems. The use of developmental methodologies such as cross-lag panel models has allowed the study of comorbid disorders in a way that determines directionality among disorders. For example, studies using this methodology have been able to confirm that antisocial behaviours predate adolescent alcohol misuse, but that bi-directional effects are also possible in some contexts (Young, Sweeting, & West, 2008). Although these types of studies provide insight into directionality, they do not provide insights into how these disorders relate or the mechanisms involved. Some studies have suggested that these disorders and adolescent substance use share a common underlying aetiology, which may account for a proportion of the comorbidity between them (Castellanos-Ryan & Conrod, 2012).

## Identifying endophenotypes: temperament and personality

One area where developmental research has made important contributions is in the study of endophenotypes. Temperamental and personality characteristics have been shown to mediate genetic risk for adolescent and adult substance use and to some extent their co-occurring disorders (Laucht, Becker, Blomeyer, & Schmidt, 2007), identifying them as important endophenotypes of substance use.

A number of developmental studies have shown that personality traits are associated with different patterns of substance-use and misuse through different motivational processes. Neuroticism, hopelessness and anxiety-sensitivity are associated with substance-use and alcohol problems, and individuals with elevated levels of these traits use substances in order to regulate a negative affective state, e.g., to cope with depression (Grant, Stewart, & Birch, 2007). However, although anxiety-sensitivity has been consistently associated with self-medication motivations for substance-use and increased substance-use in adults, this relationship has not been consistently shown in early- and mid-adolescence (Castellanos-Ryan & Conrod 2012), suggesting that this personality characteristic may be associated with vulnerability to substance-misuse only later in development.

Disinhibition/impulsivity has often been associated with the consumption of a range of different substances (Le Bon et al., 2004), with early-onset and experimentation, and with other externalising disorders (Iacono, Malone, & McGue, 2008). Sensation-seeking has also been frequently associated with adolescent alcohol-use, binge drinking and drug use (Krank et al., 2011). Individuals high in sensation-seeking generally use substances for enhancement motives (Cooper, Frone, Russell, & Mudar, 1995) and show a specific sensitivity to reward, including drug-induced reward (Leyton et al., 2002).

Children's temperament manifests early in life, and behavioural differences (e.g., undercontrolled versus inhibited) as early as three years of age have been shown to differentially predict psychopathology in adulthood, as well as to increase the likelihood of having alcohol-related problems (Caspi, Moffitt, Newman, & Silva, 1996). Thus, early in life individuals can be situated on developmental pathways that increase or decrease the likelihood of SUDs, and these risk trajectories for SUDs can be detected at various developmental stages. Thus developmental studies can identify these endophenotypes that can predict future risk before symptom onset, but also inform aetiology by identifying more specific biological and cognitive deficits that predate the onset of SUDs (Castellanos-Ryan, Rubia, & Conrod, 2011). Furthermore, these processes can be targeted in prevention approaches, offering an opportunity to prevent subsequent harm of substance use on other developmental processes, thus disentangling the cause of substance use from its consequences.

## Prevention and intervention approaches

Most prevention approaches for substance-misuse are universal in nature, with strategies targeting drinking and drug-use behaviours directly. Unfortunately, many universal approaches have largely been shown to be ineffectual (Foxcroft & Tsertsvadze, 2011). Many of these programs target misperceptions around social norms for substance-use. Universal approaches have shown effects on attitudes towards substance use, but not necessarily on behaviours, suggesting that explicit attitudes do not translate directly to behaviours or play a key role in reasons to use substances. Thus, recent research has focused on more implicit motivation or other factors identified through developmental research that could be targeted in interventions. Two selective prevention approaches informed by developmental research are showing promise in the prevention and reduction of substance-misuse in adolescence.

