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Early psychosocial deprivation and adolescent risk-taking: The role of motivation and executive control

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Abstract

Risk-taking in adolescence has been often associated with early life adversities. However, the impact of such macro-level factors on risk behavior has been rarely studied in humans. To address these gaps we recruited a sample of young adolescents who were part of a randomized control trial of foster care. Children institutionalized at or soon after birth were randomly assigned either to be removed from institutions and placed into a family/foster care intervention or to remain in institutions receiving care as usual. These children were subsequently followed up through 12 years of age and compared to a sample of children who had never been institutionalized. Using this sample, we examined the impact of early childhood deprivation on risk-taking behavior and explored the role of motivation (i.e., sensation seeking) and executive control (i.e., planning). Early psychosocial deprivation decreased engagement in risk-taking among young adolescents by reducing sensation seeking, a motivation often associated with risk-taking in adolescence. The impact of early psychosocial deprivation on sensation seeking and consequently on engagement in risk-taking was further reduced by its deleterious effects on executive control. These findings

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Context

The current research attempts to examine the long-held belief that psychosocial adversities increase adolescents' vulnerability to risk-taking. The mechanisms believed to be critical for adolescent risk behavior are motivation and executive control. Two frameworks are particularly relevant for understanding how psychosocial adversities may impact theses mechanisms and in turn, adolescent risk behavior. One approach suggests that adolescent risk behavior is the result of an imbalance between overdeveloped motivational processes and underdeveloped or weak executive control processes. However, a close review of the literature reveals that although these notions are very appealing, there is very little empirical evidence to support them. By contrast, the theoretical framework developed by the first author suggests that people engage in risk behavior (e.g., risky sexual behavior, drunk driving, substance use, overeating) as a means to different goals that are chronically accessible (e.g., sensation seeking) or become momentarily accessible (e.g., emotion regulation). Furthermore, risk behavior as goal pursuit is facilitated by executive control. Given the nature of the sample (a randomized controlled trial of foster care), we had the unique opportunity to test whether psychosocial adversities do indeed increase adolescent risk-taking vulnerability and to understand the role of motivation and executive control.

challenge the traditional view according to which risk behavior is a maladaptive response to adversities and suggest that it may represent adolescents' attempts to fulfill important motivations.

Keywords

adolescent risk-taking; deprivation; motivation; executive control

Adolescents are often perceived as the prototypical risk takers. Compared to children and older adults, they are likely to engage in crime, substance use, risky sexual behavior, intentional self-harm, and reckless driving (Steinberg, 2014 but see Defoe, Dubas, Figner, & val Alen, 2015 for alternative findings and a more nuanced comparison). These behaviors are believed to increase adolescents' mortality rate (Dahl, 2004), elevate the risk for maladaptive behavior in adulthood (e.g., substance use), and put individuals of other ages at risk (i.e., reckless driving).

The potential for negative consequences has resulted in a prevailing view that adolescent risk behavior is maladaptive, often associated with adversity and stressful life experiences. Indeed, poverty, ethnic composition, percentage of single parent families, child abuse and neglect, and institutionalization have been linked consistently to heightened vulnerability for delinquent behaviors, substance use, and other risk behaviors (Bowlby, 1952; Contia et al., 2012; Felitti et al., 1998; Goodyer, 2002; Gibbons, Gerrard, & Lune, 2004; Leventhal & Brooks-Gunn, 2000; Nelson, 2007; Rutter et al., 2007). However, the impact of adversity on risk-taking vulnerability and behavior has not been studied experimentally in humans. As a consequence, our understanding of these relations and of the mechanisms underlying them remains limited.

To address this gap, the current study took advantage of a unique sample of young adolescents who participated in a randomized control trial of foster care. These children have been subsequently followed through 12 years of age and compared to a sample of children who were never institutionalized on multiple domains of functioning. This sample offered the unique opportunity to study experimentally the impact early psychosocial deprivation (i.e. history of institutional rearing) on risky behaviors and to explore the mechanisms underlying this relation.

Early psychosocial deprivation and the mechanisms of adolescent risk behavior

Mechanisms of adolescent risk behavior.

Risk-taking refers to a choice whose outcomes, positive or negative, are uncertain (Lopes, 1987; Figner & Weber, 2011). Risk-taking is not a unitary phenomenon, or a single personality trait; rather it is domain specific (i.e., people may trade stocks but never gamble in a casino), it is influenced by different processes, and it takes different forms that could appear highly deliberative or highly impulsive (Figner & Weber, 2011). In line with this conceptualization, the research on adolescent risk behavior has examined a variety of psychosocial factors in an attempt to better understand and prevent the negative

consequences of risk taking (e.g. see Defoe et al., 2015 for a recent meta-analysis). Motivational-affective and cognitive processes figure prominently in the models of adolescent risk behavior (e.g. Somerville & Casey, 2010; Steinberg, 2007; Reyna & Rivers, 2008).

One influential perspective attributes adolescents' heightened susceptibility to risk taking to a developmentally normative gap between oversensitive motivational-affective processes on one hand and underdeveloped executive control on the other hand (Somerville & Casey, 2010; Steinberg, 2007). From this perspective, in the presence of rewarding stimuli (e.g., peers), adolescents' hypersensitive motivational-affective system may override their immature executive control increasing the likelihood of risk taking.

Despite the intuitive appeal of this perspective, it is not clear that adolescents are indeed characterized by an immature executive control system. Recent research shows that activation of brain areas associated with executive control varies tremendously depending on the task and the situation and suggests that adolescents recruit control processes in a flexible manner depending on the motivational value of the situation (e.g. Crone & Dhal, 2012; Pfeifer & Allen, 2012). In line with this notion, other perspectives downplay the role of executive control and emphasized the manner in which adolescents evaluate the situation and the risk and benefits associated with it (Reyna & Rivers, 2008). Accordingly, risk taking in adolescence reflects adolescents' evaluation that the negative consequences have a relative low probability of occurring compared to the rewards associated with risk behavior (Reyna & Rivers, 2008). The benefits (e.g. viewing a risky situation as fun) may become particularly salient in the presence of peers (Albert & Steinberg, 2011) and might contribute to engagement in risk-behavior.

Although there is no consensus regarding the relative role of motivational-affective and executive control processes in adolescent risk behavior, different perspectives agree on the importance of these processes. Thus, in order to understand the impact of early psychosocial deprivation on risk taking it is critical to understand its effect on motivational and executive processes.

The impact of early psychosocial deprivation on motivational and executive control processes.

Early psychosocial adversity in general and institutional rearing in particular has been associated with a variety of deleterious outcomes across a range of developmental domains including motivational, emotional, and executive functions (Johnson, et al, 2006; Lewis et al., 2007; Loman, Johnson, Quevedeo, Lafavor, & Gunnar, 2014; MacLean, 2003; McDerrmott, 2012, 2013; Nelso, Fox & Zeanah, 2014; Pears et al., 2010; Rutter & O'Connor, 2004; Rutter et al., 2007). Early childhood institutionalization is associated with lower performance on intelligence measures as well as on tasks that assess executive function such as working memory and inhibitory control (Hostinar et al., 2012; Lovallo, 2013, Lovallo et al., 2013; McDerrmott, 2012, 2013). Given these effects, one could argue that early psychosocial deprivation results in higher risk taking through its impact on executive control.

However, executive control in itself does not produce behavior. Rather, it is mobilized by one's desires and goals (Botvinick & Braver, 2015; Dijksterhuis & Aarts, 2010). As Botvinick and Braver (2015) put it "control is motivated" (p. 85). Indeed, executive control encompasses those functions that are responsible for encoding and maintaining a representation of the current task such as working, semantic, and episodic memory, attention, and planning (e.g., Botvinick & Braver, 2015). These processes support people's motivations and goals by facilitating the processing of relevant information the implementation of appropriate means, persistence in the face of obstacles, and inhibition of alternative goals and information that may thwart goal pursuit (Bijleveld, Custers, & Aarts, 2009; Botvinick & Braver, 2015; Dijksterhuis & Aarts, 2010; Kruglanski et al, 2012). Thus, although early adversity has deleterious effects on executive functions, it is possible that its impact on risk behavior is not direct, but rather indirect through motivational processes.

