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Early unpredictability predicts increased adolescent externalizing behaviors and substance use: A life history perspective

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Abstract

According to evolutionary life history models, environmental harshness and unpredictability can both promote a fast life history strategy characterized by increased risk taking and enacting short-term, opportunistic behaviors. The current longitudinal study tests whether environmental unpredictability during childhood has stronger effects on risky behavior during adolescence than harshness, and whether there may be an early "sensitive period" during which unpredictability has particularly strong and unique effects on these outcomes. Using data from the Minnesota Longitudinal Study of Risk and Adaptation, prospective assessments of environmental unpredictability (changes in residence, cohabitation, and parental occupation) and harshness (mean socioeconomic status) from birth into adolescence were used to predict self-reported externalizing behaviors and substance use at age 16 ($N = 220$). Exposure to greater early unpredictability (between ages 0 and 5) predicted more externalizing behaviors as well as more alcohol and marijuana use at age 16, controlling for harshness and later unpredictability (between ages 6 and 16). Harshness predicted adolescent substance use, and later unpredictability predicted adolescent externalizing behaviors at the trend level. Early unpredictability and harshness also interacted, such that the highest levels of risk taking occurred in individuals who experienced more early unpredictability *and* lived in harsher environments. Age 16 externalizing behaviors, but not substance use, mediated the association between early unpredictability and externalizing/criminal behaviors at age 23. We discuss how exposure to early environmental unpredictability may alter biological and social–cognitive functioning from a life history perspective.

Childhood psychosocial stress has well-known negative effects on physical and mental health, including increased likelihood of cardiovascular disease, cancer, asthma, autoimmune diseases, and depression (Felitti et al., 1998; Shonkoff, Boyce, & McEwen, 2009; Shonkoff & Garner, 2012). Adolescents who encounter more chronic stress during childhood are also more likely to have problems with externalizing behaviors and substance abuse (Felitti et al., 1998; Schilling, Aseltine, & Gore, 2007). Traditional developmental psychopathology models, such as allostatic load models, predict that children who are exposed to greater cumulative stress should show more functional impairment, including more mental health, physical health, and interpersonal problems later in life (e.g., Evans & English, 2002; Gutman, Sameroff, & Eccles, 2002; McEwen, 1998). More recent models, such as the adaptive calibration model (Ellis & Del Giudice, 2014), emphasize the potentially functional and adaptive nature of certain biobehavioral changes during development that may explain the connection between exposure to early life stress and these later outcomes. The adaptive calibration model proposes that organisms evolved to calibrate (adjust) their autonomic, neuroendocrine, metabolic, immunological, and behavioral systems in response to the types of environments in which they live. According to this model, early exposure to certain forms of chronic stress (e.g., unpredictable environments) should produce a pattern of physiological and behavioral responses that promote greater risk taking in order to increase reproductive fitness within these environments.

In the current longitudinal research, we borrow ideas and principles from life history theory (e.g., Kaplan & Gangestad, 2005; Stearns, 1992) and associated models (e.g., Ellis & Del Giudice, 2014) to test (a) whether exposure to certain forms of stress in childhood have stronger effects on risky behavior in adolescence than other forms, and (b) whether there is an early "sensitive period" during which exposure to certain forms of stress have particularly strong long-term outcomes. Although we know that greater cumulative stress forecasts poorer mental health and interpersonal outcomes in general, we still do not know whether it is worse for children to live in environments that are *harsh* (those that consistently have insufficient resources) and/or *unpredictable* (those that have frequent, rapid, and/or chaotic changes in the home or local environment). We also know little about whether exposure to higher levels of harshness and/or unpredictability at certain developmental ages (such as earlier vs. later in childhood) exert unique effects on these outcomes, or whether early unpredictability and harshness statistically interact to forecast the highest levels of risky, externalizing behaviors in adolescence.

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The primary goal of the current research was to fill these important gaps in our knowledge. To do so, we analyzed data from the Minnesota Longitudinal Study of Risk and Adaptation (MLSRA; Sroufe, Egeland, Carlson, & Collins, 2005), which has prospective, coder-rated assessments of both the environmental unpredictability (i.e., changes in residence, cohabitation, and parental occupation) and harshness (i.e., mean socioeconomic status [SES]) to which target participants were exposed from birth into adolescence (age 16). We tested how these measures, which were assessed multiple times during development, forecast target participants' externalizing behaviors and substance use (both markers of greater risk-taking tendencies; Boyer, 2006; Wills, Vaccaro, & McNamara, 1994) when participants were 16 years old. In addition, we tested a novel hypothesis derived from a recent life history model of social development (Ellis, Figueredo, Brumbach, & Schlomer, 2009) and consistent with recent empirical work (e.g., Simpson, Griskevicius, Kuo, Sung, & Collins, 2012): that exposure to greater unpredictability during the first 5 years of life should *uniquely* predict these risk-taking behaviors in adolescence. We also tested another novel hypothesis: that early unpredictability should result in the *most* risk-taking behaviors among those who grew up in lower SES (i.e., high harshness) households. Finally, we examined whether adolescent externalizing behaviors and substance use at age 16 mediated the link between early unpredictability (at ages 0–5) and adult externalizing/criminal behaviors at age 23.

Harshness and Unpredictability

According to recent evolutionary life history models, there are two major forms of stressors: harshness and unpredictability (Ellis et al., 2009). Harshness is a proxy for the rate at which environmental factors cause morbidity and mortality across all ages within in a population. Unpredictability refers to variability in harshness across time and space (see Ellis et al., 2009). Each dimension is conjectured to predict behavior and perhaps physiological outcomes in unique ways (see Ellis et al., 2009). For example, exposure to highly unpredictable environments characterized by frequent changes in residence or cohabitation patterns in the home (e.g., Belsky, Schlomer, & Ellis, 2012) should lead most individuals to engage in riskier, more opportunistic behaviors later in life (Ellis et al., 2009). There is some evidence that exposure to greater unpredictability during the first 5 years of life prospectively predicts engaging in sex at an earlier age, having more sexual partners, enacting more aggressive and delinquent behaviors, and being tied to criminal activities at age 23, whereas exposure to higher levels of harshness across development or to unpredictability later in development does not predict these outcomes (Simpson et al., 2012). This increase in sexual and externalizing behaviors reflects the enactment of a fast life history strategy, which involves adopting an opportunistic orientation in which individuals pursue immediate gratification and take greater risks relatively earlier in life to (unconsciously) increase the probability of reproducing prior to a possible early death (see Belsky, Steinberg, Houts, & Halpern-Felsher, 2010; Figueredo et al., 2006; Nettle, 2010).

