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Iowa Gambling Task performance and executive function predict low-income urban preadolescents' risky behaviors

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ABSTRACT

This study examines preadolescents' reports of risk-taking as predicted by two different, but related inhibitory control systems involving sensitivity to reward and loss on the one hand, and higher order processing in the context of cognitive conflict, known as executive functioning (EF), on the other. Importantly, this study examines these processes with a sample of inner-city, low-income preadolescents and as such examines the ways in which these processes may be related to risky behaviors as a function of children's levels of both concurrent and chronic exposure to household poverty. As part of a larger longitudinal study, 382 children (ages 9–11) provided a self-report of risky behaviors and participated in the Iowa Gambling Task, assessing bias for infrequent loss (preference for infrequent, high magnitude versus frequent, low magnitude loss) and the Hearts and Flowers task assessing executive functioning. Results demonstrated that a higher bias for infrequent loss was associated with higher risky behaviors for children who demonstrated lower EF. Furthermore, bias for infrequent loss was most strongly associated with higher risk-taking for children facing highest levels of poverty. Implications for early identification and prevention of risk-taking in inner-city preadolescents are discussed.

1. Introduction

The transition to adolescence is marked by increasing autonomy and decision-making regarding sexual risk-taking, substance use, and behavioral control, which carry large educational and health consequences (Harris, Duncan, & Boisjoly, 2002; Steinberg, 2008). Correspondingly, there has been a dramatic upsurge in research on the neurocognitive processes that underlie adolescents' engagement in these risky behaviors (RBs), which are associated with higher sensation-seeking and more immediate positive mood in the short run, but have potentially deleterious consequences in the long run (Hardin & Ernst, 2009). Importantly, the increase in RBs around entry into adolescence is theorized to be related to two different, but related neural systems involving "bottom up" processes of sensitivity to reward and loss (involving activation of and connectivity between the nucleus accumbens, thalamus and anterior insula and assessed through such tasks as the Iowa Gambling Task (IGT)) on the one hand and more effortful, "top down" inhibitory control processes of executive function (EF) (involving orbitofrontal and medial prefrontal cortical activation and assessed through such tasks as Hearts and Flowers) on the other (see Cho et al., 2013; Steinberg, 2008 for reviews). The current study examines the role of children's performance on two tasks that tap these respective systems in predicting RBs among younger pre-adolescent children (ages 9–11) facing high levels of environmental adversity who are correspondingly at greater health, behavioral, and educational risk.

1.1. Sensitivity to reward and loss as indexed by IGT and RB

Theory and past research using monetary incentive tasks such as the Iowa Gambling Task (IGT) suggest that individuals' sensitivity to reward and loss play a role in their ability to anticipate positive versus negative consequences that may result from their actions (Bjork et al., 2004). In the IGT, participants choose from four decks of cards across 50 trials, with the goal of acquiring as much money as possible. Decks vary in both the magnitude and frequency of rewards and losses. As such, the task can be used both to assess sensitivity to reward as well as sensitivity to loss. Importantly, the IGT is sufficiently complex that participants are unable to calculate the net gains and losses that each deck affords (Damasio, Everitt, & Bishop, 1996). Rather, according to the theory of "somatic markers," participants have to rely on covertly and overtly occurring marker signals to sense which decks are good and which are bad, with correspondingly better vs. worse likely future outcomes. For example, one study found that healthy

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subjects exhibited a skin conductance response prior to selecting a card from a bad deck, whereas patients with ventromedial frontal damage, who typically perform poorly on the task, did not (Bechara, Tranel, Damasio, & Damasio, 1996). Poor performance on the task is hypothesized to indicate individuals' less effective cue detection of these marker signals regarding possible future outcomes, which in turn may affect real-time decision-making regarding RB.

While much work using monetary incentive tasks has focused on individuals' anticipation of and preferences for gain, a small number of recent studies have also found player's detection of loss cues to be meaningfully associated with riskier behaviors such as substance use (Garavan & Stout, 2005). The IGT allows for assessment of individuals' responses to two types of loss that are relevant to risk-taking, namely losses that occur infrequently but exact a high cost (i.e. low frequency but high magnitude) versus losses that occur more frequently but are of lower cost, or magnitude. In addition, IGT performance can be analyzed for whether sensitivity to loss increases over time (via the consideration of the slope of performance as the dependent variable) or for the block of trials for which the individual has gained the most familiarity with the task, i.e. the final block of trials (Upton, Bishara, Ahn, & Stout, 2011). A higher bias for infrequent loss (IFL) slope or higher final level of IFL would indicate a preference for more maladaptive choices which result in greater losses in the long run. Prior developmental work with children, for example, suggests that they first learn to make decisions during the task based on frequency of loss and that this frequency bias decreases with age (Huizenga, Crone, & Jansen, 2007; see Cassotti, Aite, Osmont, Houde, & Borst, 2014 for a review). Few studies (to our knowledge) have linked this aspect of IGT performance to pre-adolescents' risky behavior: We hypothesize that this dimension of IGT performance is particularly relevant to this domain of psychosocial functioning, where some children may be less sensitive to the potentially large negative consequences of risk-taking decisions. Accordingly, we hypothesize that greater IFL as measured either by slope or by final level would be associated with greater RB - greater IFL indicates that individuals are insensitive to the signal that they are making decisions that have the potential to incur larger magnitude losses. The one study examining correlations between IFL and higher risk-related behavior and attitudes was equivocal in its findings with some evidence that difficulty interpreting somatic information as well as preference for lower risk may be related to higher IFL (Singh & Khan, 2009).