The first approach targets childhood psychopathology symptoms, particularly disruptive and conduct problems. One such example is a study implemented throughout the United States, which showed that 12-year old children with high levels of disruptive behaviours who were randomized to a parent-training ("family check up") intervention reported lower substance-use by the age of 14 years compared to matched controls (Stormshak et al., 2011). A Dutch study (van Lier et al., 2009) also found that children randomized to receive an intervention targeting disruptive behaviours in the classroom (the "good behaviour game") from ages 7 to 9 years had lower probabilities of tobacco use between ages 10 and 13 years. Some of the effects reported in these studies were moderate to large in size. The second promising selective approach is a personality-based model targeting personality risk-factors for early-onset drinking or illicit drug use. This school-based programme uses a brief personality questionnaire, the Substance Use Risk Profile Scale (Krank et al., 2011), to identify and target youth with elevated scores on four personality risk-factors: hopelessness, anxiety-sensitivity, impulsivity and sensation-seeking. Youth who score one standard deviation above the mean on any of these traits are invited to participate in two 90-minute intervention sessions, which are held during class-time, are manualised, and are based on a cognitive-behavioural and motivational approach. This school-based program has now been shown to prevent alcohol and substance-misuse in three separate trials across Canada and the United Kingdom (Conrod, Castellanos-Ryan, & Mackie, 2011; Conrod et al., in press). It is noteworthy that beneficial effects are found after only two brief group-based sessions, focusing entirely on management of the risk factors and not on substance use.

Studying the process by which these targeted intervention programmes have long-term effects on substance-related problems has provided new insights into the aetiology of



addiction. Regarding the personality-targeted approach, it is clear that interventions are not changing personality, rather they change how youth cope with their personality profile (Conrod et al., 2011). Furthermore, by reducing substance use in these high-risk adolescents it has now been shown that substance use in low-risk adolescents who affiliate with these peers can also be reduced (Conrod et al., in press). In this way, these intervention approaches are not only beneficial in terms of the impact they have on substance use prevention, but also provide much needed opportunity to test the clinical validity of theoretical developmental models.

## Summary and conclusion

Risk-taking behaviours and some substance-use are normative during adolescence. However, it is clear that adolescents vary in their maturation, as well as in early risk-factors such as childhood disruptiveness, impulsivity and sensation-seeking, all of which are associated with substance-related problems in later life. Although many such risk factors have been identified, there is little evidence of a prodrome for substance use disorders (i.e. a symptom or sign that forewarns that a disease is present prior to the full manifestation of the disorder; see Costello & Angold, 2010). That said, research involving developmental samples or methodologies has significantly contributed to the study of substance use disorders, both in terms of informing theories of aetiology and guiding novel prevention and intervention approaches. More specifically, this research has: 1) contributed to the development of a mental-health perspective of addiction; 2) highlighted the fact that genetic predisposition can be measured at an endophenotypic level; and, 3) identified phenotypes that can be targeted by interventions, and that by targeting disruptive or impulse-control problems in childhood, or personality characteristics in early adolescence, for example, one could pre-emptively reduce adolescent substance-use and some of its negative consequences. Research on targeted interventions should now begin to examine the mechanisms by which they produce long-term preventative effects on substance misuse, to provide guidance on how to further improve prevention efforts and identify additional targets of intervention at specific developmental stages. It is clear from the developmental literature on risk-factors for SUDs that a number of key risk-factors can be measured throughout childhood and adolescence and that these interact both positively and negatively with key developmental milestones.

## Acknowledgements / Conflicts of Interest

This research was made possible by a fellowship to NC-R from the Fonds Québécois de Recherche en Santé, and a Scientist career award to PJC (2010-2013) from the Fondation de Recherche en Santé du Québec (FRSQ), and a Canadian Institute of Health Research (CIHR) grant. MOLB is funded by an AFR grant from the Fonds

National de la Recherche (FNR) du Luxembourg and CEDIES Luxembourg.