Consistent with this view, individuals who adopt a fast life history strategy believe that the future is less knowable, predictable, and controllable and that their lives may be comparatively shorter (Griskevicius, Tybur, Delton, & Robertson, 2011; Mittal & Griskevicius, 2014), which motivates them to enact riskier behaviors at an earlier age (Hill, Ross, & Low, 1997). These behavioral tendencies should have been adaptive and increased reproductive fitness in our evolutionary past, especially among individuals who experienced less stability during their childhoods but who, as adults, could take advantage of immediate opportunities that yielded short-term benefits, even if such behaviors had long-term costs (see Belsky, Steinberg, & Draper, 1991; Belsky et al., 2010; Del Giudice, 2009; Ellis et al., 2009; Simpson & Belsky, 2016).

Focus on Unpredictability and Externalizing Behaviors

Evidence from both animal and human models indicates that environmental unpredictability can generate powerful behavioral and physiological developmental outcomes (see Ellis & Del Giudice, 2014; Ellis et al., 2009, for reviews). In animals, for example, bonnet macaque mothers who are randomly assigned to "variable foraging" conditions (in which the availability of food is highly unpredictable over time) engage in less cooperative mutual grooming behavior, are less sensitive and responsive to their infants, and behave more aggressively toward other adults in their troop than mothers who are randomly assigned to predictable foraging conditions, including consistently harsh ones (Rosenblum & Andrews, 1994; Rosenblum & Paully, 1984). Research with rodents has also documented differential effects of unpredictable stress versus chronic stress (harshness). Greater cocaine self-administration, increased exploratory behavior, and greater sensitization to dopamine in the nucleus accumbens (a component of the reward system in the brain) have all been observed in episodically stressed rodents compared to chronically stressed ones (Miczek, Nikulina, Shimamoto, & Covington, 2011). Unpredictability, therefore, appears to exert it effects on behavior and cognitive functioning at least partially through alterations in stress physiology and brain development.

In humans, exposure to more unpredictable environments during childhood has significant effects on behavior and psychological adjustment. Greater family instability is associated with more externalizing behavior in preschool children and more internalizing symptoms in first grade (Ackerman, Kogos, Youngstrom, Schoff, & Izard, 1999), and greater unpredictability as measured by Child Protective Services involvement and residence changes is related to increased behavior problems over time (Bada, 2008). For girls in particular, growing up in an unstructured or laissez-faire home early in life predicts more drug use in adolescence (Block, Block, & Keyes, 1988), whereas exposure to predictable environments,

especially stable household routines, predicts better psychological adjustment, higher achievement in school, and greater satisfaction with family members (Fiese et al., 2002; Kliewer & Kung, 1998; Repetti, Taylor, & Seeman, 2002). Therefore, unpredictability may exert a particularly strong effect on development becaude unpredictable stress may often be more difficult to adapt to than harsh but predictable stress, unless harshness becomes extreme (see Ellis et al., 2009).

According to the adaptive calibration model (Ellis & Del Giudice, 2014), however, there are distinct evolutionary advantages associated with engaging in risk-taking behavior in adolescence, especially in response to early unpredictable environments, even though these behaviors are associated with poorer health and interpersonal outcomes (see Belsky et al., 2012; Ellis et al., 2012; Simpson & Belsky, 2016). Exposure to unpredictable environments early in life should produce evolutionarily adaptive behavioral and physiological changes within individuals that allow them to not only respond to immediate stressors in a more adaptive fashion (with respect to reproductive fitness) but also prepare for the future unpredictable environments they are likely to inhabit.

For example, engaging in risky, externalizing behaviors and alcohol or drug use with peers, especially during adolescence, can draw the attention of, achieve status with, and result in more popularity with peers, particularly among individuals who lack other means of gaining notoriety and popularity (Ellis et al., 2012). Although most externalizing behaviors are not viewed positively by current society, they may be "adaptive" for adolescents who have been raised in unpredictable (and perhaps harsh) environments (Ellis & Bjorklund, 2012). These environments signal that an individual may have a shorter-than-normal life expectancy and a less certain future, which should result in the enactment of a fast life history strategy characterized by an opportunistic interpersonal orientation, less delay of gratification, and greater risk taking. Particularly during adolescence, displaying externalizing behaviors and engaging in forbidden substance use can elevate status among valued peers while simultaneously drawing the attention of potential mates, making these behaviors adaptive from a reproductive standpoint. Aggressive children and adolescents may become popular and respected, especially if externalizing behaviors are paired with prosocial strategies, which should increase the potential adaptiveness of risky behaviors (see Hawley, 2007; Pellegrini & Bartini, 2001; Rodkin, Farmer, Pearl, & Van Acker, 2006).

Extending this thinking to mating behavior, men who do not have a romantic partner typically match their level of risk taking to what they believe most females in their environment will find attractive (Frankenhuis & Karremans, 2012). With regard to substance use, affiliating with peers who use alcohol or drugs is one of the best predictors of substance use in adolescence (Hawkins, Catalano, & Miller, 1992), which further suggests that drug and alcohol use are one way to gain status in these social groups.

In sum, engagement in risky behaviors, which peak during adolescence and early adulthood, should have increased reproductive fitness in ancestral environments, even though they generate societal costs today (such as dropping out of school and lower lifetime SES; Gibbons et al., 2012). In ancestral environments, however, these behaviors, especially when displayed during adolescence, should have increased the likelihood that these individuals mated before dying, thereby increasing the probability that their genes would be passed on to subsequent generations.