1.2. Executive functions and RB

In addition to bottom up aspects of reward/loss sensitivity, higher order processes of EF also play a role in individuals' proneness to engage in risky behaviors (Berkman, Graham, & Fisher, 2012). EF is comprised of a set of skills, including working memory, inhibitory control, and attention set shifting, that promote higher order processing in the context of cognitive conflict. Generally, EF emerges in early childhood and increases until at least age 16, with a period of marked growth in early adolescence (Steinberg, 2008). Findings from this parallel literature on the relation between EF and RBs among adolescents have been more clear cut, suggesting that adolescents and young adults who demonstrate a cognitive response bias that reflects a reactive "readiness to act" rather than a more reflective or "cautious approach" on EF tasks such as Go/No-Go have also been found to be at greater risk of RBs (Endres, Rickert, Bogg, Lucas, & Finn, 2011). This literature suggests that adolescents and adults prone to greater risk taking may have difficulty in attending to and remembering the costs of risky choices, as well as more difficulty in inhibiting impulses in the face of likely bad consequences resulting from their actions. Several studies including adolescents (ages 15–17) from moderate and high-risk families have demonstrated that lower performance in key components of EF (such as poorer response inhibition and lower working memory) were related to higher risk of alcohol related problems, tobacco and illicit drug use (Nigg et al., 2006; Romer et al., 2009). Yet few if any studies have distinguished the role of adolescents' sensitivity to IFL from the role of EF processes when predicting their RB.

1.3. The current study

Across those two parallel research literatures, a number of questions remain unanswered. From a clinical perspective it is particularly important to focus on the emergence of RB in pre-adolescence given the overwhelming evidence that early age of onset is a key marker of lifetime risk of substance and alcohol problem severity (McGue, Iacono, Legrand, Malone, & Elkins, 2001). Our focus on pre-adolescence aligns with other recent studies suggesting that this period coincides with the early onset of risk-taking behavior among disadvantaged samples of urban youth (Romer et al., 2009). As such, this study considers children's sensitivity to loss and EF as independent and joint predictors of RB, when they are ages 9–11 in order to contribute to the field's understanding of the emergence of these costly behavioral risks.

Second, this study seeks to expand the field's focus on neurocognitive processes and RB in preadolescence by examining those processes among a sample of low-income children living in urban communities facing concentrated poverty. Adversity associated with income poverty has been argued to substantially increase individuals' vulnerability to exposure to negative life events, and also increases their opportunities for risk-taking where negative health, educational, and interpersonal consequences can be large (Blair & Raver, 2012; Noble, McCandliss, & Farah, 2007). Environmental adversity may be an independent predictor of RB such that propensity to engage in RBs is higher for children experiencing greater adversity, regardless of IGT performance. Additionally, however, adversity may interact with individuals' sensitivity to loss: that is, pre-adolescents who are relatively less sensitive to the "costs" of choosing from a bad versus good deck on the IGT *and* who face very high levels of adversity may be more prone to engage in RB. Among low-income, urban samples, children's episodic and chronic exposure to income poverty has been found to be a more robust indicator of their exposure to life adversity than more molar indicators of socioeconomic status such as parental education, with deep poverty (defined to be when yearly family income falls at or below at ½ of the federal poverty threshold) found to be particularly deleterious to child welfare (Magnuson & Duncan, 2006; Raver, Roy, & Pressler, 2015). Accordingly, in this paper we examine ways that concurrent exposure to income poverty as well as chronic exposure to deep poverty may exacerbate relationships between pre-adolescents' IGT performance and RB.

Third, few studies have considered both EF and IGT in order to examine the extent to which difficulties with reward/loss sensitivity and EF may be overlapping. In this study, we include both measures with the hypothesis that though EF and IGT would be related, EF would predict children's RB even after accounting for IGT. Importantly, inclusion of EF allowed us to test an additional hypothesis, namely that the relation of IGT to RB would be dependent on EF such that poorer IGT performance would be more predictive of higher RBs for children who have lower EF.

2. Methods

2.1. Sample and procedures

The Chicago School Readiness Project (CSRP) was a multifaceted intervention designed to improve urban, low-income children's