Indeed, early adversity has a significant impact on motivational processes, particularly on motivation for exploration, for "varied, novel and, complex sensations and experiences" (Zuckerman, 1979, p.10) also known as sensation seeking (Zuckerman, 1979; Zuckerman, 2014). Sensation seeking is one of the most important predictors of adolescent risk taking (Arnett, 1994; Hittner & Swickert, 2006; Kelly et al., 2006; Steinberg, 2005; Trimpop et al., 1999; Zuckerman, 1979; Zuckerman, 2014). At the same time, sensation seeking is an important developmental motivation. An increase in sensation seeking during adolescence is evident across a variety of species; it promotes exploratory behavior that is critical for learning and the development of new skills, which ensure independence and survival away from parents (Ellis et al., 2012; Crone & Dahl, 2012; Jessor, 1992; Schedler & Block, 1990; Romer, 2010; Spear, 2007). Although some forms of risk behavior associated with the increase in youth preferences for novel and exciting experiences might be problematic (e.g., substance use), most forms of adolescent risk behavior appear to serve useful developmental tasks such as peer socialization, exploration, learning, and transition to adulthood (Crone & Dahl, 2012; Jessor, 1992; Schedler & Block, 1990; Romer, 2010; Spear, 2007). From this perspective, the ability to engage in sufficient and appropriate risk taking to fulfill one's developmental needs appears to be an important developmental skill that ensures optimal adaptation. Across species, social adversity appears to interfere with this ability by decreasing exploratory behavior, preference for rewarding stimuli (e.g., sucrose), and ability to experience pleasure during peer play (Champagne & Meaney, 2007; Molet et al., 2016). Children who had experienced neglect exhibited decreased creativity, flexibility, and agency in novel situations compared to children who had experienced other forms of childhood maltreatment (Egeland, Sroufe, & Erickson, 1983). More directly relevant for the current research, institutionalization has been associated with lower levels of sensation seeking (e.g. Loman et al., 2014). Furthermore, early life adversity (prior to age 16) including different formas of stress, physical and sexual abuse, emotional neglect, poor maternal care and family conflict, as well as poverty is associated with reduced cortisol and heart rate reactivity, unstable regulation of affect (Lovallo, 2013, Lovallo et al., 2013), and perseverant behavior even when the behavior becomes inappropriate or is not rewarded any longer (Brydges, et al., 2015).

These findings suggest that adversity and deprivation during development may lower adolescent risk-taking behavior through its long-term effects on critical mechanisms

associated with motivation for rewards and novelty seeking and formulation of adaptive responses. Although the dominant perspective attributes engagement in risk behavior among adolescents to their underdeveloped executive control system, evidence from developmental as well as motivation research suggests that risk behavior is enacted to fulfill important motivations (i.e, need for novel sensations and experiences; Crone & Dahl, 2012; Jessor, 1992; Schedler & Block, 1990; Kopetz & Orehek, 2015; Romer, 2010, 2011; Spear, 2007). As strategic goal pursuit, risk behavior should be supported rather than reduced by the capacity for executive control. Indeed, preliminary findings from the adolescent literature support this argument. Specifically, while working memory (as indicative of executive function) is related to early initiation of risk and externalizing behavior, as adolescents age, the emergence of risk behavior is increasingly associated with sensation seeking and this relation is accompanied by growing rather than declining executive function (Romer et al, 2011).

In line with these notions, we suggest that the experience of psychosocial deprivation in the form of institutionalization may decrease engagement in risk-taking among adolescents through its impact on an important developmental motivations, namely, sensation seeking. Furthermore, given that executive control processes are recruited to support goal pursuit, risk-taking may be facilitated rather than decreased by an efficient executive control system. Thus, the impact of early deprivation on sensation seeking and consequently on engagement in risk-taking might be further reduced by its deleterious effects on executive control.

Methods

Overview

To test the above notions, we recruited a sample of twelve-year old Romanian children. The sample consisted of initially institutionalized children who, over the previous 12 years, had participated in a randomized clinical trial (RCT) of a foster care/family intervention and who were entering early adolescence. In this RCT, infants abandoned since birth and raised in institutions in Bucharest, Romania, were randomly assigned either to be removed from an institution and placed into a family/foster care intervention or to receive care as usual in the institutions they were living in. These children have been subsequently followed through 12 years of age and compared to a community sample of children who were raised by their birth family. Using this sample, we examined the impact of a history of institutional rearing on risky behaviors and explored the role of motivational factors (i.e., sensation seeking) and executive control processes (i.e., planning).

Participants and the operationalization of early psychosocial adversity

The sample consisted of 166 twelve-year old-children of whom114 had been recruited to take part in a longitudinal study of foster care intervention when they were less than 30 months of age and living in one of six institutions in Bucharest, Romania (Zeanah et al., 2006). Fifty-two children were recruited from the community to serve as a comparison group (never institutionalized group). Children in institutional care were randomly assigned to a foster care intervention (foster care group), or continued care as usual in the institution (care as usual group). Because all decisions following randomization about children's

placements were made by Romanian government officials, many children changed living situations over the course of the study. At age 12, individuals in the care as usual group had spent approximately 43.3% of their lives in institutions compared to 13.5% for individuals in the foster care group. More specific details on the sample, recruitment, and follow up assessments can be found in Nelson et al. (2007), Humphrey et al. (2015), and Nelson, Fox, and Zeanah (2014).

Of the 166 children who participated at follow-up at age 12, eight did not complete the measures pertaining to the current study. An additional 28 children with an IQ score less than 60 (measured at age 12 with the WISC-IV composite scale) were excluded. The decision to exclude these children was based on studies suggesting that scores in this range are indicative of profound intellectual disability (Koriakin et al., 2013) on domains including verbal comprehension, perceptual reasoning, working memory, and processing speed which might have affected by the ability to understand performance the instructions and study procedure.

The final sample for the current analyses included 130 children, of which 39 in the care as usual group, 40 in the foster care group, and 51 in the never institutionalized group. At the time of the study, among the children in the care as usual group, 10 were still in institution, 2 were living in social apartments, 7 were placed in government foster care and 1 in family foster care, 13 were reunited with their biological (including extended) family, and 6 were adopted. Among the original foster care group children, 24 were still with the original foster care family, 4 were placed in government foster care whereas 2 were placed in new family foster care, 1 was living in social apartments, 7 were reunited with the biological (including extended) family, and 2 were adopted. Sixty-nine (53.1%) of the participants were female, and 61 (46.9%) were male. In terms of ethnicity, 93 children were Romanian, 25 were Roma/Gypsy and the rest of them were unknown.

Power analysis.—Given the uniqueness of the sample, and the recruitment process, the size of the sample is based on availability of participants rather than a-priori determined through a power analysis. However, we used previous findings with this sample which have compared these groups on multiple dimensions relevant to the present application, as well as the effect sizes obtained in this research (see results section below) to determine achieved power in a post-hoc analysis using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). The analysis suggested that our sample of 130 provided a power between .80 and .86 using an alpha set at .05. to detect the effect sizes reported below (Cohen’s f for one way ANOVA between .25 -.30) using a one-ways analysis of variance (ANOVA) to examine the impact of early psychosocial adversities on risk-taking behavior, executive function, and sensation seeking). A second set of analyses were conducted to determine the achieved power when testing the impact of group on risk-taking through sensation seeking and examining the moderating effect of executive control in a regression analysis. The analyses revealed that power to detect R-squared deviation from 0 using alpha set at .05 ranged between .76 (to detect the effect of the group on the mediator) to .97 (full moderated mediation model). It is noteworthy that these last sets of analyses pertain to the overall R-squared in each model rather than to the specific direct and indirect effects.

Measures

Sensation seeking.—Participants' sensation seeking was assessed with the Brief Sensation Seeking Scale (BSSS). This measure has been validated with adolescent samples and used frequently to assess associations with risk-taking behavior among adolescents starting as early as age 9 (Hoyle et al., 2002; MacPherson et al., 2010; Romer et al., 2009; Stephenson et al., 2007). The measures distinguishes between the socially desirable dimension of sensation seeking characterized by appetitive processes such as thrill seeking and its socially undesirable dimension characterized by disinhibition (Zuckerman, 1979; Hoyle et al., 2002). The assessment of these two dimensions allows us to tease apart the role of motivational processes from that of inhibitory processes relevant for executive control. Specifically, the thrill seeking component of the BSSS was assessed with two items (e.g. "I like to do frightening things"). The items were significantly correlated ($r = .20$, $p = .027$). Disinhibition was also assessed with tow items (e.g. "I would love to have new and exciting experiences, even if they are illegal"), which were significantly correlated ($r = .42$, $p < .001$). Participants responded to these items on a 5-point scale with options ranging from "strongly disagree" to "strongly agree." Responses for each item were summed to create one score for thrill seeking, and a separate score for disinhibition.