A Sensitive Period?

The first few years of life are a sensitive period for brain development as sensory, attentional, and limbic systems are developing rapidly (Braun, 2011). The prefrontal cortex, which governs higher order thought, is also growing rapidly, even though it continues to develop well into adolescence and early adulthood. High plasticity and openness to experience characterize the infant brain and, as a result, the infant's environment affects the development of neural systems responsible for adaptive responses to stress (Susman, 2006). Inconsistent care and unpredictable environments should, and probably do, alter neural systems during early sensitive periods of brain development (Dawson, Ashman, & Carter, 2000; Susman, 2006), and they may "prepare" brain for experiencing and dealing with unpredictability later in life (Ellis & Del Giudice, 2014). Exposure to early unpredictability between birth and age 5, therefore, may have a stronger impact on how the brain is programmed than unpredictability that occurs later in childhood and adolescence.

There is also evidence that early environmental influences shape life history strategies (e.g., Belsky et al., 2007; Bereczkei & Csanaky, 1996; Ellis et al., 2003; Quinlan, 2003). For example, when exposed to unpredictability in the home environment, young children appear to make inferences about the nature of their probable future environments and (unconsciously) calibrate their responses accordingly (Belsky et al., 2012; Simpson & Belsky, 2008). As a result, exposure to unpredictable environments during the first 5 years of life should shape the trajectories of both brain development *and* behavioral approaches consistent with a fast life history strategy more strongly than exposure to unpredictability that occurs later in childhood and adolescence.

The Current Study

The current longitudinal study tested whether unpredictability (as indexed by disruptions caused by parental job changes, residence changes, and changes in cohabitation) assessed at multiple time points across development prospectively predicts more externalizing behaviors and substance use at age 16. Most prior studies have used retrospective reports of stress and SES to examine associations with concurrent outcomes, many of which may be inaccurate or biased. Using the MLSRA (Sroufe et al., 2005), coder-rated assessments of both unpredictability and harshness gathered during infancy, childhood, and adolescence were used to more accurately pre-

dict externalizing and substance use outcomes in adolescence prospectively. In addition, these data were used to test whether adolescent externalizing behaviors and substance use mediate the association between early unpredictability and early adulthood externalizing/criminal behaviors. The analyses were designed to elucidate the developmental pathways between early unpredictability and adult externalizing behaviors. The study was also designed to disentangle the effects of early and late unpredictability on adolescent externalizing behaviors and substance use, which has never been investigated. Given that most prior studies have confounded harshness and unpredictability by measuring only SES, we also attempted to disentangle them statistically in the current study. Finally, the analyses build on previous research by testing whether unpredictability and harshness interact to predict adolescent outcomes.

We hypothesized that exposure to greater unpredictability during the first 5 years of life would result in more externalizing behaviors and substance use at age 16. We also hypothesized that early unpredictability should have a stronger and unique (independent) link with externalizing behaviors and substance use relative to later unpredictability (measured at ages 6–16) and environmental harshness (measured by mean SES at ages 0–16). Finally, we examined whether early unpredictability and harshness statistically interacted to predict these behaviors (e.g., whether early unpredictability predicted the *greatest* externalizing behaviors and substance use in individuals who also grew up in lower SES [harsher] conditions). Because the most severe forms of stress are likely to include elements of both harshness *and* unpredictability, we anticipated that this combination may have the greatest impact on functioning. This more exploratory prediction differs from a cumulative risk prediction in that it does not anticipate that lower SES individuals should be at higher risk for subsequent externalizing behaviors and substance use, independent of early unpredictability. More specifically, we anticipated that individuals exposed to low early unpredictability would have the lowest risk for later externalizing behaviors and substance use, those exposed to high early unpredictability *and* high SES would have the second highest risk, and high early unpredictability *and* low SES individuals would have the highest risk.

Method

Participants

The data came from a longitudinal study of firstborn children and their mothers, who started the study in 1975–1977 living below the poverty line. Prior to the target participants' birth, mothers ($N = 267$, age range = 12–34 years, $M = 20.6$ years) were recruited for the study during the third trimester of their pregnancy. The highest study dropout rate occurred within the first 2 years due to mothers who left the project for various reasons (primarily moving away). However, there has been very little attrition in the sample since that time. The current analyses involve all individuals on whom information about early unpredictability and SES were available ($N = 220$, or 82.4% of the recruited participants). These participants did not differ from the original sample in terms of sex, mothers' age at delivery, birth weight, maternal education, or mothers' prenatal SES. Of these participants, 121 were male and 99 were female. Their racial background was 140 White, 30 Black, and 35 mixed race. Seven individuals listed "other" for race, and 8 had unknown racial backgrounds due to incomplete information about their father's race. Maternal education when participants were born ranged from 7 to 20 years of formal education ($M = 11.72$, $SD = 1.78$). At age 16, 171 individuals participated in data collection, and 162 participated at age 23. Missing data at different time points was handled using maximum likelihood estimation in Mplus.

Harshness (SES)

Consistent with recent studies (e.g., Belsky et al., 2012; Simpson et al., 2012) and theory (Ellis et al., 2009), SES was used as a measure of harshness because it is an external, independent cause of morbidity and mortality across all ages. Parent-reported information regarding SES was available at eight time points: before the target participant was born (prenatally); when the target participant was 42 and 54 months old; at Grades 1, 2, 3, and 6; and when the participant was 16 years old. An updated version of the Duncan Socioeconomic Index (SEI; Duncan, 1961; Stevens & Featherman, 1981) was used to assess occupational status. This index provides information about occupational prestige based on education and income characteristics of all men and women in the US labor force in 1970. In addition, information regarding household income and mothers' level of education was obtained. Information for each SES measure (occupational status, income, and maternal education) was not collected at every time point. All three SES measures were collected prenatally, at Grades 3 and 6, and at age 16. Only the SEI and maternal education (in years) were collected at 42 months, Grade 1, and Grade 2, and just the SEI measure was collected at 54 months.

