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Beyond Cumulative Risk: Distinguishing Harshness and Unpredictability as Determinants of Parenting and Early Life History Strategy

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Drawing on life history theory, Ellis and associates' (2009) recent across- and within-species analysis of ecological effects on reproductive development highlighted two fundamental dimensions of environmental variation and influence: harshness and unpredictability. To evaluate the unique contributions of these factors, the authors of present article examined data from a national sample 1364 mothers and their children participating in the NICHD Study of Early Child Care and Youth Development. Harshness was operationalized as income-to-needs ratio in the first 5 years of life; unpredictability was indexed by residential changes, paternal transitions, and parental job changes during this same period. Here the proposition was tested that these factors not only uniquely predict accelerated life-history strategy, operationalized in terms of sexual behavior at age 15, but that such effects are mediated by change over the early-childhood years in maternal depression and, thereby, observed maternal sensitivity in the early-elementary-school years. Structural equation modeling provided empirical support for Ellis et al.'s (2009) theorizing, calling attention once again to the contribution of evolutionary analysis to understanding contemporary human parenting and development. Implications of the findings for intervention are discussed.

Keywords: harsh parenting, unpredictable environment, sexual risk taking, life history, maternal depression

No matter what form of life interests us, it remains the case that its development must accord with basic principles of evolutionary biology. As Theodosius Dobzhansky (1973) noted 40 years ago, "nothing in biology makes sense except in the light of evolution" (p. 23). If one substitutes "the life sciences" for "biology" and acknowledges that human development is a life science, then it becomes clear that an evolutionary perspective has much to offer the field of child development (Belsky, Steinberg & Draper, 1991; Ellis & Bjorklund, 2005; Hinde & Stevenson-Hinde, 1990; Nettle, 2010; Quinlan, 2007, 2010; Simpson & Belsky, 2008).

Central to an evolutionary perspective on human development is the assumption that children and adolescents have evolved to function competently—to navigate the kinds of challenges and opportunities in their environment that recurrently influenced the fitness of their ancestors—across a variety of contexts. Because both stressful and supportive rearing environments have always been part of the human experience, developmental systems have been shaped by natural selection to respond adaptively to both putatively "positive" and "negative" developmental contexts. The term *adaptive* refers here not to mental-health outcomes (e.g., personal well-being) but to the fact that certain ways of functioning have increased the likelihood of genes being passed successfully down the generational line. Thus natural selection has not necessarily shaped humans to live long or even pleasant lives but to promote their reproductive fitness. Accordingly, when children encounter stressful environments, it does not so much disturb their development as *direct* or *regulate* it toward strategies that are adaptive under stressful conditions (or at least once were), even if those strategies are currently harmful in terms of the long-term welfare of the individual or society as a whole (e.g., teen parenthood). Conversely, when children encounter well-resourced and supportive environments, these direct or regulate development toward strategies that are adaptive in those contexts.

This evolutionary view of child development (e.g., Belsky et al., 1991, 2000; Chisholm, 1999; Ellis, Figueredo, Brumbach, & Schlomer, 2009) conceptualizes children's brains and bodies as constituting *conditional adaptations*: "evolved mechanisms that detect and respond to specific features of childhood environments, features that have proven reliable over evolutionary time in pre-

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dicting the nature of the social and physical world into which children will mature, and entrain developmental pathways that reliably matched those features during a species' natural selective history" (Boyce & Ellis, 2005, p. 290). From this perspective, parenting and other family processes serve as a means of informing and thus preparing the child for the world she or he is likely to encounter later in development, based as it is on the current and prior experience of parents in the broader, extrafamilial world. In other words, parenting provides young children with a "weather forecast" of sorts, alerting them to what they should "wear" —cognitively, emotionally, physiologically, and behaviorally—in order to succeed in the fundamental tasks of growing, mating, and eventually reproducing (Bateson, 1994; Bateson et al., 2004; Hinde, 1986). Such a perspective was central to Belsky et al.'s (1991) evolutionary reformulation of socialization theorizing, which posited that parenting and, derivatively, attachment security, functioned as mechanisms for conveying information about the external world and thus the probable future to the child in order to regulate somatic and behavioral development in ways that once, even if no longer, reliably enhanced fitness.

If, as an evolutionary perspective ineluctably implies, development has been crafted by natural selection to be responsive to rearing conditions, then a key issue involves identifying the experiences and environmental conditions that guide this process. Following Brofenbrenner's (1979) multilayered ecology of human development, many social developmentalists have called attention to the extent to which rearing environments are generally stressful or supportive, thus highlighting proximate factors like parental sensitivity and harshness and more distal ones like marital quality, parental mental health, and socioeconomic status (e.g., Belsky, 1984; Belsky et al., 1991; Conger et al., 2002; McLoyd, 1990, 1998). Although research based on such thinking has uncovered a variety of developmentally significant environmental factors, it has not been explicitly informed by evolutionary theory and, consequently, has not focused on or delineated *basic dimensions* of environmental stress and support that guide conditional adaptation. Indeed, absent a model of the *content* of environmental factors, a common (and empirically productive) practice has been to composite multiple sources of stress in family environments or to examine the additive effects of multiple stressors, consistent with Sameroff's transaction model and cumulative-deficit notion (e.g., Sameroff, Seifer, Barocas, Zax, & Greenspan, 1987; Seifer et al., 1996), in order to test the hypothesis that the more stressors children are exposed to (e.g., divorce, poverty, harsh parenting, racial discrimination), the more their developmental competencies will be compromised (e.g., Belsky & Fearon, 2002; Evans & English, 2002; Evans & Kim, 2007; Fergusson & Woodward, 2000; Scaramella, Conger, Simons, & Whitbeck, 1998; Gutman, Sameroff & Cole, 2003; Gutman, Sameroff & Eccles, 2002). While methods for measuring cumulative contextual risk have certainly been useful, they have not addressed why different types of childhood experiences matter.

Recently, Ellis and associates (2009) identified, via a within- and between-species analysis, distinct contextual dimensions which account for much of the variation in patterns of development both across and within species. This analysis was guided by life history (LH) theory (e.g., Belsky et al., 1991; Ellis et al., 2009; Roff, 2002; Stearns, 1992;), a branch of evolutionary biology whose focus is how organisms allocate time and energy to various activities over their life cycle. Due to structural and resource limitations, organisms cannot simultaneously maximize the major life functions of (a) bodily maintenance (e.g., immune function, predator defenses), (b) growth (acquisition of physical, social, and cognitive competencies), and (c) reproduction (mating and parenting). Instead, natural selection has shaped individuals to make trade-offs that prioritize resource expenditures, so that greater investment in one domain occurs at the expense of investment in other domains. There is thus a trade-off between somatic growth and current reproduction because both require substantial energetic investment; for example, some primate species (e.g., prosimians) and individuals within species have relatively short periods of growth and begin to reproduce relatively early in life, whereas some other primate species (e.g., all great apes) and individuals within species defer reproduction so that more time and energy can be devoted to growing before reproducing. Likewise there is a trade-off between quality and quantity of offspring, so that some species and individuals within species bear many offspring but provide relatively little care, whereas others invest heavily in the bearing and rearing of fewer offspring.