Executive control.—As mentioned in the introduction, executive control encompasses multiple functions. However, given our argument that risk behavior is implemented to fulfill adolescents need for novel experiences, the current the current study focused on planning which refers to individual' ability to make initial plans for action and to adapt them based on moment-to-moment changes in the state of relevant attributes (e.g., Phillips et al., 2001). Participants completed the Stockings of Cambridge (SOC), a subtask of the Cambridge Neuropsychological Test and Automated Battery (CANTAB) designed to measure planning capacity. The task has been validated and used in pediatric and adolescent populations (e.g., Luciana & Nelson, 2000).

During the computerized task, the participant is shown two displays containing three balls of different colors, and asked to move the balls in the lower display to match the balls in the index display. The balls are moved one at a time, by clicking on the ball, then clicking on its intended position. Performance was indexed as the number of problems solved in the minimum number of moves.

Risk behavior.—Engagement in risk-taking was assessed using both self-report as well as a laboratory task designed to measure risk-taking propensity.

Self-reported risk behavior.: Involvement in risk behavior was assessed using questions drawn from the Youth Risk Behavior Survey (YRBS; CDC, 2002), supplemented with several behaviors that are common among youth in Romania (e.g., provoking wild dogs). Items assess safety-compromising behaviors (e.g., not wearing a seatbelt), delinquency related behaviors (e.g., gambling money), and substance use. Participants indicated the frequency with which they engaged in each behavior in the past year using six-point scale with anchors ranging from "never" to "almost every day or more." The modified survey is available in the supplemental materials. This measure has been used successfully in previous

research with youth ranging from early through late adolescence (Aklin et al., 2005; Lejuez et al., 2003; MacPherson et al., 2010). A composite frequency score was calculated by summing responses to eight developmentally normative risk behaviors, including substance use and aggression. Only behaviors endorsed by at least 10% of participants were included in the composite score. Table 1 shows the specific behaviors included in the composite variable, as well as the percentage of participants who endorsed any past year involvement in each type of behavior. Reliability of this index was adequate (alpha = .65). Due to the substantial positive skewness of 1.31 (*SE* = .21) we log transformed the scores and used the transformed values in the data analysis.

Risk-taking propensity.: Participants' risk-taking propensity was assessed with the Balloon Analogue Risk Task–Youth (BART-Y; Lejuez et al., 2007). In this task, participants inflate a computer-generated balloon using the mouse to click on a box that pumps up the balloon. They earn one point for each click. If the balloon is pumped past its explosion point, then all points accrued for that balloon are lost. Participants could stop pumping the balloon at any time prior to an explosion and allocate the accrued points to a permanent prize meter. The probability that a particular balloon will explode is 1/128 for the first pump, 1/127 for the second pump, and so on until the 128th pump at which point the probability is 1/1 such that explosion values form a normal distribution around 64 pumps (Lejuez et al., 2002). Participants' score on this measure reflects the adjusted average that equals the average number of pumps on balloons that did not explode. After each balloon explosion or point collection, the subject's exposure to that particular balloon ends and a new balloon appears until 30 balloons (i.e., trials) have been completed. At this point, the prize meter will indicate the prize won by the participant, which may be small, medium, large, or a bonus, depending on the number of points collected. All prizes consisted of cash.

We hypothesized that early deprivation would result in diminished thrill seeking at age 12, which in turn would be associated with less frequent engagement in risk behavior. Furthermore, we expected that the impact of early psychosocial deprivation would be due to its effects on appetitive processes (i.e., the thrill seeking dimension of sensation seeking) rather than on inhibitory processes (i.e., the disinhibition dimension of sensation seeking). Finally, we hypothesized that the indirect effect of deprivation on risk behavior through thrill seeking would be conditional upon level of executive control.

Results

Preliminary analyses

Correlations between study variables are presented in Table 2. Importantly, time spent in institutions was not significantly linearly related to risk behavior, thrill seeking, or executive control, indicating that the effects of group on the outcomes of interest are not simply explained by opportunities for experiences outside of the institutions.

We first assessed the direct effects of institutional rearing (care as usual group and foster care group vs. never institutionalized group) on risk-taking behavior (YRBS and the BART), sensation seeking, and executive control. As presented in Table 3(a), the children with a history of institutional rearing had significantly lower scores compared to never

institutionalized children on both sub-scales of the sensation seeking, thrill seeking $F(1,126) = 4.54$, $p = .035$, $\eta^2 = .04$, and disinhibition $F(1,126) = 4.00$, $p = .048$, $\eta^2 = .03$. Similarly, a history of institutional rearing was associated with lower scores on risk-taking, both on self-reported risk behaviors, $F(1,125) = 5.91$, $p = .016$, $\eta^2 = .05$, as well as on the BART, $F(1,125) = 3.60$, $p = .06$, $\eta^2 = .03$. Finally, children in institutional rearing (foster care and care as usual groups) performed more poorly than never institutionalized children on the planning task, $F(1,123) = 4.05$, p = .046, $\eta^2 = .03$. To determine the extent to which the foster care intervention alleviated some of the effects of early institutionalization, we ran Tuckey post-hoc analyses. The foster group did not differ significantly from the care as usual group in terms of risk taking (self report: $p = .315$, BART: $p = .828$), disinhibition ($p = .845$), or planning ($p = .203$) but it did have higher scores on thrill seeking ($p = .040$) Table 3(b).

Self-reported risk behavior

Our main hypothesis states that early deprivation diminishes thrill seeking, which in turn is associated with less frequent engagement in risk behavior. Furthermore, we hypothesized that this indirect effect is conditional upon the level of executive control, such that higher thrill seeking would result in higher risk taking only among participants with higher executive control. We also hypothesized that these effects are due to its effects on appetitive processes (i.e., thrill seeking) rather than on inhibitory processes, we ran similar analysis testing the indirect effect of disinhibition.

To test these hypotheses we used the PROCESS macro for SPSS (Hayes, 2012; Hayes & Preacher, 2014), Model 14 with 1000 iterations. This is a path analysis approach that allows us to estimate the magnitude of indirect effects (the effect of early deprivation on risk taking though thrill seeking/disinhibition) and the extent to which they are conditional upon different levels of the moderator (executive control). Because early deprivation was a three-level categorical variable, dummy codes were created with the care as usual as the reference group. Following the recommendation of Hayes and Preacher (2014), two separate indirect effects models were assessed: the first model specified the never institutionalized dummy code as the independent variable and the foster care group as a covariate, and the second model specified the foster care group as dummy code as the independent variable and the never institutionalized group as a covariate. This approach is mathematically equivalent to an analysis of variance and reproduces the observed and adjusted group means while also generating interpretable relative indirect effects (Hayes & Preacher, 2014). A diagram presenting the conceptual model is depicted in Figure 1.

The first set of analyses tested the impact of early deprivation on risk behavior through thrill seeking[2]. Results indicate that relative to the care as usual group, both the never

[2]It is noteworthy that the mediator and the outcome are assessed concurrently rather than in a longitudinal manner. Although this may raise questions regarding the causal relationship between the two variables, the theoretical analysis suggests a motivation or a goal (i.e., sensation seeking) is the reason to enact a behavior (i.e., risk behavior) rather than the other way around. In addition to the theoretical basis of our approach, we also attempted to rule out reverse causality statistically (Kenny, 2007). Specifically, we tested the indirect effect of early adversity on thrill-seeking via risk behavior. The indirect effect of foster care group compared to the care as usual group was not significant, $B = -.08$, $SE = .09$, 95% CI [−.29, .06]; the indirect effect of the never institutionalized group compared to the care as usual group was also not significant, $B = .13$, $SE = .09$, 95% CI [−.01, .34]. Similarly, there were no effects of the foster care group compared to the care as usual group ($B = .02$, $SE = .04$, 95% CI [−.03, .14]) or of the never institutionalized group compared to the care as usual group ($B = .05$, $SE = .05$, 95% CI [−.01, .19]) on participants' BART scores.

institutionalized participants, *B* (*SE*) = .55 (.23), 95% CI [.09, .1.00] and the foster care participants, *B* (*SE*) = .66 (.23), 95% CI [.23, 1.08]; reported higher levels of thrill seeking. In turn, higher thrill seeking was associated with increased risk behavior, *B* (*SE*) = .27 (.07), $p < .001$. The indirect effect of group (foster care vs. care as usual) on risk behavior via thrill seeking was significant, *B* (*SE*) = .15 (.07), 95% CI [.03, .31]; however, the direct effect was not significant, *B* (*SE*) = −.34 (.18), 95% CI [−.68, .01]. Similarly, when comparing the never institutionalized group to the care as usual group, the indirect effect of group on risk behavior through thrill seeking was significant, *B* (*SE*) = .18 (.08), 95% CI [.06, .37] whereas the direct effect was not, *B* (*SE*) = .12 (.17), 95% CI [−.21, .45].