To create an overall measure of childhood harshness, z scores of all available SES items within each assessment period were computed. These values were then transformed to t scores (i.e., $M = 50$, $SD = 10$) to remove negative values. An average of these eight scores was then obtained, yielding a mean SES score ($\alpha = 0.89$; $M = 50.1$, $SD = 8.76$). This average score was centered at zero for all analyses. Lower scores indicated lower SES (signifying more harshness). A mean harshness (SES) score from 0 to 16 was used in all analyses for parsimony, given that early (ages 0–5) and later (ages 6–16) harshness revealed no significant associations with any of the dependent variables.

Although all target participants were born below the poverty line, SES mean and variability increased substantially from early infancy to adolescence. For example, a 10-point average increase in Duncan SEI scores occurred between the prenatal period and age 16 (prenatal SEI range = 0.00–82.50, $M = 19.35$, $SD = 10.65$; age 16 SEI range = 10.00–88.30, $M = 29.79$, $SD = 15.71$). Duncan SEI scores can range from 0 to 100, with the highest prestige jobs

(such as lawyers, physicians, actuaries, dentists, and professors) typically receiving scores in the 80s and 90s during this particular time period (Stevens & Featherman, 1981). Occupations with SEI scores similar to the prenatal average in our sample include buyers/shippers, sales/billing clerks, cashiers, hair dressers, mail carriers, boilermakers, air conditioning and heat mechanics, and sheet metal workers. SEI scores similar to the age 16 average reflect occupations such as building, farming, restaurant managers, receptionists, tool and die makers, dental assistants, airline attendants, and policemen (Stevens & Featherman, 1981). Thus, within our sample, there was a clear upward mobility trend from infancy to adolescence, and the shift in SEI category usually occurred well before age 16. For example, although most household heads were categorized as "unemployed" prenatally, by Grade 6, the modal SEI category was clerical.

Unpredictability

Unpredictability was assessed using measures of mothers' life stress in three areas: changes in employment, changes in residence, and changes in cohabitation. This measure has been used in previous research (e.g., Belsky et al., 2012; Simpson et al., 2012). Information about these three areas was obtained from the Life Events Schedule (LES; Egeland, Breitenbucher, & Rosenberg, 1980), which was measured at five time points during early childhood (when each target was 12, 18, 48, 54, and 64 months old) and at five time points later in childhood (Grades 1, 2, 3, and 6, and age 16). Coders rated the total number of relevant events mentioned by each mother along with the intensity of disruption associated with each one (0 = *no disruption*, 3 = *severe disruption*). All interrater reliabilities were greater than 0.90.

Each participant's scores on the three measures were added within each assessment period. An average was then generated across the first five time points (adjusted for the total number of early childhood assessments each mother completed) to create an early childhood unpredictability score from ages 0 to 5. The same procedure was used with the later childhood time points to generate a later childhood unpredictability score for each participant from ages 6 to 16. Both early and later unpredictability scores had acceptable internal consistencies given the small number of time points on which they were based ($\alpha = 0.59$ and 0.54, respectively). Higher scores indicated exposure to more unpredictable experiences. Early unpredictability ranged from 0 to 5.2 ($M = 1.39$, $SD = 0.89$), and later unpredictability ranged from 0 to 4.2 ($M = 1.43$, $SD = 1.09$).

Adolescent substance use

Information about substance use was obtained using the Adolescent Health Survey (AHS) when each participant was age 16. This survey is a modified version of Blum, Resnick, and Bergeissen's (1989) Adolescent Health Survey. The AHS asks about various risk factors associated with poor physical or emotional health (including substance use) that participants had experienced during the prior year. Because there are no scales or subscales for the AHS, individual items were examined.

With regard to frequency of marijuana use, beer/wine consumption, and hard liquor consumption, participants answered the following question: "How often do you use the following (without a doctor telling you to)?" Participants reported their responses on a 6-point scale (1 = *never* to 6 = *daily*). Responses ranged from 1 to 6 for all variables with the following means and standard deviations: beer/wine ($M = 2.20$, $SD = 1.23$, median = 2), hard liquor ($M = 1.88$, $SD = 1.17$, median = 1), and marijuana ($M = 1.60$, $SD = 1.21$, median = 1). Despite the broad range of substance use reported, the low mean/median indicates that this was a generally low drug- and alcohol-using sample at age 16. On average, participants used substances at a frequency of once or twice per year. The three questions about frequency of drug and alcohol use were combined to create an age 16 substance use latent variable ($\alpha = 0.85$).

Adolescent externalizing behaviors/symptoms

Externalizing behaviors were assessed using the Youth Self-Report (YSR; Achenbach, 1991) when each participant was age 16. The YSR is a standardized measure consisting of 119 items that screen for various emotional and behavioral problems in youth between the ages of 11 and 18. Participants rated how true each item was for them on a 3-point scale (0 = *not true*, 1 = *somewhat or sometimes true*, and 2 = *very true or often true*). The attention problems subscale (range = 50–90, $M = 57.05$, $SD = 7.87$), the delinquent subscale (range = 50–86, $M = 59.78$, $SD = 8.32$), and the aggressive behavior subscale (range = 50–87, $M = 57.81$, $SD = 7.72$) were used to construct an age 16 externalizing problems latent variable ($\alpha = 0.72$). The *t* scores on the YSR greater than 70 reflect clinically significant problems, while *t* scores greater than 67 suggest "borderline" clinically significant behaviors. Some individuals in our sample are classified within borderline or clinical categories. Based on the mean levels of aggressive and delinquency problems, our sample was mild to moderate risk.