According to LH theory, natural selection favors individuals that are able to "schedule" development and activities (i.e., allocate resources) in a manner that optimizes trade-offs over the life course and across varying ecological conditions. Further, both within and across species, developmental patterns that arise from different trade-offs vary on a slow–fast continuum. Humans, of course, are not immune to these processes. Thus, some people adopt slower strategies characterized by later reproductive development and behavior, a preference toward relatively stable pair bonds, higher quality parental investment, and fewer offspring, whereas others display faster strategies characterized by the opposite pattern (Griskevicius, Delton, Roberson, & Tybur, 2011; Kaplan & Gangestad, 2005; Nettle, 2010; Quinlan, 2007, 2010; Simpson & Belsky, 2008). Indeed, it was this variation in development that was central to Belsky et al.'s (1991) evolutionary theory of socialization.

Because the costs and benefits of different LH trade-offs vary as a function of individual characteristics and local circumstances (e.g., resource availability, local mortality rates), the optimal LH strategy—in fitness terms—for one individual may not be the same for another. According to recent advances in LH theory, *energetic conditions, harshness*, and *unpredictability*, as signaled by observable cues, are the key dimensions of the environment that affect the development of slow versus fast LH strategies (Ellis et al., 2009); it is just these dimensions to which humans should have evolved to be sensitive and responsive.

Development of fast LH strategies depends on adequate bioenergetic resources (low resource scarcity/energetic stress) to support growth and development. Once this energetic threshold is crossed, environmental harshness and unpredictability become salient determinants of LH strategy. Harshness constitutes the rates at which extrinsic factors cause disability and death at each age in a population. In Western societies, socioeconomic status (SES) is a key indicator of environmental harshness, as lower levels of SES are linearly related to higher levels of virtually all forms of morbidity and mortality (e.g., Adler, Boyce, Chesney, Folkman, & Syme, 1993; Chen, Matthews, & Boyce, 2002). According to LH theory, then, given permissive energetic conditions (i.e., sufficient nutrients), developmental exposures to environmental harshness, such as low SES or other ecological cues to a short life expectancy, bias allocation of resources toward a faster LH strategy (i.e., investments in current over future reproduction and quantity over quality of offspring; Belsky et al., 1991; Chisholm, 1993, 1999; Ellis et al., 2009; Pennington & Harpending, 1988; Quinlan, 2007). Ellis et al. (2009) provided a review of much research consistent with this claim.

In addition to the effects of environmental harshness, stochastic variation in salient environmental conditions—unpredictability—also regulates development of LH strategies (Ellis et al., 2009). In environments that vary unpredictably (e.g., changing randomly between Conditions A and B, so that exposure by parents or their young offspring to Condition A does not reliably forecast whether offspring will mature into Condition A or B), long-term investment in a development of a slow LH strategy does not optimize fitness; after all, all of the energy invested in the future would be wasted if the individual matures into an environment where life expectancy is short. Instead, given adequate bioenergetic resources, the psychobiological mechanisms regulating LH strategies should detect and respond to proximal cues to environmental unpredictability (e.g., stochastic changes in ecological context, geography, economic conditions, family composition, parental behavior) by entraining faster LH strategies.[1]

Because harshness and unpredictability are conceptually distinct, developmental exposures to each of these environmental factors should uniquely and thus additively contribute to variation in LH strategy (Ellis et al., 2009). This is a prediction we tested in the research reported herein. Because LH models have emphasized the first 5–7 years of life as a sensitive period for the effects of familial and ecological conditions on development of reproductive strategies (Belsky et al., 1991; Draper & Harpending, 1982), the current study focused on exposures to harsh versus unpredictable environmental conditions in early childhood.

As it turns out, a good deal of available research on the determinants of parenting (Belsky, 1984; Belsky & Jaffee, 2006) and the effects of parenting on child development (Holden, 2010; Maccoby, 1980) accords reasonably well with the evolutionary analysis just advanced. Widely appreciated, for example, is that insufficient income, a marker of environmental harshness, undermines parental warmth, sensitivity, and responsiveness, fostering hostility and/or detachment, and, in consequence, undermines child well-being (in the mental-health sense of the term; McLoyd, 1990, 1998). At the same time, various markers of environmental unpredictability, such as parental transitions and residential changes, have also been linked to lower quality parenting and more child behavior problems (e.g., Baumer and South, 2001; Capaldi, Crosby, & Stoolmiller, 1996; Crowder and Teachman, 2004; Woodward, Fergusson, & Horwood, 2001, as reviewed in Ellis et al., 2009). Lacking in past research, however, is a more explicit treatment of the concept of unpredictability, including any attempt to assess overall levels of ecological unpredictability in the child's life (through construction, for example, of a latent variable with multiple relevant indicators) or to specifically compare the effects of harsh versus unpredictable environmental conditions (though see Brumbach, Figueredo, & Ellis, 2009). This is exactly what we sought to do with the present research.

The relative importance of unpredictable environments has been documented in a series of experiments in which bonnet macaque (*Macaca radiata*) mothers were exposed to harsh versus unpredictable feeding conditions: (a) low foraging demand (LFD) where food was available *ad lib*, (b) high foraging demand (HFD) where food was more difficult to obtain and widely dispersed within their enclosure, and (c) variable foraging demand (VFD) where foraging schedules oscillated between LFD and HFD in 2-week intervals. Mothers in the unpredictable conditions (VFD) were most aggressive toward other adults, engaged in the least grooming behavior, were most anxious, and were least responsive toward infants (Rosenblum & Andrews, 1994; Rosenblum & Paully, 1984). These data suggest that exposures to stochastic environmental conditions may be especially likely to undermine maternal functioning (e.g., aggression, anxiety) and, through it, parental investment.

Such a mediating role for maternal functioning linking ecological conditions with parenting and, thereby, child functioning is also highlighted by the family stress model (Conger et al., 1990, 2002). Indeed, consistent with the theorizing of Belsky (1984) and McLoyd (1998), the family stress model posits that depression mediates the effect of economic pressure on parenting, which in turn mediates the effect of both on child functioning. In the present inquiry, such theoretical and empirical work was cast in an evolutionary perspective, as we examined the mediating role of maternal depressive symptomology in linking both harsh and unpredictable environmental conditions to parenting and child development (i.e., faster LH strategy).