This indirect effects analysis was repeated with disinhibition replacing thrill seeking as the mediator. This model was not significant: early psychosocial deprivation did not have an effect on disinhibition. The care as usual participants did not report differential levels of disinhibition relative to the never institutionalized participants, *B* (*SE*) = −.14 (.24), 95% CI [−.61, .32], or the foster care participants, *B* (*SE*) = .29 (.22), 95% CI [−.75, .73]. Although disinhibition significantly predicted risk behavior, *B* (*SE*) = .32 (.06), 95% CI [.19, .44], neither the direct effect of the foster care group compared to the care as usual group, *B* (*SE*) = −.14 (.17), 95% CI [−.47, .18], nor the indirect effect, *B* (*SE*) = −.04 (.08); 95% CI [−.21, .09], was significant. Similarly, neither the direct effect of the never institutionalized group compared to the care as usual group, *B* (*SE*) = .20 (.16), 95% CI [−.11, .52], nor the indirect effect, *B* (*SE*) = .09 (.08), 95% CI [−.05, .27], was significant.

The second set of analyses tested the full conceptual model (Figure 1). Specifically, it tested the extent to which the effect of deprivation on risk taking through thrill seeking is moderated by executive control (i.e., planning). We ran a conditional process model where the effect of thrill seeking on risk behavior was tested as a function of executive control. The analyses suggest that the indirect effect (through thrill seeking) of early childhood adversity on risk-taking was moderated by executive control. Hayes' Index of Moderated Mediation was *B (SE)* = .05 (.04), 95% CI = [.001, .16] when comparing the foster care group to the care as usual group and *B (SE)* = .06 (.05), 95% CI = [.003, .19] when comparing the never institutionalized group to the care as usual group. These findings suggest that thrill seeking mediates the association of early deprivation on risk behavior among youth with average and high executive control but not among children with the lowest executive control. In other words, higher levels of thrill seeking are associated with higher levels of risk-taking, but only among participants with moderate and high levels of executive control. The full statistical model is presented in Figure 2. The tables containing the regression coefficients and the confidence intervals associated with these analyses are presented in Tables 4, 5, and 6 in supplemental information.

Risk-taking propensity

The analyses above were repeated with participants' scores on the BART as the dependent variable. The results suggest that relative to the care as usual group, both the never institutionalized participants, *B* (*SE*) = .62 (.23), 95% CI = [.16, 1.07], and the foster care participants, *B* (*SE*) = .71 (.22), 95% CI = [.29, 1.14], reported higher levels of thrill

seeking. The indirect effect of group through thrill seeking on the BART scores was not significant.

However, when the full model was testing by introducing the executive control (planning) as a moderator of the relationship between thrill seeking and performance on the BART, the pattern of findings replicated those observed for self-reported risk-taking. Specifically, higher thrill seeking was associated with higher BART scores, but only at high levels of executive control. Specifically, Hayes' Index of Moderated Mediation was *B (SE)* = 1.08 (.65), 95% CI = [.20, 2.80] when comparing the foster care group to the care as usual group and *B (SE)* = 1.24 (.67), 95% CI = [.26, 2.81] when comparing the never institutionalized group to the care as usual group (Figure 3 and Tables 4 - 6).

This indirect effects analysis was repeated with disinhibition replacing thrill seeking as the mediator. The model was not significant, with results indicating that early psychosocial deprivation did not have an effect on disinhibition. The care as usual group did not report different levels of disinhibition relative to the never institutionalized group, *B* (*SE)* = −.14 (.24), 95% CI [−.61, .32], or to the foster care group, *B* (*SE)* = .29 (.22), 95% CI [−.15, .73]. Disinhibition significantly predicted the BART, *B* (*SE)* = 2.45 (1.01), 95% CI [.44, 4.45]. However, neither the direct nor the indirect effects of early deprivation were significant.

Discussion

The current study explored the impact of psychosocial deprivation in the form of institutional rearing on risk-taking among young adolescents and the mechanisms underlying these relations, namely motivation and executive control.

The results suggest that children who were institutionalized early in life had lower rates of risk-taking behavior at age 12 compared to children who were never institutionalized. This effect was mediated by thrill seeking, the socially desirable dimension of sensation seeking. The effect is unique to this appetitive motivation. Indeed, the socially undesirable aspect of sensation seeking characterized by disinhibition does not appear to account for these effects. Furthermore, the impact of early deprivation on motivation for risk behavior and consequently on actual risk-taking was further enhanced by its deleterious effects on executive function. Indeed, the effects of deprivation on risk-taking through thrill seeking were stronger among participants with higher capacity for planning suggesting that risk-taking is enhanced in the presence of stronger executive control processes.

These findings support previous research and highlight the importance of motivational and executive processes in adolescent risk behavior (e.g. Crone & Dhal, 2012; Pfeifer & Allen, 2012; Somerville & Casey, 2010; Steinberg, 2007; Reyna & Rivers, 2008). In addition, our research provides an integrative framework based on motivation research and uses an experimental study to understand how motivation and executive control processes operate to increase risk-taking and how early psychosocial deprivation may impact these processes and consequently risk taking. Specifically, our findings support the importance of motivational processes in understanding risk behavior. In line with previous research they suggest that risk behavior among young adolescents is facilitated by an increased interest in novel and

exciting experiences. Furthermore, early psychosocial deprivation appears to reduce adolescent risk taking due to its diminishing effects on sensitivity to rewards. From this perspective, the current research suggests that risk taking may serve an important developmental motivation that encourages individual to try new things and become independent and that early psychosocial deprivation may interfere with this adaptive function of risk behavior. It is interesting to note, that although the rates of risk behavior were significantly lower among the institutionalized children compared to the children who were never institutionalized, risk behavior did not vary as a function of the foster care intervention. In other words, removing infants from institutions and placing them in foster care did not have an effect on risk behavior later in life (i.e. adolescence) despite the fact that the foster care group had significantly higher scores on thrill seeking than the care as usual group. This finding may warrant a more nuanced view of early psychosocial deprivation and its impact on risk behavior. It is possible that the foster care intervention does ameliorate the effects of early deprivation on sensitivity to rewards. In turn, risk taking among these children, similar to risk taking among never institutionalized children, is a function of their sensitivity to rewards. However, the fact that children who remained or who spent most of their life in institution have similar rates of risk behavior (if not slightly higher) than the foster care group could indicate some form of adaptation. Indeed, this possibility is suggested by evolutionary psychology literature. Accordingly adverse environments (including psychosocial deprivation) provide cues that suggest dangerous, adversary, and unsupportive environments. This might prompt an accelerated maturation and more risk taking that would presumably ensure survival and reproduction Belsky et al., 1991, Rickard et al., 2014). In line with this idea, Loman et al. (2014) also showed that institutionalization was associated with lower levels of risk taking and sensation seeking. However, sensation seeking was lower only among pre/early pubertal, but not among mid/late pubertal youth. They suggested that although there might be a developmental delay in sensation seeking as a result of early deprivation, puberty may increase neuronal plasticity and may result in recalibration and adaptation.

Regarding the role of executive processes, our findings show that sensation seeking is associated with higher rates of risk taking, particularly among adolescents with higher planning ability. Early psychosocial deprivation reduces both the motivation and the capacity for planning resulting in lower rates of risk behavior. These findings support the notion that executive processes are mobilized in a flexible manner as a function of the situation and the motivational factors relevant for the adolescent in the moment (Crone & Dhal, 2012; Pfeifer & Allen, 2012; Defoe et al., 2015). Indeed, recent research has also shown that most forms of adolescent risk activity are *facilitated* (rather than reduced) by higher levels of executive function assessed both at the neurological (maturation in the prefrontal cortex; Berns, Moore, & Capra, 2009) as well as at the cognitive level (working memory; Romer et al, 2011). Furthermore, a recent study of adolescents suggests that working memory (as indicative of executive function) is related to early initiation of risk and externalizing behavior; however, as adolescents age, the emergence of risk behavior is increasingly associated with sensation seeking and this relation is accompanied by growing rather than declining executive function (Romer et al, 2011). We believe that, a high capacity for executive control allows individuals to plan efficiently, to overcome the potential obstacles,

and to avoid negative consequences. Early psychosocial deprivation impacts both motivation and executive processes and may therefore reduce the tendency to engage in risk behavior that involves strategizing. It is possible however, that certain risk behaviors may require executive control to a lesser extent. This should particularly the case for behaviors that are easy to implement, or that adolescents simply mimic in a social context (e.g. smoking). To better understand the role of executive control in risk taking, future research should take into account the level of difficulty involved in engagement in different risk taking behaviors.