Adult crime and delinquency

The Young Adult Self-Report (YASR; Achenbach, 1997) was also completed by each participant at age 23 to assess delinquent and aggressive behavior. Participants rated how true each item was on a 3-point scale (0 = *not true*, 1 = *somewhat or sometimes true*, and 2 = *very true or often true*). The delinquent behavior subscale of the YASR assesses behaviors such as lying/cheating, breaking rules, setting fires, stealing, and substance (drug) use. The aggressive behavior subscale measures behaviors such as jealousy, teasing, attacking, arguing, and being mean to others. Theoretically, higher scores on both scales should reflect a faster life history strategy. The two measures were positively correlated (*r* overall = .60, *r* male = .70, *r* female = .51, all *p*s < .001). At age 23, aggressive behavior *t* scores ranged from 50 to 90 ($M = 54.23$, $SD =$

6.56; median = 51) and delinquent behavior *t* scores ranged from 50 to 80 ($M = 55.34$, $SD = 6.72$; median = 53), meaning that our sample as mild to moderate risk.

Participants' involvement in and/or association with criminal behavior was assessed using the LES (Egeland et al., 1980) at age 23. Three sources of criminal activity were considered. Specifically, participants indicated whether they or their immediate family members had experienced any of the following within the past year: (a) criminal conviction for legal violations (e.g., speeding, DWI, parking tickets, assaults, drug possession, theft, prostitution, or rape); (b) jail sentencing; and/or (c) debt beyond means of repayment, sometimes resulting in repossessions or legal actions. Trained coders reviewed each participant's interview responses to these items and rated the total number of stressful events mentioned, as well as the intensity of disruption associated with each one, on a scale ranging from 0 (*no disruption due to changing life event*) to 3 (*severe disruption*). The interrater reliability (intraclass correlation) for this scale was 0.97. Overall, the sample scored relatively low in criminality, with an average of less than one criminal event endorsed at age 23 (range = 0–10, $M = 0.84$, $SD = 1.71$). The sum of the three LES items indexing criminal activity, the YASR aggressive behavior subscale, and the YASR delinquency subscale were used to create an age 23 criminal delinquency latent variable ($\alpha = 0.64$).

Results

Data analytic plan

To test our hypotheses, correlations were first computed using SPSS Version 21, after which a mediated moderation model in a structural equation modeling framework was tested using MPlus 7.2 (Muthén & Muthén, 1998–2012). Three latent variables were created. The first latent variable reflected substance use at age 16, which involved three variables: frequency of beer and wine consumption, frequency of liquor consumption, and frequency of marijuana use. The second latent variable indexed the three externalizing behaviors measured by the YSR at age 16: delinquent behaviors, aggressive behaviors, and attention problems. The third latent variable assessed the age 23 externalizing behaviors (e.g., delinquent behavior and aggressive behavior) reported on the YASR as well as criminal activity rated from the LES.

A mediated moderation model was then fit to test for direct associations between the independent variables (early unpredictability and harshness) and the age 23 dependent latent variable, consisting of delinquent behaviors, aggressive behaviors, and criminal activity. The possible mediating role of substance use and externalizing behaviors assessed at age 16 (mediating the early unpredictability → age 23 externalizing/criminal behaviors link) was also tested, and the potential role of SES as a moderator of the early unpredictability and age 16 substance use/externalizing behaviors associations was also examined. Bootstrapping with 10,000 sample replicates was conducted to estimate the standard errors and test the indirect effects of multiple mediators using 95% confidence intervals (MacKinnon, 2008; Preacher & Hayes, 2008). Maximum likelihood estimation was used to estimate missing data. Early (ages 0–5) and later (ages 6–16) SES were examined separately, but neither was significantly related to any of the dependent variables, so mean SES (harshness) across childhood (0–16) was included in the analyses. The control variables were later unpredictability and gender. The correlation between the error terms of substance use and externalizing behaviors at age 16 was also added to the model.

Correlations

Zero-order correlations between the variables are reported in Table 1. As anticipated, exposure to more unpredictability early in life was significantly related to greater frequency of beer/wine, liquor, and marijuana use at age 16, greater delinquency, aggressive behaviors, and attention problems at age 16, and more aggressive behaviors and criminal activity at age 23. Early unpredictability was also positively related to both later unpredictability, $r\ (190) = .25$, $p < .001$, and SES (harshness), $r\ (220) = –.18$, $p < .01$, with greater early unpredictability being associated with lower SES on average. Greater later unpredictability was also associated with lower SES, $r\ (190) = –.37$, $p < .001$.

Latent variable loadings and model fit

The variables that loaded on the latent age 16 substance use factor were frequency of beer/wine consumption ($\beta = 0.84$), liquor consumption ($\beta = 0.91$), and marijuana use ($\beta = 0.70$). The variables that loaded on the latent age 16 externalizing behaviors factor were delinquent behaviors ($\beta = 0.88$), aggressive behaviors ($\beta = 0.70$), and attention problems ($\beta = 0.44$). Variables loading on the latent age 23 externalizing/criminal behaviors factor were delinquent behaviors ($\beta = 0.78$), aggressive behaviors ($\beta = 0.76$), and association with criminal behavior ($\beta = 0.46$). All factor loadings were statistically significant (all *p*s < .001). The measurement model had acceptable goodness of fit, root mean square error of approximation = 0.07, standard root mean square residual = 0.07, comparative fit index = 0.89 (see Bentler, 1990; Browne & Cudek, 1993; Hu & Bentler, 1999).