In summary, building on earlier work informed by Belsky's (1984), McLoyd's (1990), and Conger, Ge, Elder, Lorenz, & Simons's (1994) models of how ecological factors shape parent–child relationships and, through it, child development, the work presented herein extends research on the ecology of parenting and human development by casting these factors in LH terms. For purposes of this inquiry, environmental harshness is operationalized in terms of limited income relative to family needs (defined by number of individuals in the household) and environmental unpredictability in terms of, collectively, paternal transitions, residential changes, and parental job changes. The primary hypothesis, depicted in Figure 1, is that lower income-to-needs ratios as well as more changes in the lives of family members across a child's first 5 years of life will predict, independent of each other, greater increases in maternal depressive symptoms over the same time period and, thereby, lower levels of maternal sensitivity in the child's early-primary schools years and thus accelerated development of LH strategy, as indicated by more sexual partners by age 15 years. To test this hypothesis, we employed data from the large-scale National Institute of Child Health & Human Development (NICHD) Study of Early Child Care and Youth Development (NICHD Early Child Care Research Network, 2005).

Method

Participants

The NICHD Study of Early Child Care and Youth Development (SECCYD) recruited 1,364 families through hospital visits shortly

[1] It should be noted that an alternative model proposes that individuals should spend more time sampling their environments in unpredictable ecologies before "choosing" a reproductive strategy, as more information is needed before committing to a strategy (Frankenhuis & Panchanathan, 2010).

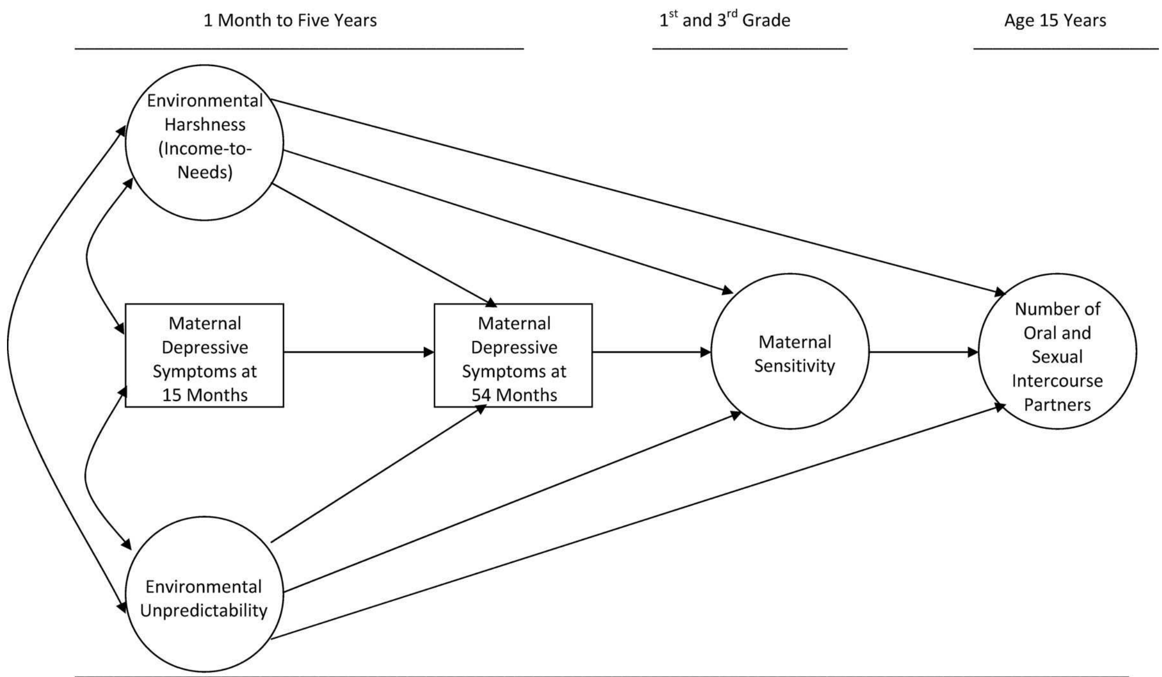

Figure 1. The theoretical model.

after the birth of a child in 1991 at 10 U.S. locations; for detailed description of recruitment procedures and sample characteristics, see NICHD Early Child Care Research Network (2001; information about this public data set can be found at http://secc.rti.org/). During selected 24-hour intervals, all women giving birth (N = 8,986) were screened for eligibility. From that group, 1,364 families completed a home interview when the infant was 1 month old and became the study participants. Details of the sampling plan can be found in NICHD Early Child Care Research Network (2005). In terms of demographic characteristics, 26% of the mothers had no more than a high school education at time of enrollment; 21% had incomes no greater than 200% of the poverty level at 6th grade (~11 years old); and 22% were minority (i.e., not non-Hispanic European American).

As with any longitudinal study, not all families participated in every wave of data collection. When the children in the sample were 15 years old, measures of adolescent outcomes were obtained for 958 youth (70% of the original recruitment sample of 1,364), and almost all children had some missing data. Missing data on study variables ranged from a low of 1.6% to a high of 30.5%. Children who had missing data at age 15 tended to be from families that had more residential changes, $t(1298) = 2.80$, $p < .01$. Families with and without missing data did not significantly differ, however, with respect to other study variables: paternal transitions, parental job changes, lifetime oral sex or sexual intercourse partners, maternal depression, maternal sensitivity, income-to-needs ratio, or ethnicity.

Data from all children were included in the current analyses by using full information maximum likelihood (FIML) estimation. One advantage of FIML estimation is that data are assumed to be missing at random (MAR), in contrast to the more restrictive assumption of missing completely at random (MCAR: see Schlomer, Bauman, & Card, 2010, for a review). Under the MAR assumption, missing data can be dependent on other variables in the data set; however, under the MCAR assumption, missing data cannot be dependent on other variables in the data set. Thus FIML estimation permits nonrandom patterns of missing data *between* groups (for example, ethnicity) but stipulates that patterns of missing data are random *within* groups (see Gazelle & Spangler, 2007, for an example). Under the MAR assumption, variables in the data set that predict missing data must be included in the model. In the present SEM model, the mechanism of missing data (number of moves) is included in the model; thus, potential biases due to missing data as a result of this factor are accounted for. Another advantage of FIML is that estimates for structural equation modeling (SEM) parameters with missing data are estimated in a single step (rather than in two steps such as in multiple imputation), making it a much less cumbersome procedure. Lastly, variables that are not found to be associated with the mechanism of missingness but that prove to be substantively correlated with model variables (e.g. ethnicity, repeated measures of income-to-needs ratio, maternal depression, and so forth) are also included in the model. These variables serve to improve parameter estimates in the SEM model under FIML estimation when other (possibly unknown) mechanisms of missingness are not explicitly included in the analysis model (Collins, Schafer, & Kam, 2001).