Limitations and future directions

This research provides initial evidence that adolescent risk behavior may serve important developmental goals and motivations. However, it focuses exclusively on one motivation, namely the need for novel and exciting experiences. This may raise questions about the extent to which these findings apply to other adolescent goals and motivations, such as the need to belong, to be accepted and admired. It is well established that adolescent risk-taking is more likely to occur in groups. However, this is contingent on the adolescent's sensitivity to rewards and the extent to which the risk behavior is normative within the group (e.g. Perrine & Aloise-Young, 2004, but see Rawn & Vohs, 2011 for an extensive discussion). Furthermore, there is behavioral as well as fMRI evidence suggesting flexible recruitment of control processes as a function of social goals (Rawn & Vohs, 2011, Crone & Dahl, 2012). This seems to suggest that peer pressure in itself is not necessarily associated with impulsivity and risk-taking. Rather, engagement in risk-taking is a function of the extent to which the behavior is perceived as instrumental to one's social goals and it is supported by control processes. In other words, the same motivational processes appear to underlie engagement in adolescent risk-taking regardless of the motivational content. This possibility, although theoretically plausible and suggested by existing research, should be tested in future studies.

Another aspect that may call into question the generalizability of our findings refers to the type of adversity we focused on in this research, namely, institutional rearing. It is possible that other forms of adversity such as growing in disadvantaged neighborhoods, dysfunctional families, and experiencing discrimination, may enhance other developmentally important motivations such as the need to belong and to be accepted and respected by one's peers. In such cases, adversity may result in increased risk-taking and delinquency (e.g., crime, rule breaking, fighting, reckless driving, excessive drinking, and substance use) to ensure reputation for toughness and bravery, and consequently social dominance. Although the motivational processes investigated in the current research should still be relevant, as discussed above, this possibility needs to be examined more directly for a broader understanding of how adversity and deprivation may impact risk behavior.

A third limitation refers to the age of our sample. One could argue that 12 may be too early to observe risk behavior and that the relationship between sensation seeking and risk-taking may decrease as the adolescents age. This is certainly a possibility that should be addressed in further longitudinal studies. Several lines of research that tested the relationship between sensation seeking and risk-taking prospectively suggest that sensation seeking becomes more predictive of risk-taking as adolescents age (e.g. MacPherson et al., 2010; Romer et al.,

2011). This does not exclude the possibility that the motivating impact of sensation on risk-taking decreases as adolescents have the opportunity to experience new things and thus fulfill this motivation.

Previous studies which have taken into account the pubertal status of 12 year olds showed that institutionalization was associated with lower risk taking regardless of pubertal age whereas the relationship between institutionalization and sensation seeking became weaker at older pubertal ages (Loman et al., 2014). They suggested that although institutionalization is associated with a decrease in risk taking and sensation seeking, institutionalized children might recalibrate and show an increase in sensation seeking, as they grow older. Our findings are limited regarding the development of these variables. It is possible that risk taking, sensation seeking, and executive control may change developmentally. Older adolescents might engage in different forms of risk taking and they might do it for other motives (e.g. social goals). However, we believe that our findings and the theoretical argument do not depend on the content of the motivation, or on the type of risk taking. Rather they emphasize the general motivational process and suggest that risk-taking may serve important developmental motivations. In the process, a high capacity for executive control would allow the individual to plan efficiently, to overcome the potential obstacles, and to avoid negative consequences. Early psychosocial deprivation has an impact on risk-taking to the extent to which it affects these motivations and control processes. We believe that regardless of the motivational content and the manner in which adversity influences one motivation or another, the same processes (and pattern of relationships) should apply.

Finally, our study does not address the issue of mental health. The mental health characteristics of this sample are discussed in detail in several publications (e.g., Humphreys et al., 2015; Nelson et al., 2007; Nelson, Fox, & Zeanah, 2014). Institutionalization tends to be related to several mental health issues. However, it is not clear how these issues may be related to the variables of interest here. Previous research seems to provide a mixed picture regarding the relationship between early psychosocial deprivation, mental health, and risk behavior. For instance, Loman et al. (2014) did not find any differences in anxiety and depressive symptoms between institutionalized and non-institutionalized children. Although institutionalized children did have significantly more conduct problems than non-institutionalized children, there was no association between any of the mental health variables and risk behavior. Thus, although based on previous research there is no reason to believe that mental health would be a confounding variable (would systematically impact the outcome variables) in the current study, this aspect should be explored in future research.

In summary, exploring the impact of deprivation/social neglect on adolescent risk behavior has important implications for understanding the development and function of this behavior and consequently for developing efficient prevention and intervention strategies. Although risk behavior may have negative consequences, it fulfills important developmental motivations. Approaching risk behavior as motivated behavior suggests that parents, educators, and policy makers should work around these motivations rather than against them in order to reduce the potential negative consequences of risk-taking.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

Aklin WM, Lejuez CW, Zvolensky MJ, Kahler CW & Gwadz M (2005). Evaluation of behavioral measures of risk-taking propensity with inner city adolescents. Behaviour Research and Therapy, 43(2), 215–228. [PubMed: 15629751]

Albert D, & Steinberg L (2011). Judgment and decision making in adolescence. Journal of Research on Adolescence, 21(1), 211–224. doi:10.1111/j.1532-7795.2010.00724.x

Belsky J, Steinberg L, & Draper P (1991). Childhood experience, interpersonal development, and reproductive strategy: An evolutionary theory of socialization. Child Development, 62(4), 647–670. doi: 10.2307/1131166 [PubMed: 1935336]

Berns GS, Moore S, & Capra CM (2009). Adolescent engagement in dangerous behaviors is associated with increased white matter maturity of frontal cortex. PloS One, 4(8), e6773. [PubMed: 19707512]

Bijleveld E, Custers R, & Aarts H (2009). The unconscious eye opener pupil dilation reveals strategic recruitment of resources upon presentation of subliminal reward cues. Psychological Science, 20(11), 1313–1315. [PubMed: 19788532]

Botvinick M & Braver T (2015). Motivation and cognitive control: from behavior to neural mechanism. Psychology, 66(1), 83–113.

Bowlby J (1952). Maternal care and mental health (Vol. 2). Geneva: WHO.

Brydges NM, Holmes MC, Harris AP, Cardinal RN, & Hall J (2015). Early life stress produces compulsive-like, but not impulsive, behavior in females. Behavioral Neuroscience, 129(3), 300–308. [PubMed: 26030429]

Centers for Disease Control and Prevention (2002). Youth risk behavior surveillance—United States, 2001. Morbidity and Mortality Weekly Report, 51, 1–64.

Champagne FA & Meaney MJ (2007). Transgenerational effects of social environment on variations in maternal care and behavioral response to novelty. Behavioral Neuroscience, 121(6), 1353. [PubMed: 18085888]

Contia G, Hansman C, Heckman JJ, Novak MFX, Ruggiero A, & Suomi SJ (2012). Primate evidence on the late health effects of early-life adversity. Proceedings of the National Academy of Sciences of the United States of America, 109(23), 8866–8871. [PubMed: 22615410]

Crone EA & Dahl RE (2012). Understanding adolescence as a period of social–affective engagement and goal flexibility. Nature Reviews Neuroscience, 13(9), 636–650. [PubMed: 22903221]

Dahl RE (2004). Adolescent brain development: A period of vulnerabilities and opportunities. Annals of the New York Academy of Sciences, 1021(1), 1–22. [PubMed: 15251869]

Defoe IN, Dubas JS, Figner B, & van Aken MAG (2015). A meta-analysis on age differences in risky decision making: Adolescents versus children and adults. Psychological Bulletin, 141(1), 48–84. doi:10.1037/a0038088 [PubMed: 25365761]

Delacre M, Lakens D, Mora Y, & Leys C (2018, 1 31). Why Psychologists Should Always Report the W-test Instead of the F-Test ANOVA. Retrieved from osf.io/jyqmg

Dijksterhuis A & Aarts H (2010). Goals, attention, and (un)consciousness. Annual Review of Psychology, 61, 467–490.

