Published in final edited form as:

Child Dev Perspect. 2011 November ; 5(4): 219–222. doi:10.1111/j.1750-8606.2011.00193.x.

The Contributions of Developmental Science to the Study of Substance Use and Disorder: Introduction to a Special Section of *Child Development Perspectives*

Andrea M. Hussong

University of North Carolina

Abstract

This Special Section of *Child Development Perspectives* highlights the contributions of developmental science to the study of substance use and disorder. It focuses on the specific question of how genetic, biological, and environmental factors vary in the way they interactively predict substance use and disorder over the course of development. The first three articles outline answers to this question that are emerging from the study of substance use disorder and contributing contexts, particularly the work on the externalizing or behavioral-undercontrol risk pathway to substance use disorder. The markers of risk and contextual variation are further integrated in the final contribution, which evaluates current evidence for this pathway to substance use disorder.

Developmental science has gained increasing prominence within the multidisciplinary study of substance use and disorder in recent decades. This increasing prominence is perhaps most evident in the growing body of findings that address two fundamental questions about the developmental processes underlying substance use and disorder--namely, What develops? and How is etiology informed by the child's own development or maturation?

Substance use and disorder remain significant public health concerns. Adolescent substance use is associated with the three leading causes of death during this developmental period (i.e., suicide, homicide, and accidents; USDHHS, 2007). Adolescent substance use is also associated with engaging in delinquent and criminal activity, poor school performance and retention, early and unplanned pregnancy, and various mental health problems (Chassin, Hussong, & Beltran, 2009; Windle & Windle, 2006). Moreover, the use of substances in early adolescence (before age 14) may increase the likelihood of having an adult alcohol use disorder by as much as 35% (Grant & Dawson, 1997). The negative effect of adult alcohol and drug disorder on public health and productivity loss are, in turn, well-documented (Research Society on Alcoholism, 2009). Importantly, treatment of substance use disorder is challenging, and the typical course of recovery is marked by repeated relapse and multiple interventions, perhaps particularly among those with externalizing symptoms (Winters, Stinchfield, Latimer, & Stone, 2008). The current collective wisdom thus suggests that understanding the development of substance use disorder is especially important in informing preventions that could prove more effective than treatment (Zucker, Donovan, Masten, Mattson, & Moss, 2008).

Indeed, substance use actually begins much earlier than once thought, with between 6 and 9% of 9-year-olds and as many as 18% of fourth-graders having initiated drinking

(Donovan, 2007). Moreover, reliable predictors and perhaps precursors of substance use can be identified in early childhood (Zucker et al., 2008). Therefore, to answer the question of “what develops” requires a broader understanding of the psychological processes involved in substance use that moves beyond simple behavioral indicators. The developmental question about “what develops” thus focuses on phenomenology, and in this respect is similar to a related question in the clinical psychology literature, namely, What is the fundamental deficit? Arguably, the core deficit that has received the greatest attention is the regulation of externalizing or disinhibited behaviors.

Externalizing behaviors are perhaps the most widely researched diagnostic issue within child clinical psychology (Kerig, 2006). A large body of literature shows a strong and consistent association between externalizing behavior and substance use and disorder (e.g., Krueger, Markon, Patrick, Benning, & Kramer, 2007). And there is growing evidence that, at least for some individuals, the two may be one in the same. The recognition that substance use is a component of deviant behavior and that both are governed by a similar etiological framework was posed in the writings of Jessor and colleagues (e.g., Jessor, Donovan, & Costa, 1991). However, the idea that such deviant behaviors may be identified earlier in the life course than adolescence through behaviors other than substance use has been articulated more recently in the writings of Tarter et al. (1999) and Zucker (2006). For some individuals, then, substance use may simply be an expression of externalizing behaviors that are more likely to be seen in and after adolescence, and less likely to be seen in childhood. Thus, the answer to the question of “what develops” for these individuals may be deficits in behavioral regulation. The concept of heterotypic continuity, in which a single underlying construct develops over time but is expressed through different behaviors over time, captures this posited relationship between externalizing behavior and substance use well.

Importantly, developmental pathways permit an earlier identification of risk processes that may contribute to eventual disorder. Indeed, several studies indicate that early externalizing behaviors (in children as young as 2 to 5 years old) predict greater risk for substance use in adolescence and early adulthood (for a review, see Zucker et al., 2008). Such early identification has the potential to inform prevention programs that may alter such risk processes early in the life course. Guidelines for the development of effective prevention programs emphasize the importance of developmental timing in matching risk mechanisms and the targets for intervention (e.g., Nation et al., 2003). Relatedly, several researchers recognize the potential import of early intervention, arguing that such intervention has the potential to alter risk considered more malleable early in the life (e.g., Olds, Sadler, & Kitzman, 2007). For example, the Family-Nurse Partnership program developed by David Olds targets expectant mothers and their infants through repeated prenatal and postnatal home visits until the child is 2 years old (Olds, 2006). A 15-year follow-up of this program implemented in Elmira, New York, indicated that children of poor, unmarried mothers who participated in the program experienced more positive outcomes than did children in a control group, including fewer instances of running away, fewer arrests and convictions, fewer sex partners, and, notably, lower rates of drinking and alcohol-related problems.