Measures

Multiple indicators or single but repeated measures were used to assess environmental unpredictability, environmental harshness, maternal depressive symptomology, maternal sensitivity, and accelerated-LH strategy. These constructs are described in turn.

Environmental unpredictability. Three measures were used to assess levels of unpredictability in and around the family in the first 5 years of the target child's life. These measures were paternal transitions (changes in the male parental figure), household moves, and parental employment changes.

Paternal transitions. The number of paternal transitions was based on information provided about household composition when children were 1, 3, 6, 9, 12, 15, 18, 21, 24, 30, 33, 36, 42, 46, 50, 54, and 60 months of age. More specifically, mothers provided information about individuals currently in the household as well as individuals in the household from the previous assessment period. For each household person identified, information was gathered regarding the relationship of that person to the target child and whether the person was still in the home, no longer in the home, or new to the home. For each time period starting when the target child was 3 months old, if the individual identified was coded as the child's biological father or mother's partner *and* was either no longer living in the home or was new to the home, that change was counted as a transition occurring between measurement points. Transitions in this coding scheme are thus defined as the entrance *or* exit of a male paternal figure to or from the home. Some 310 children (23.1%) experienced at least one paternal transition in their first 5 years of life. Among those 310 children, the average number of transitions was two (M = 1.98, SD = 1.15; range = 1–9). No children experienced more than two paternal transitions between any two time points.

Missing data at each wave of data collection presented a challenge with respect to the count of the number of transitions. At different waves of data collection, missing data on household composition ranged from 6.6% to 27.2%. When data were missing for a previous time point but present for a proceeding time point, transitions were based on the most recently available time point. For example, when constructing the paternal transitions variable for the 6-month data collection, the question was asked, Was there a transition between the 3 and 6 months? If data were not available at 3 months, then data from 1 month were used. In addition, if data were missing for the current time point but present for a previous time point, the current data point was left missing. Because it is impossible to determine from the available data if a transition actually occurred, the data were left missing while we submitted the data to FIML analysis.

To create an aggregate of the number of paternal transitions that occurred during the first five years of life, we averaged together and standardized the number paternal transitions from each time point. This measure was only computed, however, if a case had at least six data points on which to base this figure; 22 children (2.0%) fell below this threshold.

Household moves. As preparation for home visits with study families, a list of current addresses and the dates at which families moved in or out of a given address was generated. Data were then available for the date that a family started living at an address and the date the family stopped living at an address. For each target child, residency start and stop dates were examined. The total number of unique stop dates were counted to obtain a total number of residency changes experienced by the child across the first 5 years of life. A total of 868 (63.6%) children experienced at least one household move in their first 5 years of life. Among those 868 children, the average number of moves was about two (M = 2.08, SD = 1.50; range = 1–12). Ten children (< 1%) were missing data on total number of household moves.

Parental employment transitions. Detailed data on the mother's and father's employment were collected across the child's first 5 years in approximately 3-month intervals. A set of questions about employment, including currently working for pay and employed but currently on extended leave (1 month or more), was administered. Transitions in employment were defined by changes in employment status between adjacent time points. For example, both transitioning from being employed to unemployed and transitioning from being unemployed to employed between adjacent time points were treated as employment transitions. In addition, instances in which a parent was employed at one time point at the same job but then was on leave for at least 1 month at the following time point was also counted as a transition.

Between the 1- and 3-month data collection, 41.4% (565) of mothers reported a change in employment due, no doubt, to their returning to work from maternity leave. By the 60-month data collection, 84% (1,146) of the mothers had experienced at least one employment transition (M = 2.41, SD = 1.92; range = 0–10) during the child's first 5 years of life. Among fathers, 50.7% (691) had experienced at least one employment transition (M = 2.31, SD = 1.63; range = 0–11) by the 60-month data collection. There were some instances in which the mother reported having a new husband/partner between adjacent time points; comparisons of employment status between the previous husband/partner and the new husband/partner were deemed inappropriate and were therefore omitted. When mothers reported a new husband/partner at a specific time point, their data were used at that time point to establish the employment status of the paternal figure and changes in paternal employment assessed thereafter.

To create an aggregate of the number of employment transitions, separately for mothers and fathers, during the first 5 years of the child's life, we averaged together and standardized the number of job changes from each time point. When data were present for both the mother and father (i.e., neither had missing data), their two scores were averaged together. If data were present for only the mother or only the father, the data that were available were used. If both the mother's and the father's data were missing, then the case was left missing with the intention that FIML would be used to estimate complete data parameters with this variable This scheme resulted in 111 missing cases (8.1%). The averaged parental employment transitions variable was then standardized for use in the analysis.

Environmental harshness. We based environmental harshness on an index of income to needs, assuming that limited economic resources challenge the coping capacities of families. When the target children were ages 1, 6, 15, 24, 36, 54, and 60 months, mothers were asked detailed information about their finances. The income-to-needs ratio is an index of a family's income as a proportion of the official federal poverty line for a family of that size; in other words, this index is adjusted for family size so that it is not simply the case that larger families end up with lower income scores. A higher income-to-needs ratio indicates greater financial resources per person in the household. Family income (exclusive of welfare payments) was divided by the poverty threshold adjusted for total family size; a ratio of 1 thus indicates that family income equals the federal poverty threshold for a family of that size (though a ratio below 2 can be regarded as reflecting a status of being "near poor"). In 1991, the year the children participating in the study were born, the poverty threshold (income-to- needs ratio = 1) for a family of four was an annual income of $13,812.

Mean level of income to needs was relatively stable across the 1, 6, 15, 24, 36, 54, and 60 month time points: 2.86 (*SD* = 2.61), 3.66 (*SD* = 3.10), 3.70 (*SD* = 3.21), 3.72 (*SD* = 3.04), 3.61 (*SD* = 3.05), 3.59 (*SD* = 3.17), and 3.49 (*SD* = 2.69), respectively. Across the seven data collection periods, income-to-needs scores ranged from a low of .08 to a high of 56.96. To examine the influence of potential outliers, we conducted a series of regression analyses between income-to-needs ratio at each time point and all other measured variables. In each of these analyses, Cook's distances were saved and examined to determine if individual cases had an undue influence on regression parameters. Inspection revealed no instances where the distances exceeded 1.0 (which could exert undue influence on the regression model; see Cohen, Cohen, West, & Aiken, 2003). Thus, although a few cases were several standard deviations above the mean, none overly influenced regression parameters. To obtain an overall measure of income to needs, the repeated measures of income-to-needs ratios (from each time point) were used as indicators of a latent construct within the structural equation model (see Results).