Egeland B, Sroufe A, & Erickson M (1983). The developmental consequence of different patterns of maltreatment. Child Abuse & Neglect, 7(4), 459–469. doi: 10.1016/0145-2134(83)90053-4 [PubMed: 6686797]

Ellis BJ, Del Giudice M, Dishion TJ, Figueredo AJ, Gray P, Griskevicius V, & Wilson DS (2012). The evolutionary basis of risky adolescent behavior: implications for science, policy, and practice. Developmental Psychology, 48(3), 598–623. [PubMed: 22122473]

Felitti VJ, Anda RF, Nordenberg D, Williamson DF, Spitz AM, Edwards V, & Marks JS (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The Adverse Childhood Experiences (ACE) Study. American Journal of Preventive Medicine, 14(4), 245–258. [PubMed: 9635069]

Figner B, & Weber EU (2011). Who takes risks when and why? Determinants of risk taking. Current Directions in Psychological Science, 20(4), 211–216. doi:10.1177/0963721411415790

Galvan A, Hare TA, Parra CE, Penn J, Voss H, Glover G, & Casey BJ (2006). Earlier development of the accumbens relative to orbitofrontal cortex might underlie risk-taking behavior in adolescents. The Journal of Neuroscience 26(25): 6885–6892. [PubMed: 16793895]

Gibbons FX, Gerrard M, Lune LSV, Wills TA, Brody G, & Conger RD (2004). Context and cognitions: Environmental risk, social influence, and adolescent substance use. Personality and Social Psychology Bulletin, 30(8), 1048–1061. [PubMed: 15257788]

Goodyer IM (2002). Social adversity and mental functions in adolescents at high risk of psychopathology. The British Journal of Psychiatry, 181(5), 383–386. [PubMed: 12411262]

Hayes AF (2012). PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling. [White paper]. Retrieved from http://www.afhayes.com/public/process2012.pdf

Hayes AF, Preacher KJ (2014). Statistical mediation analysis with a multicategorical independent variable. British Journal of Mathematical and Statistical Psychology, 67(3), 451–470. [PubMed: 24188158]

Hoyle RH, Stephenson MT, Palmgreen P, Lorch EP, & Donohew RL (2002). Reliability and validity of a brief measure of sensation seeking. Personality and Individual Differences, 32(3), 401–414.

Humphreys KL, Gleason MM, Drury SS, Miron D, Nelson CA, Fox NA, & Zeanah CH (2015). Effects of institutional rearing and foster care on psychopathology at age 12 years in Romania: follow-up of an open, randomised controlled trial. The Lancet Psychiatry, 2(7), 625–634. [PubMed: 26303560]

Jessor R (1992). Risk behavior in adolescence: A psychosocial framework for understanding and action. Developmental Review, 12(4), 374–390.

Kopetz C & Orehek E (2015). When the end justifies the means self-defeating behaviors as “rational” and “successful” self-regulation. Current Directions in Psychological Science, 24(5), 386–391.

Koriakin TA, Mccurdy MD, Papazoglou A, Pritchard AE, Zabel TA, Mahone EM, & Jacobson LA (2013). Classification of intellectual disability using the Wechsler Intelligence Scale for children: Full scale IQ or general abilities index? Developmental Medicine & Child Neurology, 55(9), 840–845. [PubMed: 23859669]

Kruglanski AW, Bélanger JJ, Chen X, Köpetz C, Pierro A, & Mannetti L (2012). The energetics of motivated cognition: A force-field analysis. Psychological Review, 119(1), 1–20. doi:10.1037/a0025488 [PubMed: 21967165]

Lejuez CW, Aklin WM, Zvolensky MJ, & Pedulla CM (2003). Evaluation of the Balloon Analogue Risk Task (BART) as a predictor of adolescent real-world risk-taking behaviours Journal of Adolescence, 26(4), 475–479.

Leventhal T & Brooks-Gunn J (2000). The neighborhoods they live in: The effects of neighborhood residence on child and adolescent outcomes. Psychological Bulletin, 126(2), 309–337. [PubMed: 10748645]

Lewis EE, Dozier M, Ackerman J, & Sepulveda-Kozakowski S (2007). The effect of placement instability on adopted children's inhibitory control abilities and oppositional behavior. Developmental Psychology, 43(6), 1415–1427. [PubMed: 18020821]

Loman MM, Johnson AE, Quevedo K, Lafavor TL, & Gunnar MR (2014). Risk-taking and sensation-seeking propensity in postinstitutionalized early adolescents. Journal of Child Psychology and Psychiatry, 55(10), 1145–1152. doi:10.1111/jcpp.12208 [PubMed: 24552550]

Lopes LL (1987). Between hope and fear: The psychology of risk In Berkowitz L & Berkowitz L (Eds.), Advances in experimental social psychology, *Vol.* 20 (pp. 255–295). San Diego, CA, US: Academic Press.

Lovallo WR, Farag NH, Sorocco KH, Acheson A, Cohoon AJ, & Vincent AS (2013). Early life adversity contributes to impaired cognition and impulsive behavior: Studies from the Oklahoma Family Health Patterns Project. Alcoholism: Clinical and Experimental Research, 37(4), 616–623. doi: 10.1111/acer.12016

Lovallo WR (2013). Early life adversity reduces stress reactivity and enhances impulsive behavior: Implications for health behaviors. International Journal of Psychophysiology, 90(1), 8–16. [PubMed: 23085387]

Luciana M & Nelson CA (2000). Neurodevelopmental assessment of cognitive function using the Cambridge Neuropsychological Testing Automated Battery (CANTAB): Validation and future goals Functional Neuroimaging in Child Psychiatry. Cambridge University Press, Cambridge: 379–397.

MacLean K (2003). The impact of institutionalization on child development. Development and Psychopathology, 15(04), 853–884. [PubMed: 14984130]

MacPherson L, Magidson JF, Reynolds EK, Kahler CW, & Lejuez CW (2010). Changes in sensation seeking and risk-taking propensity predict increases in alcohol use among early adolescents. Alcoholism: Clinical and Experimental Research, 34(8), 1400–1408.

MacPherson L, Reynolds EK, Daughters SB, Wang F, Cassidy J, Mayes LC, & Lejuez CW (2010). Positive and negative reinforcement underlying risk behavior in early adolescents. Prevention Science, 11(3), 331–342. [PubMed: 20309633]

McDermott JM, Troller-Renfree S, Vanderwert R, Nelson CA, Zeanah CH, & Fox NA (2013). Psychosocial deprivation, executive functions, and the emergence of socio-emotional behavior problems. Frontiers in Human Neuroscience, 7(167), 239–249. [PubMed: 23755004]

Molet J, Heins K, Zhuo X, Mei YT, Regev J, Baram TZ, & Stern H (2016). Fragmentation and high entropy of neonatal experience predict adolescent emotional outcome. Translational Psychiatry, 6(1), 1–7.

Nelson CA (2007). A neurobiological perspective on early human deprivation. Child Development Perspectives, 1(1), 13–18.

Nelson CA, Fox NA, & Zeanah CH (2014). Romania's Abandoned Children: Deprivation, Brain Development and the Struggle for Recovery. Cambridge, MA: Harvard University Press.

Nelson CA, Zeanah CH, Fox NA, Marshall PJ, Smyke AT, & Guthrie D (2007). Cognitive recovery in socially deprived young children: The Bucharest Early Intervention Project. Science, 318(5858), 1937–1940. [PubMed: 18096809]

Pears KC, Fisher PA, Bruce J, Kim HK, & Yoerger K (2010). Early elementary school adjustment of maltreated children in foster care: The roles of inhibitory control and caregiver involvement. Child Development, 81(5), 1550–1564. [PubMed: 20840240]

Perrine NE, & Aloise-Young PA (2004). The role of self-monitoring in adolescents' susceptibility to passive peer pressure. Personality and Individual Differences, 37(8), 1701–1716.

Pfeifer JH, & Allen NB (2012). Arrested development? Reconsidering dual-systems models of brain function in adolescence and disorders. Trends in Cognitive Sciences, 16(6), 322–329. doi:10.1016/j.tics.2012.04.011 [PubMed: 22613872]

Phillips LH, Wynn VE, McPherson S, & Gilhooly KJ (2001). Mental planning and the Tower of London task. The Quarterly Journal of Experimental Psychology: Section A, 54(2), 579–597.