## References

- Casey, B. J., & Jones, R. M. (2010). Neurobiology of the adolescent brain and behavior: Implications for substance use disorders. *Journal of the American Academy of Child and Adolescent Psychiatry*, 49, 1189-1201.
- Casey, A., Moffitt, T. E., Newman, D. L., & Silva, P. A. (1996). Behavioral observations at age 3 years predict adult psychiatric disorders. Longitudinal evidence from a birth cohort. *Archives of General Psychiatry*, 53, 1033-1039.
- Castellanos-Ryan, N., & P. J. Conrod (2012). Personality and substance misuse: Evidence for a four factor model of vulnerability. In Verster, J., Brady, K., Galanter, M., & Conrod, P. J. (Eds.) *Drug Abuse and Addiction in Medical Illness: Causes, Consequences and Treatment* (pp. 47-62). New York, NY: Springer Press.
- Castellanos-Ryan, N., Rubia, K., & Conrod, P. J. (2011). Response inhibition and reward response bias mediate the predictive relationships between impulsivity and sensation seeking and common and unique variance in conduct disorder and substance misuse. *Alcoholism: Clinical and Experimental Research*, 31, 140-155.
- Conrod, P. J., Castellanos-Ryan, N., & Mackie, C. J. (2011). Long-term effects of a personality-targeted intervention to reduce alcohol use in adolescents. *Journal of Consulting and Clinical Psychology*, 79, 296-306.
- Conrod, P. J., O'Leary-Barrett, M., Newton, N., Topper, L., Al-Khudhairy, N., Castellanos-Ryan, N., & Mackie, C. (in press). A cluster randomized trial demonstrates the effectiveness of a selective, personality-targeted prevention program for adolescent alcohol misuse. *JAMA-Psychiatry* (formerly, *Archives of General Psychiatry*).
- Cooper, M. L., Frone, M. R., Russell, M., & Mudar, P. (1995). Drinking to regulate positive and negative emotions: A motivational model of alcohol use. *Journal of Personality and Social Psychology*, 69, 990-1005.
- Costello, E. J., & Angold, A. (2010). Developmental transitions to psychopathology: Are there prodromes of substance use disorders? *Journal of Child Psychology and Psychiatry*, 51, 526-532.
- Crews, F., He, J., & Hodge, C. (2007). Adolescent cortical development: A critical period of vulnerability for addiction. *Pharmacology Biochemistry and Behavior*, 86, 189-199.
- Dawes, M. A., Antelman, S. M., Vanyukov, M. M., Giancola, P., Tater, R. E., Susman, E. J.,...Clark, D. B. (2000). Developmental sources of variation in liability to adolescent substance use disorders. *Drug and Alcohol Dependence*, 61, 3-14.
- Edwards, C. L., Bennett, G. G., Wolin, K. Y., Johnson, S., Fowler, S., Whitfield, K. E.,...Robinson, E. (2008). Misestimation of peer tobacco use: understanding disparities in tobacco use. *Journal of National Medical Association*, 100, 299-302.
- Fergusson, D. M., Horwood, L. J., & Ridder, E. M. (2007). Conduct and attentional problems in childhood and adolescence and later substance use, abuse and dependence: Results of a 25 year longitudinal study. *Drug and Alcohol Dependence*, 88S, S14-S26.
- Foxcroft, D. R., & Tsertsvadze, A. (2011). Universal school-based prevention programs for alcohol misuse in young people. *The Cochrane Database of Systematic Reviews*(5): CD009113.
- Gardner, M., & Steinberg, L. (2005). Peer influence on risk taking, risk preference, and risky decision making in adolescence and adulthood: An experimental study. *Developmental Psychology*, 41, 625-635.
- Gladwin, T. E., Figner, B., Crone, E. A., & Wiers, R. W. (2011). Addiction, adolescence, and the integration of control and motivation. *Developmental Cognitive Neuroscience*, 1, 364-376.
- Grant, B. F., & Dawson, D. A. (1998). Age of onset of drug use and its association with DSM-IV drug abuse and dependence: Results from the national longitudinal alcohol epidemiologic survey. *Journal of Substance Abuse*, 10, 163-173.