Maternal functioning. Two maternal functioning constructs are central to this inquiry, maternal depressive symptoms and maternal sensitivity

Change in maternal depressive symptoms. Maternal reports of depressive symptoms were obtained at 15 and 54 months with the Center for Epidemiological Studies Depression Scale (CES–D; Radloff, 1977). Cronbach's alphas were at .90 for both occasions. Scores range from 0 to 60, with a score of 16 or higher considered to have clinical significance (Radloff, 1977). Mean levels of maternal depressive symptoms were 9.04 (*SD* = 8.18) and 9.83 (*SD* = 8.70) for the 15- and 54-month intakes, respectively. The measure of change in maternal depressive symptoms was depressive symptoms at 54 months residualized for depressive symptoms at 15 months.

Maternal sensitivity. Measures of parenting quality were collected when children were in first and third grades (~6 and 8 years old). Mother–child interactions were videotaped during 15-min semi-structured tasks (NICHD Early Child Care Research Network, 2003). In first grade, the interaction activities included two tasks that were too difficult for the child to carry out independently and required the parent's instruction and assistance. A third activity was included that encouraged play between mother and child. These activities provided a context for observing the mother's support for the child in activities that could be frustrating but also an opportunity for fun together. Two activities were used to assess maternal sensitivity when the target child was in third grade. The first was a discussion task of topics that were sources of disagreement between the mother and child, and the second activity was a planning task.

Tapes from all data collection sites were shipped to a central location for coding. Teams of five or six coders scored the videotapes from each time period, with some overlapping membership in the teams across the different ages. Coders were blind as to other information about the families. Coders received intensive training and supervision and met periodically to recode tapes together as a group throughout the period of formal scoring. Complete operational and observation manuals can be found at http://secc.rti.org/.

Trained observers rated three categories of behavior: (a) supportive presence, (b) respect for autonomy, and (c) hostility. Ratings were made on a scale that ranged from 1 to 7 for each category, with higher numbers indicating greater prevalence of the parenting characteristic. Scales with complete data were summed (with hostility reverse coded) to create an overall measure of maternal sensitivity. Internal consistency for these scales was high (first grade α = .82; third grade α = .78). For purposes of analysis, scores were rescaled to a 4-point scale. Mean sensitivity was 3.31 (*SD* = .50) and 3.22 (*SD* = .42) at first and third grades, respectively.

Accelerated-LH strategy. We calculated the number of oral and sexual intercourse partners as an index of an accelerated LH strategy. When adolescents were approximately 15 years old, they were asked the following two questions: (a) "How many different partners have you had oral sex with in your entire life?" and (b) "How many different partners have you had sexual intercourse with in your entire life?" The response scale for these items ranged from 0–5. Mean number of oral sex partners was 0.33 (*SD* = 0.92); mean number of sexual intercourse partners was 0.28 (*SD* = 0.89). The range of the actual scores reflected the range of the scale for both items. These two items were correlated by .70 ($p <$ .001) and were used to create a latent measure of accelerated life history strategy as the main outcome variable.

Results

Bivariate relations between the measurements included in this report are reported first. This is followed by a test of the environmental unpredictability measurement model. The unpredictability latent factor is then included in a structural equation model to test hypotheses about the prospective influence of early life conditions and experiences on adolescent sexual behavior.

Bivariate Relations

Correlations between model indicator variables are displayed in Table 1. As expected, correlations between repeatedly measured variables (i.e., maternal depressive symptoms, income-to-needs ratio) were moderate to high, indicating relative stability in the constructs across time. Correlations between indicators of unpredictability—paternal transitions, number of moves, and employment transitions—and other model variables were small to moderate, with the highest correlations with income to needs providing some evidence of construct validity. Most notably, perhaps, more paternal transitions, moves, and employment transitions and lower income-to-needs ratios were associated with greater maternal depressive symptoms, less maternal sensitivity, and more adolescent lifetime oral and sexual intercourse partners.

Ecological Unpredictability and Harshness Confirmatory Factor Analysis (CFA)

To test the structure of the unpredictability construct, we first conducted a confirmatory factor analysis. In this model, paternal transitions, number of moves, and employment transitions were specified as indictors of a latent construct labeled *environmental*

Table 1
Bivariate Relationships Between Model Variables

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Paternal transitions	—															
2. No. of moves	.42*	—														
3. Employment transitions	.27*	.28*	—													
4. Income-to-needs ratio (1 month)	.18*	.21*	.23*	—												
5. Income-to-needs ratio (6 months)	.24*	.24*	.24*	.72*	—											
6. Income-to-needs ratio (15 months)	.23*	.24*	.23*	.70*	.83*	—										
7. Income-to-needs ratio (24 months)	.22*	.22*	.26*	.66*	.77*	.78*	—									
8. Income-to-needs ratio (36 months)	.24*	.24*	.26*	.65*	.76*	.74*	.83*	—								
9. Income-to-needs ratio (54 months)	.21*	.23*	.24*	.53*	.74*	.72*	.70*	.76*	—							
10. Income-to-needs ratio (60 months)	.25*	.22*	.25*	.34*	.75*	.72*	.78*	.81*	.86*	—						
11. Maternal depressive symptoms (15 months)	.24*	.19*	.12*	.15*	.18*	.21*	.20*	.17*	.18*	.19*	—					
12. Maternal depressive symptoms (54 months)	.23*	.20*	.17*	.17*	.20*	.18*	.23*	.20*	.22*	.26*	.39*	—				
13. Maternal sensitivity (1st grade)	.22*	.18*	.19*	.21*	.26*	.26*	.23*	.25*	.27*	.27*	.17*	.24*	—			
14. Maternal sensitivity (3rd grade)	.25*	.13*	.12*	.25*	.28*	.27*	.25*	.26*	.25*	.28*	.17*	.20*	.46*	—		
15. No. of lifetime oral sex partners	.18*	.14*	.07*	.11*	.12*	.13*	.13*	.12*	.11*	.11*	.06	.07*	.15*	.18*	—	
16. No. of lifetime sexual intercourse partners	.12*	.11*	.03	.14*	.16*	.15*	.15*	.14*	.14*	.14*	.08*	.07*	.15*	.16*	.70*	—

Note. *N*s for bivariate correlations ranged from 858 to 1,291.
* $p < .05$.

unpredictability. Factor loadings were freely estimated, and the latent variance was fixed to 1.0. Residual indicator variances were left uncorrelated. Specification resulted in a just-identified model and thus the model perfectly fit the data (Kline, 2005). Loadings for the indicators were .64, .66, and .42 for paternal transitions, number of moves, and employment transitions, respectively.

The factor structure of the harshness latent variable was estimated from measurements of income-to-needs ratios obtained at 1, 6, 15, 24, 36, 54, and 60 month as indicators of the latent construct. Similar to the unpredictability model, factor loadings were freely estimated, and the latent variance was fixed to 1.0. Given the longitudinal nature of the data, an autoregressive covariance structure was specified for the indicator residual variances. Results of this model showed adequate fit to the data, $\chi^2(8) = 114.62$, $p < .001$; comparative fit index (CFI) = .99; root-mean-square error of approximation (RMSEA) = .099, 90% confidence interval (CI) [.084, .116]. Despite the significant chi-square result, which is to be expected with a sample size this large, other fit indices were within range of conventional values considered to reflect good model fit in social science (e.g., CFI ≥ .90, RMSEA ≤ .10; Kline, 2005) Factor loadings were high ranging from .75 to .88.