Rawn CD, & Vohs KD (2011). People use self-control to risk personal harm: An intra-interpersonal dilemma. Personality and Social Psychology Review, 15(3), 267–289. [PubMed: 20807858]

Reyna VF, & Rivers SE (2008). Current theories of risk and rational decision making. Developmental Review, 28(1), 1–11. doi:10.1016/j.dr.2008.01.002 [PubMed: 19255598]

Rickard IJ, Frankenhuis WE, & Nettle D (2014). Why are childhood family factors associated with timing of maturation? A role for internal prediction. Perspectives on Psychological Science, 9(1), 3–15. doi: 10.1177/1745691613513467 [PubMed: 26173236]

Romer D (2010). Adolescent risk-taking, impulsivity, and brain development: Implications for prevention. Developmental Psychobiology, 52(3), 263–276. [PubMed: 20175097]

Romer D, Betancourt LM, Brodsky NL, Giannetta JM, Yang W, & Hurt H (2011). Does adolescent risk taking imply weak executive function? A prospective study of relations between working memory performance, impulsivity, and risk taking in early adolescence. Developmental Science, 14(5), 1119–1133. doi: 10.1111/j.1467-7687.2011.01061.x [PubMed: 21884327]

Romer D, Betancourt L, Giannetta JM, Brodsky NL, Farah M, & Hurt H (2009). Executive cognitive functions and impulsivity as correlates of risk-taking and problem behavior in preadolescents. Neuropsychologia, 47(13), 2916–2926. [PubMed: 19560477]

Rutter M, Colvert E, Kreppner J, Beckett C, Castle J, Groothues C, & Sonuga-Barke EJ (2007). Early adolescent outcomes for institutionally-deprived and non-deprived adoptees. I: Disinhibited attachment. Journal of Child Psychology and Psychiatry, 48(1), 17–30. [PubMed: 17244267]

Rutter M, Colvert E, Kreppner J, Beckett C, Castle J, Groothues C, & Sonuga-Barke EJ (2007). Early adolescent outcomes for institutionally-deprived and non-deprived adoptees. I: Disinhibited attachment. Journal of Child Psychology and Psychiatry, 48(1), 17–30. [PubMed: 17244267]

Shedler J, & Block J (1990). Adolescent drug use and psychological health: A longitudinal inquiry. American Psychologist, 45(5), 612–630. [PubMed: 2350080]

Somerville LH & Casey BJ (2010). Developmental neurobiology of cognitive control and motivational systems. Current Opinion in Neurobiology, 20(2), 236–241. [PubMed: 20167473]

Spear LP (2000). Neurobehavioral changes in adolescence. Current Directions in Psychological Science, 9(4), 111–114.

Spear LP (2007). The developing brain and adolescent-typical behavior patterns: An evolutionary approach In Walker E, Romer D (Eds.,) Adolescent Psychopathology and the Developing Brain: Integrating Brain and Prevention Science (pp. 9–30) New York, NY: Oxford University Press.

Spear LP (2009). Heightened stress responsivity and emotional reactivity during pubertal maturation: Implications for psychopathology. Development and Psychopathology, 21(1), 87–97. [PubMed: 19144224]

Steinberg L (2007). Risk-taking in adolescence new perspectives from brain and behavioral science. Current Directions in Psychological Science, 16(2), 55–59.

Steinberg L (2014). Age of opportunity: Lessons from the new science of adolescence. Boston, MA: Eamon Dolan/Houghton Mifflin Harcourt.

Stephenson MT, Velez LF, Chalela P, Ramirez A, & Hoyle RH (2007). The reliability and validity of the Brief Sensation Seeking Scale (BSSS-8) with young adult Latino workers: implications for tobacco and alcohol disparity research. Addiction, 102(s2), 79–91. [PubMed: 17850617]

Zeanah CH, Nelson CA, Fox NA, Smyke AT, Marshall P, Parker SW, & Koga S (2003). Designing research to study the effects of institutionalization on brain and behavioral development: The Bucharest Early Intervention Project. Development and Psychopathology, 15(04), 885–907. [PubMed: 14984131]

Zuckerman M (1979). Sensation seeking, Hillsdale, NJ: Lawrence Erlbaum Association.

Zuckerman M (2014). Sensation Seeking (Psychology Revivals): Beyond the Optimal Level of Arousal, Psychology Press.

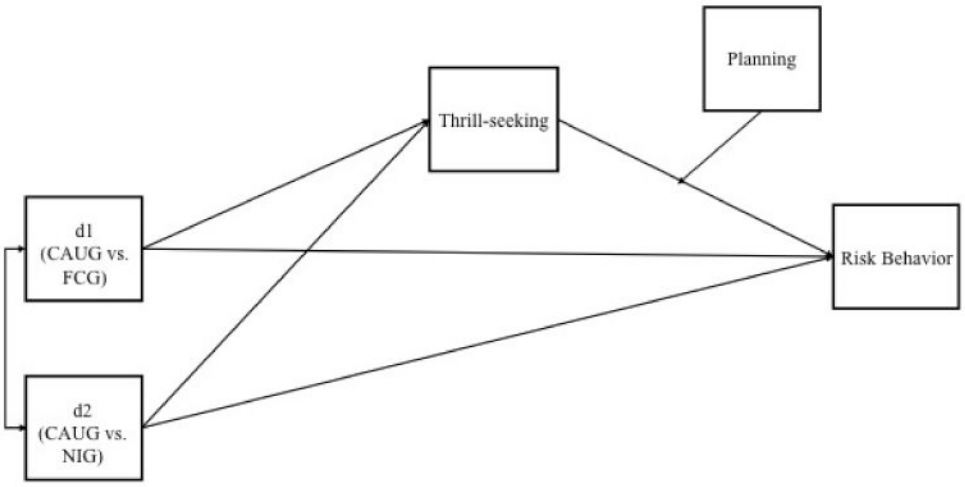

Figure 1.
The conceptual model
Note. CAUG = care as usual group; FCG = foster care group; NIG = never institutionalized group

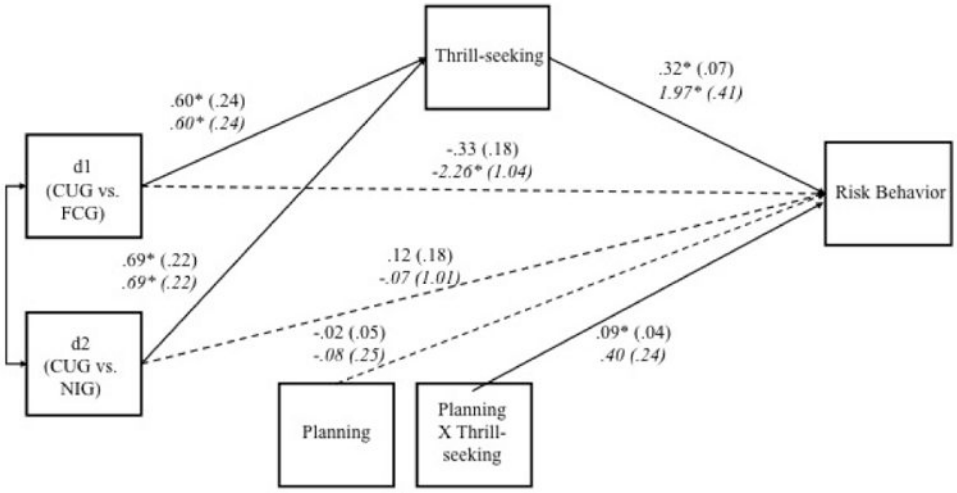

Figure 2.

Statistical model depicting the effects (unstandardized beta coefficients and SEs) of early psychosocial deprivation on self-reported risk behavior through thrill-seeking and the moderating effect of planning.

Note 1. CAUG = care as usual group; FCG = foster care group; NIG = never institutionalized group.

Note 2. The analyses we ran on log transformed data. In addition to the unstandardized beta coefficients and SEs, the italicized coefficients represent the exponential transformation and therefore the geometric mean of the raw data.

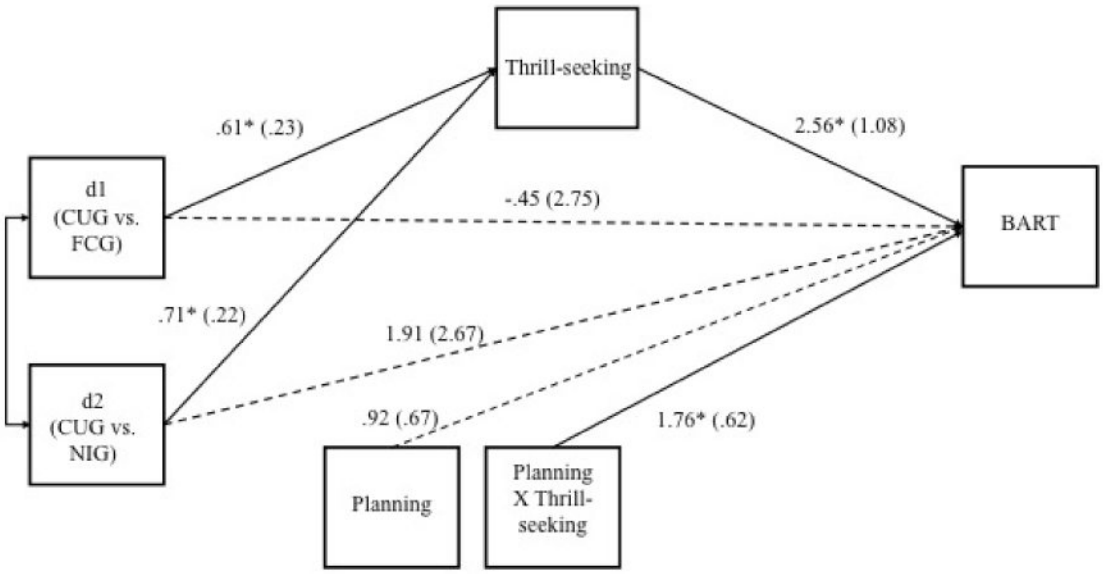

Figure 3.