Tests of hypotheses

In terms of the structural paths (see Figure 1), early unpredictability significantly predicted age 16 substance use and age 16 externalizing behaviors (both *p*s < .01; see Table 2 for direct and indirect paths). Age 16 externalizing behaviors, in turn, positively predicted age 23 externalizing/criminal behaviors ($p < .001$), but age 16 substance use did not predict age 23 outcomes ($p = .65$). There was a significant indirect effect of early unpredictability on age 23 externalizing/criminal behavior through age 16 externalizing behaviors ($p < .05$), but the indirect effect through age 16 substance use was not sig-

Table 1. *Correlations between the independent and dependent variables*

	1	2	3	4	5	6	7	8	9	10	11	12
1. Early unpredict	—											
2. Later unpredict	.25***	—										
3. SES mean	−.18**	−.37***	—									
4. Attention 16	.21**	−.15*	−.08	—								
5. Aggressive 16	.23**	.06	−.06	.43***	—							
6. Delinq 16	.25***	.01	−.06	.35***	.59***	—						
7. Beer/wine	.17*	.01	−.09	.13†	.34***	.49***	—					
8. Liquor	.20**	.00	−.07	.11	.38***	.55***	.76***	—				
9. Marijuana	.18*	−.04	−.08	.14†	.39***	.52***	.58***	.61***	—			
10. Aggressive 23	.23**	−.02	−.11	.16*	.30***	.23**	.11	.20**	.11	—		
11. Delinq 23	.13†	−.09	−.02	.11	.14†	.29***	.18*	.27***	.15†	.60***	—	
12. Criminal 23	.35***	.07	−.10	.04	.16*	.20**	.13	.23**	.25**	.31***	.37***	—
13. Sex: female	.10	.08	.00	.17*	.05	.12†	.05	.12	.01	.05	.06	.00

Note: $N = 220$ (range = 149–220 due to missing variable data). SES, Socioeconomic status; SES mean, harshness.
†$p \leq .10$. *$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

nificant ($p = .66$). The total indirect effects of early unpredictability on age 23 externalizing/criminal behavior were significant ($p < .05$), but controlling for the total indirect effects, the direct effect of early unpredictability on age 23 externalizing/criminal behavior was not significant ($p = .11$).

Overall, then, early unpredictability had a significant positive total (direct and indirect) effect on age 23 externalizing/criminal behavior ($p < .01$). The model accounted for 17.6% of the variance in externalizing behaviors at age 16, 21.0% of the variance in substance use at age 16, and 24.4% of the variance in externalizing/criminal behaviors at age 23.

Moderation analyses. As shown in Figure 1, the interaction of early unpredictability and mean SES (harshness) on age 16 externalizing behaviors was significant at the level of a trend ($\beta = -0.18$, $p = .08$; see Figure 2 for the pattern), and the interaction significantly predicted age 16 substance use ($\beta = -0.36$, $p < .001$; see Figure 3 for the pattern). Thus, the strength of the paths between early unpredictability and age 16 externalizing behaviors/substance use were dependent on the level of SES (harshness). As predicted, simple slopes analyses revealed that the effect of early unpredictability on age 16 substance use was significant at lower levels of SES (1 *SD* below the mean; $t = 4.90$, $p < .001$), but not at higher levels of SES, $t = -1.33$, $p = .19$. In other words, early unpredictability predicted higher substance use at age 16 for those with the lowest SES levels. For age 16 externalizing behaviors, early unpredictability was significant at lower SES (i.e., higher harshness) levels (1 *SD* below the mean; $t = 4.47$, $p < .001$), but not at higher SES levels ($t = 0.87$, $p = .38$). In sum, as expected, individuals exposed to lower SES and higher early unpredictability displayed the *highest* levels of externalizing behaviors at age 16.

Covariate analyses. Additional analyses revealed that mean SES (harshness) predicted age 16 substance use ($\beta = -0.18$, $p < .05$), with lower SES (greater harshness) forecasting more frequent substance use. SES, however, did not predict either more externalizing behaviors at 16 ($p = .15$) or more externalizing/criminal behavior at 23 ($p = .43$). Later unpredictability predicted greater age 16 externalizing behaviors at the trend level ($\beta = -0.14$, $p = .09$), but it was unrelated to both age 16 substance use ($p = .11$) and age 23 externalizing/criminal behavior ($p = .16$). Sex significantly predicted age 16 substance use ($\beta = 0.12$, $p < .05$) and age 16 externalizing behaviors ($\beta = 0.14$, $p < .01$), with girls being more likely than boys to engage in substance use and externalizing behaviors. This sex difference in externalizing behaviors appears to be primarily attributable to differences in self-reported attention problems (see Table 1). Gender was not related to externalizing/criminal behavior at age 23 ($p = .89$).

Discussion

Using data from the MLSRA, this study tested a novel set of life history-based predictions regarding how two major forms of stress, unpredictability (changes in residence, cohabitation,

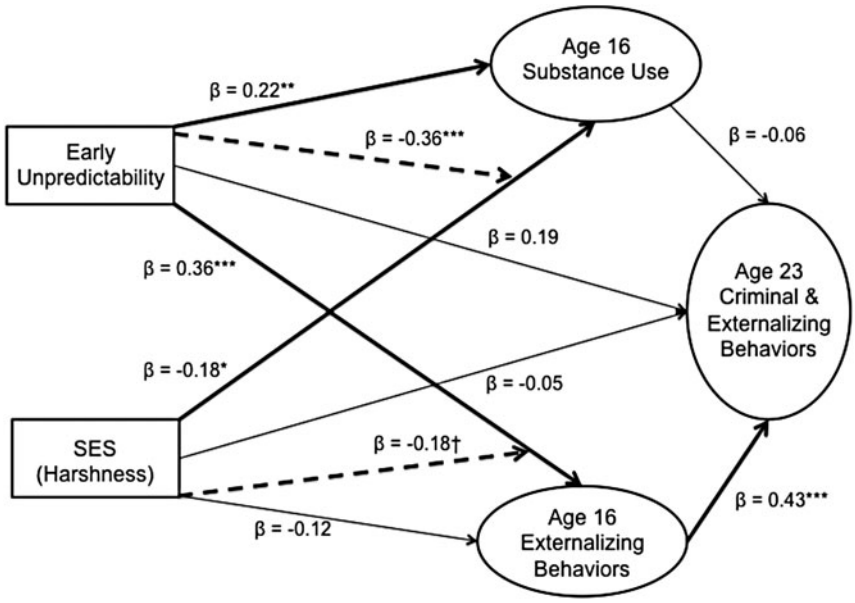

Figure 1. Age 16 substance use and externalizing behaviors as mediators of early unpredictability, socioeconomic status (SES; harshness), and the Early Unpredictability × SES (harshness) interaction predicting age 23 criminal/externalizing behaviors. Standardized path coefficients are presented. Dotted lines represent interaction coefficients between early unpredictability and SES (harshness) on the dependent variable of interest. †$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