- Grant, V. V., Stewart, S. H., & Birch, C. D. (2007). Impact of positive and anxious mood on implicit alcohol-related cognitions in internally motivated undergraduate drinkers. *Addictive Behaviors, 32*, 2226-2237.
- Guyer, A. E., Chaote, V. R., Pine, D. S., & Nelson, E. (2012). Neural circuitry underlying affective response to peer feedback in adolescence. *Social Cognitive and Affective Neuroscience, 7*, 81-92.
- Hasin, D. S., Stinson, F. S., Ogburn, E., & Grant, B. F. (2007). Prevalence, correlates, disability, and comorbidity of DSM-IV alcohol abuse and dependence in the United States: Results from the National Epidemiologic Survey on Alcohol and Related Conditions. *Archives of General Psychiatry, 64*, 830-842.
- Hawkins, J. D., Catalano, R. F., & Miller, J. Y. (1992). Risk and protective factors for alcohol and other drug problems in adolescence and early adulthood: Implications for substance abuse prevention. *Psychological Bulletin, 112*, 64-105.
- Hibell, B., Guttormsson, U., Ahlström, S., Balakireva, O., Bjarnason, T., Kokkevi, A., & Kraus, L. (2012). The 2011 ESPAD Report - Substance Use Among Students in 36 European Countries. Stockholm, Sweden: The Swedish Council for Information on Alcohol and Other Drugs (CAN).
- Houben, K., Wiers, R. W., & Jansen, A. (2011). Getting a grip on drinking behavior: Training working memory to reduce alcohol abuse. *Psychological Science, 22*, 968-975.
- Iacono, W. G., Malone, S. M., & McGue, M. (2008). Behavioral disinhibition and the development of early-onset addiction: Common and specific influences. *Annual Review of Clinical Psychology, 4*, 925-948.
- Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2012). Monitoring the Future national results on adolescent drug use: Overview of key findings, 2011. *Ann Arbor: Institute for Social Research, The University of Michigan*.
- Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2011). Monitoring the Future national results on adolescent drug use: Overview of key findings, 2010. *Ann Arbor: Institute for Social Research, The University of Michigan*.
- Kandel, D. B., Johnson, J. G., Bird, H. R., Weissman, M. M., Goodman, S. H., Lahey, B. B.,... Schwab-Stone, M. E. (1999). Psychiatric comorbidity among adolescents with substance use disorders: Findings from the MECA Study. *Journal of the American Academy of Child and Adolescent Psychiatry, 38*, 693-699.
- King, S. M., Iacono, W. G., & McGue, M. (2004). Childhood externalizing and internalizing psychopathology in the prediction of early substance use. *Addiction, 99*, 1548-1559.
- Krank, M., Stewart, S. H., O'Connor, R., Woicik, P. B., Wall, A. M., & Conrod, P. J. (2011). Structural, concurrent, and predictive validity of the Substance Use Risk Profile Scale in early adolescence. *Addictive Behaviors, 36*, 37-46.
- Laucht, M., Becker, K., Blomeyer, D., & Schmidt, M. H. (2007). Novelty seeking involved in mediating the association between the dopamine D4 receptor gene exon III polymorphism and heavy drinking in male adolescents: Results from a high-risk community sample. *Biological Psychiatry, 61*, 87-92.
- Le Bon, O., Basiaux, P., Streele, E., Tecco, J., Hanak, C., Hansenne, M.,... Dupont, S. (2004). Personality profile and drug of choice: A multivariate analysis using Cloninger's TCI on heroin addicts, alcoholics, and a random population group. *Drug and Alcohol Dependence, 73*, 175-182.
- Leyton, M., Boileau, I., Benkelfat, C., Diksic, M., Baker, G., & Dagher, A. (2002). Amphetamine-induced increases in extracellular dopamine, drug wanting, and novelty seeking: A PET/[11C]raclopride study in healthy men. *Neuropsychopharmacology, 27*, 1027-1035.