Statistical model depicting the effects (unstandardized beta coefficients and SEs) of early psychosocial deprivation on the BART through thrill-seeking and the moderating effect of planning.

Note 1. CAUG = care as usual group; FCG = foster care group; NIG = never institutionalized group.

Note 2. The analyses we ran on log transformed data. In addition to the unstandardized beta coefficients and SEs, the italicized coefficients represent the exponential transformation and therefore the geometric mean of the raw data.

Table 1.

Percentage of respondents endorsing engagement in risk behaviors in the past year ($N = 127$)

Behavior	% Endorsing
Rode in car without seatbelt	62.2%
Drank alcohol	52.0%
Crossed street recklessly	43.3%
Started a physical fight	27.6%
Gambled money	21.3%
Smoked cigarettes	14.2%
Provoked street dogs	13.4%
Visited inappropriate websites	10.2%

Table 2.

Bivariate correlations between variables

	1	2	3	4	5	6
Risk Behavior	-					
BART	.173	-				
Planning	.012	.170	-			
Thrill seeking	.342**	.176	.035	-		
Disinhibition	.438**	.232*	−.095	.534**	-	
% time in institution	.065	.052	−.075	−.134	−.095	-

* $p < .05$

** $p < .001$

Table 3.

Group comparisons[1]

a)

	CAUG + FCG	NIG				
Variable	***M (SD)***	***M (SD)***	***F***	***p***	***W***	***p***
Thrill-seeking	1.89 (0.96)	2.28 (1.08)	4.54	.035*	4.30	.041*
Disinhibition	1.73 (0.98)	2.10 (1.07)	4.00	.048*	3.85	.053
Planning	7.38 (1.57)	7.94 (1.49)	4.05	.046*	4.13	.044*
Risk behavior	4.47 (4.56)	6.46 (4.60)	5.91	.016*	5.83	.018*
BART	24.62 (11.47)	28.76 (12.85)	3.60	.060	3.44	.066

b)

	CAUG	FCG	NIG				
Variable	***M (SD)***	***M (SD)***	***M (SD)***	***F***	***p***	***W***	***p***
Thrill-seeking	1.62 (0.96)	2.17 (0.88)	2.28 (1.08)	5.40	.006*	5.42	.006*
Disinhibition	1.79 (1.13)	1.67 (0.81)	2.10 (1.07)	2.14	.122	2.36	.101
Planning	7.06 (1.39)	7.67 (1.68)	7.94 (1.49)	3.53	.032*	3.99	.023*
Risk behavior	5.24 (5.35)	3.75 (3.34)	6.46 (4.60)	4.04	.020*	5.28	.007*
BART	23.79 (11.62)	25.41 (11.42)	28.76 (12.85)	1.96	.145	1.88	.160

Note. CAUG = care as usual group; FCG = foster care group; NIG = never institutionalized group

[1]Levene's test of homogeneity of variance was not significant for any of the ANOVA analyses reported here. However, in line with the suggestions (Delacre, Lakens, Mora, & Leys, 2018), we also included the results corresponding to the Welch-test.

Table 4.

Unstandardized regression coefficients with confidence intervals estimating the effect of early childhood deprivation on risk behavior through thrill seeking and disinhibition.

	Risk Behavior (YRBS)				BART			
	Thrill Seeking		Risk Behavior		Thrill Seeking		BART	
Variable	***B(SE)***	**95% CI**	***B(SE)***	**95% CI**	***B(SE)***	**95% CI**	***B(SE)***	**95% CI**
Constant	1.62*(.16)	1.30 - 1.95	1.05*(.16)	.72 - 1.37	1.57*(.16)	1.25 - 1.89	21.11*(2.54)	16.08 - 26.14
NIG vs. CAUG	.55*(.23)	.09 - 1.00	−.34 (.18)	.68 - .01	.62*(.23)	.16 - 1.07	.41 (2.77)	−5.08 - 5.89
FCG vs. CAUG	66*(.22)	.23 - 1.08	.12 (.17)	−.21 - .45	.71*(.22)	.29 - 1.14	3.05 (2.64)	−2.17 - 8.27
Thrill seeking	-	-	.27*(.07)	.14 - .41	-	-	1.71 (1.06)	−.40 - 3.82
	Disinhibition		**Risk Behavior**		**Disinhibition**		**BART**	
Variable	***B(SE)***	**95% CI**	***B(SE)***	**95% CI**	***B(SE)***	**95% CI**	***B(SE)***	**95% CI**
Constant	1.81*(.17)	1.48 - 2.15	.91*(.17)	.59 - 1.24	1.80*(.17)	1.46 - 2.13	19.39*(2.62)	14.20 - 24.59
NIG vs. CAUG	−.14 (.24)	−.61 - .32	−.14 (.17)	−.47 - .18	−.14 (.24)	−.61 - .33	1.80 (2.66)	−3.47 - 7.07
FCG vs. CAUG	.29 (.22)	−.15 - .73	.20 (.16)	−.11 - .52	.30 (.22)	−.14 - .74	3.53 (2.51)	−1.45 - 8.50
Disinhibition	-	-	.32*(.06)	.19 - .44	-	-	2.45*(1.01)	.44 - 4.45

*$p < .05$

Table 5.

Unstandardized regression coefficients with confidence intervals estimating the effect of early childhood deprivation on risk behavior through thrill seeking and the moderating effect of executive control.

	Risk Behavior (YRBS)				BART			
	Thrill Seeking		Risk Behavior		Thrill Seeking		BART	
Variable	*B(SE)*	95% CI	*B(SE)*	95% CI	*B(SE)*	95% CI	*B(SE)*	95% CI
Constant	−.47*(.17)	−.81 – −.13	1.60*(.14)	1.33– 1.86	−.48*(.17)	−.81 – −.14	25.27*(2.00)	21.31-29.23
NIG vs. CAUG	.69*(.22)	.25 – 1.13	.12 (.18)	−.23 – .48	.71*(.22)	.27 – 1.14	1.91 (2.67)	−3.35 – 7.17
FCG vs. CAUG	.60*(.24)	.13 – 1.06	−.33 (.18)	−.70 – −.03	.61*(.23)	.15 – 1.08	−.45 (2.75)	−5.88 – 4.98
Thrill seeking			.32*(.07)	.17 – .46			2.56*(1.08)	.43 – 4.70
Planning			−.02 (.05)	−.11 – .07			.92 (.67)	−.41 – 2.25
Thrill seeking X Planning			.09*(.04)	.01 – .17			1.76*(.62)	.52 – 2.99
	R^2= .082 F(2,119) = 5.29, p = .006		R^2= .203 F(5,116) = 5.90, p < .001		R^2= .087 F(2,120) = 5.70, p = .004		R^2= .122 F(5,117) = 3.25, p = .009	

*p < .05

Table 6.

Conditional indirect effects of early childhood adversity on risk behavior for youth with different levels of executive function

	Risk Behavior (YRBS)		BART	
Level of Planning	**Indirect Effect (SE)**	**95% CI**	**Indirect Effect (SE)**	**95% CI**
NIG (vs. CAUG)				
Low (−1 SD)	.12 (.08)	−.01 – .31	−.13 (.97)	−2.44 – 1.53
High (+1 SD)	.32 (.13)	.10 – .64	3.76 (1.77)	1.13 – 8.31
FCG (vs. CAUG)				
Low (−1 SD)	.10 (.07)	−.01 – .30	−.12 (.92)	−2.53 – 1.25
High (+1 SD)	.27 (.12)	.08 – .56	3.25 (1.69)	.64 – 7.45