Table 2. *Path coefficients of direct and indirect effects of mediated moderation model*

	B (β)	*SE*	95% CI
Direct Effects			
EU → Age 16 SU	0.26 (0.22)	0.10	0.06, 0.45**
SES → Age 16 SU	−0.20 (−0.18)	0.08	−0.37, –0.06*
EU × SES → Age 16 SU	−0.44 (−0.36)	0.12	−0.67, –0.20***
EU → Age 16 Ext	2.96 (0.36)	0.73	1.56, 4.48***
SES → Age 16 Ext	−0.93 (−0.12)	0.64	−2.19, 0.44
EU × SES → Age 16 Ext	−1.50 (−0.18)	0.86	−3.28, 0.23†
EU → Age 23 Crim/Ext	0.17 (0.19)	0.10	−0.05, 0.36
SES → Age 23 Crim/Ext	−0.04 (−0.05)	0.05	−0.15, 0.05
Age 16 SU → Age 23 Crim/Ext	−0.04 (−0.06)	0.09	−0.22, 0.13
Age 16 Ext → Age 23 Crim/Ext	0.05 (0.43)	0.01	0.02, 0.07***
Indirect Effects			
EU → Age 23 Crim/Ext	0.12 (0.14)	0.05	0.05, 0.23*
Via Age 16 SU	−0.01 (−0.01)	0.03	−0.07, 0.03
Via Age 16 Ext	0.13 (0.15)	0.05	0.06, 0.25*
Total Direct and Indirect			
EU → Age 23 Crim/Ext	0.29 (0.33)	0.10	0.06, 0.48**

Note: EU, Early unpredictability; SU, substance use; SES, socioeconomic status (harshness); EU × SES, Early Unpredictability × Harshness interaction; Ext, externalizing behaviors; Crim, criminal behaviors.

and parental occupation) and harshness (mean socioeconomic status), prospectively forecast externalizing behaviors and substance use at age 16 as well as aggression, delinquency, and ties with criminal activity at age 23. These behaviors are markers of risk-taking tendencies in adolescence and early adulthood.

Summary and implications of the findings

As predicted, we found that being exposed to more unpredictable environments early in life (between ages 0 and 5) forecasted more externalizing behaviors and more alcohol/mari-

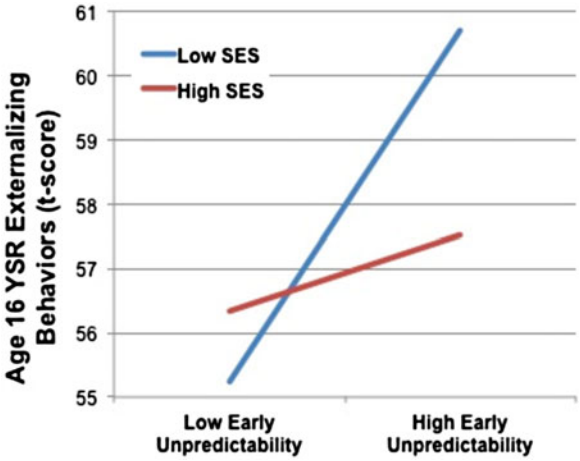

Figure 2. (Color online) Mean of Youth Self-Report externalizing behaviors for the highest and lowest quartiles of socioeconomic status (harshness) and early unpredictability. The Youth Self-Report has a population mean of 50 and standard deviation of 10. Thus, all four groups had average externalizing behaviors above the general population mean.

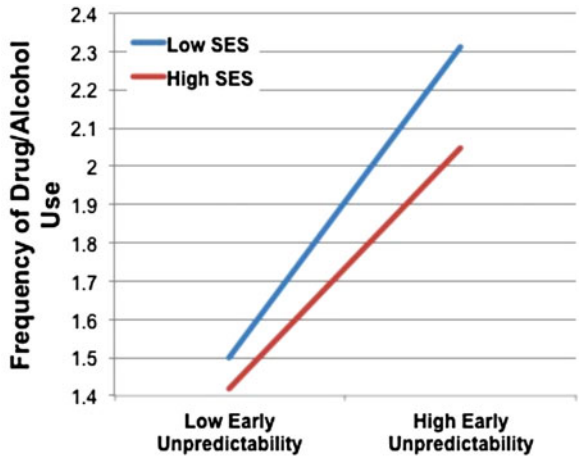

Figure 3. (Color online) Mean frequency of drug/alcohol use for the highest and lowest quartiles of socioeconomic status (harshness) and early unpredictability. A score of 3 indicates that participants used these substances less than monthly.

juana use at age 16, above and beyond the effects of childhood SES (harshness) and later unpredictability. Greater environmental harshness did predict greater age 16 substance use, and unpredictability encountered later in childhood (between ages 6 and 16) was associated at the trend level with more externalizing behaviors. Thus, early unpredictability was associated with adolescent risky behaviors more broadly than either environmental harshness during childhood or later unpredictability. This provides further evidence that unpredictability encountered early in life may play a central role in the development of "fast" life history strategies considering that it should be more difficult to adapt well and fully to unpredictable stressful early environments than it is to consistently harsh (but more predictable) ones. We also found that the age 16 externalizing behaviors mediated the connection between early unpredictability and externalizing/criminal behaviors in early adulthood (at age 23), suggesting that exposure to early unpredictability may place children on a developmental trajectory toward externalizing and criminal behaviors, which are markers of a fast reproductive strategy, continuing into early adulthood.

In addition, we found that early unpredictability and harshness statistically interacted to predict externalizing behaviors (at a trend level) and substance use (significantly) at age 16, with the highest levels of risk taking occurring for those who encountered greater early unpredictability *and* lived in harsher environments as children. Engaging in externalizing behaviors is a hallmark of a fast life history strategy, in which individuals take risks and pursue immediate, short-term opportunities as a way to adapt to an uncertain future (Belsky et al., 2010; Ellis et al., 2009). Consistent with our hypotheses, individuals who experienced high early unpredictability in combination with low SES (high harshness) during childhood enacted the most risk-taking behaviors in adolescence, whereas those who experienced low levels of unpredictability generally displayed the lowest levels of risk-taking behaviors. Thus, our results revealed that the effect of unpredictability was most pronounced at low levels of SES (in harsher environments).