- Mason, W. A., Hitchings, J. E., & Spoth, R. L. (2007). Emergence of delinquency and depressed mood throughout adolescence as predictors of late adolescent problem substance use. *Psychology of Addictive Behaviors, 21*, 13-24.
- McQueeney, T., Schweinsburg, B. C., Schweinsburg, A. D., Jacobus, J., Bava, S., Frank, L. R., & Tapert, S. F. (2009). Altered white matter integrity in adolescent binge drinkers. *Alcoholism: Clinical and Experimental Research, 33*, 1278-1285.
- Merikangas, K. R., He, J. P., Burstein, M., Swanson, S. A., Avenevoli, S., Cui, L.,... Swendsen, J. (2010). Lifetime prevalence of mental disorders in U.S. adolescents: Results from the National Comorbidity Survey Replication - Adolescent Supplement (NCS-A). *Journal of the American Academy of Child and Adolescent Psychiatry, 49*, 980-989.
- Nash, S. G., McQueen, A., & Bray, J. H. (2005). Pathways to adolescent alcohol use: Family environment, peer influence, and parental expectations. *Journal of Adolescent Health, 37*, 19-28.
- Robison, A. J., & Nestler, E. J. (2011). Transcriptional and epigenetic mechanisms of addiction. *Nature Reviews Neuroscience, 12*, 623-637.
- Salvo, N., Bennett, K., Cheung, A., Chen, Y., Rice, M., Rush, B.,... the Evidence on Tap Concurrent Disorders Collaborative Team (2012). Prevention of Substance Use in Children/Adolescents with Mental Disorders: A Systematic Review. *Journal of the Canadian Academy of Child and Adolescent Psychiatry, 21*, 245-252.
- Sher, K. J., Grekin, E. R., & Williams, N. A. (2005). The development of alcohol use disorders. *Annual Review of Clinical Psychology, 1*, 493-523.
- Squeglia, L. M., Spadoni, A. D., Infante, M. A., Myers, M. G., & Tapert, S. F. (2009). Initiating moderate to heavy alcohol use predicts changes in neuropsychological functioning for adolescent girls and boys. *Psychology of Addictive Behaviors, 23*, 715-722.
- Steinberg, L. (2008). A Social Neuroscience Perspective on Adolescent Risk-Taking. *Developmental Review, 28*, 78-106.
- Stormshak, E. A., Connell, A. M., Veronneau, M. H., Myers, M. W., Dishion, T. J., Kavanagh, K., & Caruthers, A. S. (2011). An ecological approach to promoting early adolescent mental health and social adaptation: Family-centered intervention in public middle schools. *Child Development, 82*, 209-225.
- Thatcher, D. L., & Clark, D. B. (2008). Adolescents at risk for substance use disorders: Role of psychological dysregulation, endophenotypes, and environmental influences. *Alcohol Research and Health, 31*, 168-176.
- van Lier, P. A. C., Huizink, A., & Crijnen, A. (2009). Impact of a preventive intervention targeting childhood disruptive behavior problems on tobacco and alcohol initiation from age 10 to 13 years. *Drug and Alcohol Dependence, 100*, 228-233.
- White, H. R., Xie, M., Thompson, W., Loeber, R., & Stouthamer-Loeber, M. (2001). Psychopathology as a predictor of adolescent drug use trajectories. *Psychology of Addictive Behaviors, 15*, 210-218.
- Wittchen, H. U., Fröhlich, C., Behrendt, S., Günther, A., Rehm, J., Zimmermann, P.,... Perkonig, A. (2007). Cannabis use and cannabis use disorders and their relationship to mental disorders: A 10-year prospective-longitudinal community study in adolescents. *Drug and Alcohol Dependence, 88 Suppl 1*, S60-70.
- World Health Organization. (2011). Global status report on alcohol and health. Geneva.
- Young, M. M., Saewyc, E., Boak, A., Jahrig, J., Anderson, B., Doiron-Brun, Y.,... Clark, H. (2011). Cross-Canada Report on Student Alcohol and Drug Use: Technical report. Ottawa, Canadian Centre on Substance Abuse.
- Young, R., Sweeting, H., & West, P. (2008). A longitudinal study of alcohol use and antisocial behavior in young people. *Alcohol and Alcoholism, 43*, 204-214.