Structural Equation Model: Testing the Primary Hypothesis

Measurement issues. We entered the latent environmental unpredictability and income-to-needs variables into a larger structural equation model to evaluate structural relations between these variables, as well as their putative influence on maternal depressive symptomology, maternal sensitivity, and accelerated-LH strategy (i.e., sexual behavior) in adolescent children. The theoretical model is shown in Figure 1. We conducted the analyses using Mplus 5.21 (Muthén & Muthén, 1998–2009) with FIML estimation.

Maternal sensitivity and sexual behavior each only included two indicators of the latent construct, making them locally unidentified in the SEM model. Because these two constructs would otherwise be underidentified, CFA on these constructs was not appropriate; instead, it was necessary to establish tau equivalence (Brown, 2006) between the two indicators of each construct. The larger SEM model was thus tested twice for each construct, with and without equality constraints for each pair of loadings. Tests of model misfit revealed that constraining the factor loadings for maternal sensitivity at first and third grades produced significant model misfit, $\chi^2(1) = 6.16$, $p < .05$, but that constraining factor loadings for oral and sexual intercourse partners did not, $\chi^2(1) = 1.09$, *ns*. Nonetheless, to prevent one indicator from overly influencing the maternal sensitivity latent construct (and thus subsequent relationships with the latent variable),we retained the constrained factor loadings for maternal sensitivity in the larger SEM model. Standardized factor loadings were .63 and .74 for maternal sensitivity when children were in first and third grade, respectively, and .83 and .85 for oral and sexual intercourse partners, respectively.[2]

To model change in maternal depressive symptomology over the early years of the child's life, a regression path was estimated between maternal depressive symptoms measured when the child was 15 and 54 months old ($\beta = .31$). Controlling for initial depressive symptoms enabled us to test for the effects of income-to-needs ratio and unpredictability on the growth of depressive symptoms over time, as well as to examine the effects of change in these symptoms on other model constructs.

Model fit. The analysis model, as directly specified by the theoretical model, is shown in Figure 2. Despite the significant chi-square result, $\chi^2(96) = 602.06$, $p < .001$), the analysis model displayed an overall good fit (CFI = .95; RMSEA = .062, 90% CI [.057 - .067]). As can be seen in Figure 2, one path (from income-to-needs ratio to sexual behavior) was dropped from the model due

[2] In Mplu, unstandardized factor loadings will be equal when equality constraints are placed on factor loadings. However, standardized loadings will not be equal. This is due to the different variances used to calculate the loadings. For a discussion of this issue in Mplus, see Muthén (2005).

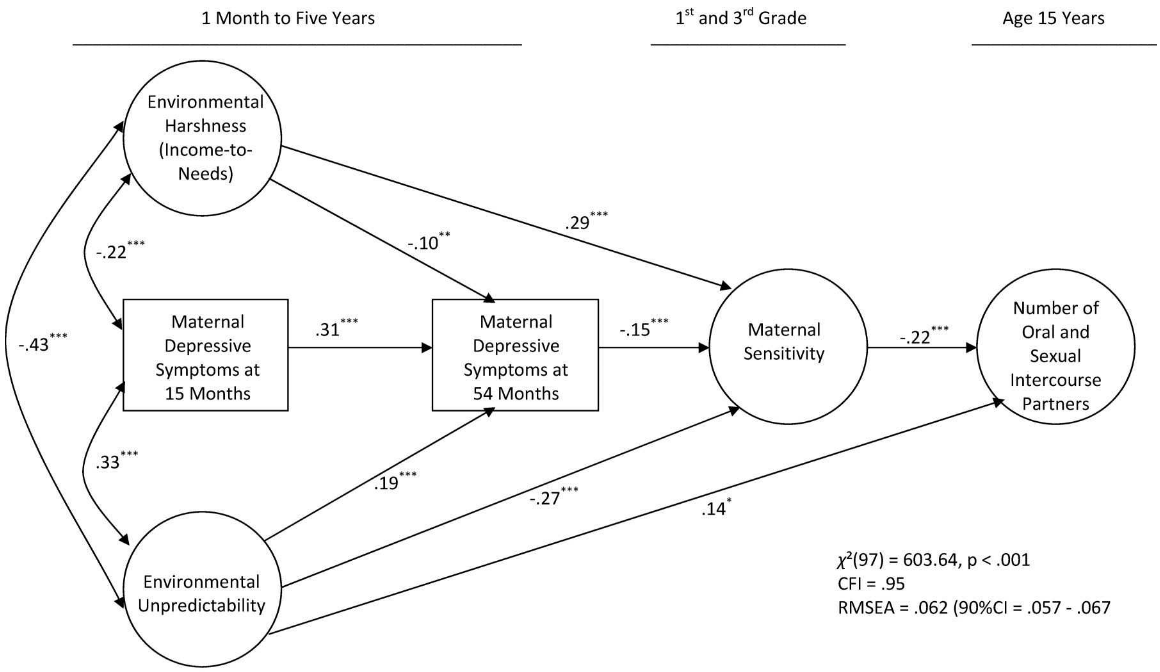

Figure 2. The analysis model. CFI = comparative fit index, RMSEA = root-mean-square error of approximation. $^{*} p < .05$. $^{**} p < .01$. $^{***} p < .001$.

to nonsignificance; otherwise, the analysis model was identical to the theoretical model. Dropping this path from the analysis model did not create significant model misfit, $\chi^2(1) = 1.58$, *ns*, and had no impact on other fit indices. Because the research was theory-driven, and because of the longitudinal nature of the study (which precludes switching the position of temporally ordered variables), alternative models were not tested.

Direct and indirect effects. Highlighted first in further describing model results are direct effects, followed by consideration of indirect effects. As expected, environmental unpredictability significantly predicted change in maternal depressive symptoms when children were age 54 months ($\beta = .19$). Environmental unpredictability also uniquely predicted maternal sensitivity ($\beta = -.27$) as well as adolescent sexual behavior ($\beta = .14$). Thus, families that experienced greater environmental unpredictability tended to experience more growth (or less decline) in maternal depressive symptoms over the early years of the child's life, less maternal sensitivity when the child was in first and third grades, and more precocious sexual behavior when the child was in adolescence (i.e., age 15). In addition, income-to-needs ratio also uniquely predicted change in maternal depressive symptoms at 54 months ($\beta = -.10$) and maternal sensitivity ($\beta = .29$), indicating that higher income-to-needs ratio was associated with less growth in maternal depression and greater maternal sensitivity over the first 5 years of the child's life.