To our knowledge, this is the first research to document the effects of exposure to unpredictability early in life on later adolescent externalizing behaviors in a prospective study. Our results suggest that individuals who have experienced more unpredictability early in life may be on a developmental pathway involving greater substance use, aggression, and delinquency as they move into adulthood. There is clear evidence that aggressive and "acting out" behaviors are associated with later adult crime, violent offending, and criminal convictions (Farrington, 1989; Moffitt, 1993; Thornberry, Lizotte, Krohn, Smith, & Tobin, 2003). Our results confirm that some of these externalizing behaviors enacted during adolescence partially mediate the relation between exposure to early unpredictability and externalizing/criminal behavior in early adulthood.

We did not find evidence that adolescent substance use mediated the relation between early unpredictability and adult externalizing/criminal behavior. Adolescent substance use could, however, influence later functioning in domains other than externalizing/criminal behavior in adulthood. Substance use during adolescence, for example, may affect important changes in the brain that normally occur during adolescence. Both animal and human studies suggest that brain changes during adolescence may make teens more vulnerable to the effects of alcohol consumption (e.g., Guerri & Pascual, 2010), and that particular brain changes induced by alcohol use might affect both impulse control and goal-directed behavior tendencies (Monti et al., 2005). Future research needs to clarify these associations among early unpredictability, adolescent substance use, and adult functioning. Our results do, however, reveal that adolescent externalizing behaviors partially mediate the connection between early unpredictability and adult externalizing/criminal behaviors. In doing so, they provide provisional evidence that these adolescent outcomes may have important implications for adult functioning.

In addition, we found that greater unpredictability encountered during the *first 5 years of life* independently predicted more externalizing behaviors in both adolescence (directly) and early adulthood (indirectly), whereas exposure to later unpredictability forecasted externalizing behaviors only at the trend level. These results suggest that there may be a "sensitive window" during development when individuals are more strongly affected by these early experiences. According to life history theorists (Belsky et al., 1991; Simpson & Belsky, 2016), parents are the primary window through which young children assess the quality, nature, and challenges posed by the environments in which they live. If environments have sufficient resources and are stable over time (i.e., predictable), children should have received better and more sensitive care as well as more parental time, attention, and investment. These environments should have instilled more secure working models, higher levels of trust and cooperation, less risk taking to achieve status and popularity with peers, and a longer term orientation to adult romantic relationships (see Belsky et al., 1991). If, however, environments were unstable (i.e., unpredictable), children should have received poorer and less sensitive care along with less time, attention, and investment from their parents (Quinlan, 2007). These environments should have produced more insecure working models, less trust and cooperation, more risk taking designed to elevate status and popularity with peers, and a shorter term orientation to adult romantic relationships (see Ellis et al., 2009; Simpson & Belsky, 2008).

To our knowledge, this is the first study to document theoretically meaningful statistical interactions between early unpredictability and environmental harshness. Ellis et al. (2009) did not formulate predictions about the conditions in which harsh environments, unpredictable environments, or the interaction of harsh and unpredictable environments should be associated with specific behavioral outcomes. However, according to recent life history accounts such as the adaptive calibration model (Ellis & Del Giudice, 2014), externalizing behaviors and substance use enacted by individuals who have experienced more early life unpredictability *and* greater environmental harshness should result in behavioral adaptations that increase social status and the probability of attracting mates, especially within adolescent social groups. In our study, relevant adolescent externalizing behaviors were highest for those individuals from low SES (harsher) backgrounds who experienced high levels of early unpredictability, and these behaviors mediated the link between early unpredictability and later externalizing/criminal behaviors in early adulthood. This suggests that adolescence may be an important developmental period that "sets the stage" for these behavioral tendencies, at least in early adulthood.

Limitations and conclusions

This longitudinal study does have some limitations. The current study, for example, did not measure other aspects of unpredictability, such as inconsistent parenting practices across time (Koblinsky, Morgan, & Anderson, 1997). Although our definition and operationalization of unpredictability is consistent with previous theory (e.g., Ellis et al., 2009) and investigations (e.g., Belsky et al., 2012; Simpson et al., 2012), researchers should assess other features of unpredictability in future work. In addition, the findings of this study should be interpreted with caution given the low and somewhat restricted range of SES when participants were born (because mothers were recruited because they were below the poverty line during their pregnancies). Even though the mean and variability of SES in the sample increased notably as participants grew up, the nonsignificant findings for SES could be partially attributable to the low and rather restricted initial SES level of the sample.

The results of this study also call for greater attention to the operationalization of stress. Different approaches to defining stress continue to impede our understanding of how stress affects social and physical development. Previous researchers have highlighted the inconsistent associations between life stress and risky adolescent behaviors, including alcohol and marijuana use. In a recent review, Hanson and Chen (2007) noted that 5 of 28 studies of SES and adolescent alcohol use found negative associations, and 16 of 28 studies reported no connection. They postulate that substance use may be more strongly influenced by proximal factors such as peer relations in adolescence than by distal family variables such as experiences of harshness. However, the failure of past research to clearly characterize stressful environments according to the level and timing of unpredictability that people experience during their childhoods might partially explain some of these inconsistent findings.

In conclusion, the current research suggests that there may be an early sensitive period during which environmental unpredictability starts to shape the development of a fast life history strategy in humans, as indexed by heightened externalizing behaviors and greater substance use in adolescence and early adulthood. This association might be systematically related to the rapid brain development that is occurring during this critical period of life, during which unpredictability may alter neural circuits that govern emotion and behavior regulation. These findings are important for researchers studying the antecedents of adolescent risk taking as well as for policymakers working to reduce risky behaviors in teens (see Ellis et al., 2012).

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