The articles in this Special Section focus on the conceptualization of substance use disorders as an outgrowth of externalizing behavior that develops over the early life course and beyond. Within this framework, it poses the second developmentally guided question, How is etiology informed by ontogeny or maturation of the child? Specifically, the included articles focus on how maturation alters the interacting contributions of genetic, biological, and environmental factors in predicting substance use and disorder.

In her article, Danielle Dick (in press) establishes the developmental trends in genetic influences on adolescent alcohol involvement, pointing out that early adolescent alcohol

initiation and use are largely influenced by shared environmental factors, with increasing genetic effects across adolescence as individuals move from initial experimentation to more established patterns of use. Rather than being specific to alcohol involvement, this genetic risk appears to be associated with a broader set of disinhibited behaviors and is more evident in environments marked by lower social control (e.g., lower parental monitoring and higher peer deviance) and other sensitivity indicators (e.g., lower parental warmth and more punitive discipline). These findings, which are from twin studies, are guiding gene identification studies. As this line of research progresses, Dick suggests, the genetic risk may be found to be multivariate, with some portion of genetic variation contributing to disinhibited behavior more generally and another portion contributing to specific behaviors such as alcohol involvement.

Recognizing cross-species generalities in adolescent development, Linda Spear (in press) demonstrates the utility of animal models in showing the sensitivity of the adolescent brain to alcohol. She notes that the neural transformations accompanying adolescence relate to findings suggesting that, compared with adults, young adolescents are more sensitive to the rewards of alcohol (such as social facilitation) and less sensitive to the negative consequences (such as lethargy and hangovers). These differences in behavioral reinforcements, in turn, may result in greater levels of alcohol use per sitting in adolescents than in adults. Higher levels of alcohol use early in adolescence may be particularly concerning given the potential toxicity effects on brain development, notably in memory impairment and plasticity. Moreover, individual differences in these behavioral reinforcement patterns may signal risk for alcohol use disorder down the road. Such findings have spurred a large body of research seeking to understand whether the relationship between early alcohol use and both deficits in brain functioning and the risk for substance use disorder is causal, correlational, or epiphenomenal.

The article by William Iacono and Stephen Malone (in press) addresses the role of developmental processes in understanding a salient endophenotype for substance use and disorder--amplitude reduction in the P300 wave of the visual event-related potential (an index of neural inhibition and attentional processing). Previous work shows that P300 amplitude reductions predict a wide array of externalizing problems, are present in high-risk offspring prior to periods of typical drinking onset (preadolescence), predict later substance misuse and disorder, and are, in part, genetically mediated, as evidenced both in twin studies and in studies showing a genetic association underlying their link to externalizing symptoms. These authors argue that the ability of this marker to act as an endophenotype for substance use and disorder may vary developmentally or even be best indicated by specific patterns of developmental variation in this index. The emerging focus on developmental patterns of P300 responding, rather than on single-session indicators of P300 responding, speaks to the developmental embeddedness of this risk marker.

In the final paper, Robert Zucker, Joel Nigg, and Mary Heitzig (in press) provide a broader understanding of how these markers of risk could be woven together in explaining the externalizing or behavioral-undercontrol pathway to substance use disorder. They articulate a central challenge to defining this pathway, namely, specifying the core characteristics of risk, currently captured under the umbrella of behavioral undercontrol or disinhibition. They emphasize two neurocognitive response systems that, in dynamic tension with each other, underlie this behavioral phenotype: an effortful control system and an incentive reactivity system. The effects of these neurocognitive systems are posited to be contextually embedded and developmentally graded, with the two systems maturing at different rates over periods of high risk for substance involvement--adolescence and early adulthood.

Together, the articles in this Special Section examine developmental influences on substance use across multiple levels of analysis. Such an epigenetic approach to understanding the action of alcohol and the development of substance use disorder has been gaining ground in the field (e.g., Huot, Thirivikraman, Meaney, & Plotsky, 2001; Shukla et al., 2008). This approach demands theoretical integration of the multiple levels of influence that interactively form the etiological mechanisms that engage children in, and move them along, the externalizing or behavioral-undercontrol risk pathway to substance use and disorder. However, most empirical research continues to fail to integrate influences across levels, and many of the purported theories focus on developmental processes that are first recognized and targeted in middle to late childhood or beyond. Given the inherently multidisciplinary nature of the study of substance use and disorder and the increasing push for collaborative research, this state of affairs may be slowly changing. The current Special Section is thus an attempt to synthesize related lines of inquiry that collectively recognize the heterotypic continuity of substance use over the life course, the interacting multiple levels of influences that contribute to this etiology, and the salience of the child's maturation in etiological models of substance use and disorder.

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