To assess the unique effect of change in depressive symptoms on parenting, we also estimated a regression path between maternal depressive symptoms at child age 54 months and maternal sensitivity ($\beta = -.15$), controlling for maternal depressive symptoms at 15 months. Growth in maternal depressive symptomology over the first 5 years of the child's life was thus associated with lower levels of maternal sensitivity when the children were in elementary school. Furthermore, as expected, higher maternal sensitivity at first and third grades predicted less precocious sexual behavior in adolescence ($\beta = -.22$).

In addition to these direct effects, we also evaluated four indirect paths using Sobel's test (Sobel, 1986). Table 2 shows a decomposition of the direct, indirect, and total effects of the mediated pathways. As can be seen in Table 2, all indirect pathways were significant. In total, levels of unpredictability in the family had both statistically significant direct effects on maternal sensitivity and adolescent sexual behavior and indirect effects through change in maternal depression (mediating the effect on maternal sensitivity) and maternal sensitivity (mediating the effect on sexual behavior). By contrast, income-to-needs ratio had both a statistically significant direct effect on maternal sensitivity and an indirect effect operating through change in maternal depression, but it only had an indirect effect on sexual behavior (which operated through maternal sensitivity). Indeed, the indirect effect of this latter pathway (.064) was actually larger than the direct effect (.058) and accounted for 52% of the total effect (.122).

Tests for sex difference and racial/ethnic differences in observed pathways. To test for between-group variation in the previously described model (Figure 2), we conducted multiple group analyses for sex (male: $N = 705$: 51.7%; female: $N = 659$: 48.3%) and race/ethnicity (coded as a dummy variable; 0 = White [$N = 1042$: 76.4%] and 1 = Other [$N = 322$: 23.6%]). The Other category included Native Americans ($n = 5$), Asian/Pacific Islanders ($n = 22$), African Americans ($n = 176$), Hispanics ($n = 55$), and others not specified (by respondents, $n = 64$). These analyses were conducted to evaluate whether any of the 11 pathways or correlations shown in Figure 2 significantly differed by either sex

Table 2
Total and Indirect Effects of Mediated Pathways

Mediated path	Effect			Sobel's z
	Direct	Indirect	Total	
Unpredictability → Maternal depression → Maternal sensitivity	−.273	−.029	−.302	$z = 2.78, p < .01$
Unpredictability → Maternal Sensitivity → Adolescent sexual behavior	.139	.060	.199	$z = 3.01, p < .01$
Income-to-needs → Maternal depression → Maternal sensitivity	.292	.015	.307	$z = 2.21, p < .05$
Income-to-needs → Maternal sensitivity → Adolescent sexual behavior	.058	.064	.122	$z = 3.34, p < .001$

Note. Maternal depression refers to maternal depressive symptoms when target child was age 54 months; Adolescent sexual behavior refers to number of oral and sexual intercourse partners.

or race/ethnicity, resulting in a total of 22 statistical tests. Given this number of analyses, one pathway or correlation was expected to significantly differ across groups by chance. Indictors of latent constructs were constrained to be equal across groups to establish measurement invariance (Kline, 2005). Results of the two multiple group analyses showed that only one of the 22 paths or correlations differed significantly across groups: the effect of maternal sensitivity on sexual behavior was larger in males than females, and constraining these two paths to be equal created significant model misfit, $\chi^2(1) = 4.82$, $p < .05$. Because one between-group difference was expected on the basis of chance, it was not interpreted.

Discussion

It is not uncommon in longitudinal developmental research like that presented in this report for investigators to composite markers of ecological risk, as for example Sameroff and his coworkers have often done (Gutman et al., 2003;Sameroff et al., 1987; Seifer et al., 1996), to create measures of cumulative contextual risk (Belsky & Fearon, 2002; Evans & English, 2002; Evans & Kim, 2007; Fergusson & Woodward, 2000; Scaramella et al., 1998). Indeed, such approaches have proven informative and accord with views that when it comes to forecasting children's behavioral problems or intellectual competencies, the accumulation of risk factors is often more important than any particular contextual liability. What the compositing of diverse indicators reflects perhaps more than anything else, however, is the general absence of a differentiated and refined theory of the developmentally influential features of the environment. This is not to say, however, that the field of human development has not witnessed substantial movement in this direction, perhaps beginning with Bronfenbrenner's (1979) concentric-circle model of the ecology of human development but also including Belsky's (1984; Belsky & Jaffee, 2006) determinants-of-parenting model, McLoyd's (1990, 1998) model of how economic deprivation shapes child development, and Conger et al.'s (2002) family-stress model.

Of interest and importance is that although these conceptual frameworks (and others like them) have proven fruitful in guiding work addressing the proximate issue of *how* ecological circumstances come to influence human development, they do not address the issue of ultimate causation central to an evolutionary analysis. That is, they do not account for *why* development operates the way it does, or, more specifically, why exactly human development is influenced in the way it is by different kinds of environmental stressors and adversity. Fortunately, this is exactly the issue that Ellis and associates (2009) illuminated upon considering how development is modified by ecological circumstances in their within- and across-species analysis of contextual forces shaping development.

From an evolutionary perspective, the fundamental goal of life is dispersion of genes in future generations. And central to a behavioral–ecological and LH perspective is appreciation that the optimal way of enhancing fitness may vary across contextual conditions. Thus, ways of developing and behaving that promote fitness in one ecological niche (or at least that did so in the environments of evolutionary adaptation) may simply not do so in another. And what Ellis and associates (2009) discovered was that two core ecological dimensions that shape LH strategies within and across a variety of species are the harshness of the environment and its unpredictability, but most important in motivating the current inquiry was their empirical claim that these forces operate independently of one another, again both within and across species.

When it comes to regulating development, the lesson of a harsh environment is that because the risk of death before reaching reproductive age is increased, it makes biological sense to initiate sexual activity earlier rather than later. The lesson of an unpredictable environment is that if the future is more rather than less uncertain, then efforts to mitigate risk are less likely to pay off in terms of enhancing reproductive fitness. After all, efforts toward such ends take time, effort and, critically, energy, so if such investments are less likely to generate anticipated payoffs, as would be the case in more rather than less unpredictable environments, then parents should adjust their rearing accordingly. The same goes for children when it comes to regulating their own development. It needs to be appreciated, of course, that such evolutionary analysis in no way presumes conscious planning or future-oriented reasoning on the part of individuals, be they parents or children. Rather, the notion that developmental strategies and tactics vary as a result of environmental programming is founded on the assumption that such "adaptive developmental plasticity" has evolved in the human developmental repertoire because it increased the likelihood, in the evolutionary past, of genes being dispersed to future generations (Belsky et al., 1991; Chisholm, 1999; Kaplan & Gangestad, 2005).

Despite this observation, it would be a mistake to conclude that conscious thought and even planning play no role whatsoever in the regulation of life history. Not only does personal introspection reveal this to be the case but so too does qualitative research

(Harden, Brunton, Fletcher & Oakley, 2009). Perhaps most noteworthy in this regard is Geronomus's (1996) work on teenage parenting and the consciously appreciated forces that incline some girls to become parents at an early age.

In light of the Ellis et al. (2009) analysis of evolutionarily significant features of the environment that human development should track, we tested the proposition that a marker for ecological harshness, income-to-needs, and a latent construct of environmental unpredictability based on multiple indicators (i.e., paternal transitions, household moves, employment transitions) would each *uniquely* influence—or at least predict—children's family environments and, through it, their early reproductive behavior. Although the correlational nature of the data presented does not afford strong causal inference, the results displayed in Figure 2 proved consistent with Ellis et al.'s (2009) unique-contribution hypothesis, while at the same time according well with the thinking of developmentalists like Belsky (1984); McLoyd (1998) and Conger et al. (2002). They are also in line with Nettle, Coall, and Dickins' (2011) recent study, which also employed structural equation modeling, to illuminate linkages between teenage pregnancy, SES, paternal absence and household moves.

Recall that in the present inquiry low income-to-needs and greater environmental unpredictability in the first 4.5 years of life each uniquely predicted increased maternal depressive symptoms across the toddler and preschool years, which itself predicted less maternal sensitivity during the middle-childhood years and, thereby, increased sexual activity in adolescence. In addition to this multi-step pathway, low income-to-needs and greater environmental unpredictability in the first 4.5 years of life each uniquely predicted lower levels of maternal sensitivity and, thereby, greater adolescent sexual activity. And even with these two pathways taken into account, greater environmental unpredictability, though not lower income-to-needs, forecast greater adolescent sexual activity in a direct, unmediated fashion.

Although it is conceivable that this latter effect is truly direct and unmediated, it seems more likely that it simply appears that way in this inquiry due to the inclusion of only a limited number of possible mediators. Thus, future research should further explore whether other meditational pathways might account for what appears in the research presented herein as a direct effect. One worth considering, for example, would be pubertal timing. Another possibility is the father's behavior; recall that in this research only mothering was evaluated as a parenting mediator. Quite conceivably, harsh or unsupportive fathering and/or earlier pubertal development could turn out to be mechanisms by which ecological harshness and/or unpredictability come to influence life-history strategy. After all, evidence shows that risky sexual behavior in the case of females is predicted by early puberty (e.g., (Belsky, Steinberg, Houts, Halpern-Fisher, & The NICHD Early Child Care Research Network, 2010; Ellis, 2004), as well as by problematic fathering (e.g., Ellis, Schlomer, Tilley, & Butler, in press).

But there is also reason to wonder whether the results which emerged–including the apparent direct, unmediated effect of income-to-needs on sexual activity—might have been a function, at least in part, of the sample investigated in this inquiry. The fact of the matter is that the NICHD Study sample does not have a very good representation of the most economically disadvantaged children and families, even though efforts were made to over sample such research participants. This raises the question of whether the same findings would have emerged in a sample that was significantly poorer or otherwise more distressed. We would encourage investigators working with such samples to evaluate this issue empirically.

One of the important implications of the findings of this study, should they reflect actual causal processes, is that there would appear to be multiple ways of delaying the onset and frequency of sexual activity in adolescence, should that be desired. Not only should efforts to enhance family SES, perhaps by increasing welfare payments and/or training and employment opportunities for parents, succeed in deferring and/or attenuating adolescent sexual activity, but so would efforts to reduce environmental unpredictability; and these effects, in principle, should prove *additive* in their influence, not redundant. The fact that increased maternal depressive symptoms from infancy to the time the child was about to start school and maternal insensitivity mediated unique effects of environmental harshness and environmental unpredictability means that these two could be direct targets of intervention, as well. Thus, even without influencing the two ecological conditions of primary interest here—environmental harshness and unpredictability–efforts that reduced maternal depressive symptoms and/or fostered more sensitive parenting, should also contribute to reducing adolescent sexual activity. Needless to say, it will take experimental interventions to determine whether the anticipated outcomes of any and all such efforts would achieve such an end.

Given this discussion of possible intervention implications of the findings of the current study, as well as related findings from other investigations, we should make clear that as evolutionary-minded developmentalists, the authors do not assume that delaying the onset or reducing the amount of adolescent sexual activity is *inherently* preferable to not doing so. That is, we explicitly reject the concept of so-called "optimal" development embraced by many developmentalists as such language is often used to express the view that it is inherently better for children to develop one way rather than another; and in the current context this means for adolescents to engage in later and/or less sex than earlier and/or more sex. The life-history framework central to the current work makes clear that what is optimal in one ecological niche, at least in terms of enhancing reproductive fitness, may not be so in another. Ultimately, then, it will be human values rather than the presumed nature of evolved developmental mechanisms that determines whether a community or society seeks to regulate adolescent sexual activity in one way or another. Ideally, we would like to rid developmental discourse of notions of "optimal" development due to the fact that it is antithetical to evolutionary analysis. As Cameron and associates (2005, p.846) recently observed, "the idea that any form of phenotypic variation in and of itself is necessarily positive or negative is an anathema to biology"—and thus the life sciences of which human development is surely a part.

It seems eminently possible that some developmentalists will question the contribution of this inquiry. After all, they could ask, "did we not already know or at least suspect that early harsh and unpredictable environments influence adolescent sexual behavior, either directly or indirectly?" Although in some respects the answer to this question is "yes", it should not be forgotten that what is unique to this inquiry is that it is not just directly informed by evolutionary theory, but that it offered an original prediction, namely, that well appreciated forces shaping family functioning and/or child development operate independently of one another. This original prediction led us to explicitly measure and model overall levels of ecological unpredictability in the child's life—something that has been lacking in almost all previous research. Moreover, the theoretical approach adopted raises questions about the common and certainly useful practice of simply adding together risk factors, rather than distinguishing between them. Ultimately, additional research will determine how fruitful such evolutionary insights prove to be.

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Correction to Belsky et al. (2011)

The article "Beyond Cumulative Risk: Distinguishing Harshness and Unpredictability as Determinants of Parenting and Early Life History Strategy," by Jay Belsky, Gabriel L. Schlomer, and Bruce J. Ellis (*Developmental Psychology*, Advance online publication. July 11, 2011. doi:10.1037/a0024454) contained a production-related error. In the fourth paragraph of the Results section, and in the caption for Figure 2, CFI is defined as "confirmatory fit index" when it should be "comparative fit index." All versions of this article have been corrected.

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