Secure infant-mother attachment buffers the effect of early-life stress on age of menarche

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Abstract

Prior research indicates that being reared in stressful environments is associated with earlier onset of menarche in girls. In this research, we examine (a) whether these effects are driven by exposure to certain dimensions of stress (harshness vs. unpredictability) during the first 5 years of life, and (b) whether the negative effects of stress on the timing of menarche is buffered by secure (versus insecure) infant-mother attachment. Results revealed that (1) exposure to greater harshness (but not unpredictability) during the first five years of life predicted earlier menarche, and (2) secure infant-mother attachment buffered girls from the effect of harsh environments accelerating pubertal timing. By connecting attachment research to its evolutionary foundations, these results illuminate how environmental stressors and relationships early in life jointly impact pubertal timing.
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Decades of theory and research converge on the conclusion that exposure to stressful environments in childhood accelerates pubertal development in girls as measured by onset of menarche (e.g., Belsky et al., 2007; Belsky, Steinberg, Houts, Halpern-Felsher, 2010; Deardorff et al., 2011; Ellis & Garber, 2000; Ellis & Essex, 2007; Moffit, Caspi, Belsky, & Silva, 1992; Surbey, 1990; for reviews, see Ellis, 2004, and Belsky, 2012). Although age at menarche is heritable (e.g., Belsky, 2000; Rowe, 2000), studies incorporating genetic controls have confirmed that the association between early life stress and age at menarche is robust (e.g., Belsky, Houts, & Fearon, 2010; Tither & Ellis, 2008).

Many studies, however, have operationalized early life stress broadly at the cost of specifying which types of stress may be more or less important in predicting menarcheal timing. Drawing on Belsky et al.’s (1991; Belsky, 1997) evolutionary theory of socialization and Ellis and colleagues’ (2009) life history model of environmental stress, we address two important questions about the connection between stress and reproductive maturity: (1) Do specific types of environmental stress encountered early in life uniquely predict age of menarche? And (2) are the effects of environmental stress on menarcheal age buffered by the security of the infant-mother attachment relationship?

Life History Theory, Stress, and Age of Menarche

Life history theory explains how organisms allocate their inherently limited resources to optimize reproductive fitness (Kaplan & Gangestad, 2005; Stearns, 1992). According to this evolutionary-biological theory, a fundamental trade-off that developing organisms face is between allocating resources to somatic effort (i.e., growth and maintenance) versus reproductive effort (i.e., sexual maturation and mating). Central to life history thinking is the premise that the
specific strategy an individual adopts depends in part on his/her early rearing environment (Belsky et al., 1991; Chisholm, 1999). In harsh and/or unpredictable environments, for example, faster strategies that prioritize greater reproductive effort increase the likelihood of reproducing before death. However, when harshness and/or unpredictability are low (or can be managed), slower strategies that prioritize investment in somatic effort are more adaptive (Belsky et al., 1991; Ellis et al., 2009). Neither fast nor slow strategies are inherently “better.” Instead, the evolutionary benefit of a given strategy depends on the environment in which an individual develops (Belsky, 1997; Belsky et al., 1991; Caudell & Quinlan, 2012; Kuzawa, McDade, Adair, & Lee, 2010; Simpson & Belsky, 2008, 2016).

Belsky et al. (1991) were the first to specify how life history strategies should unfold across the lifespan. They advanced a unique prediction about the effects of childhood stress on development: that exposure to greater childhood stress (e.g., inadequate resources, father absence, insensitive or harsh parenting, and marital conflict) should accelerate pubertal maturation. Considerable evidence consistent with this proposition has emerged for females, particularly with regard to age of menarche (Belsky, 2012). For example, greater family disruption (and especially fathers’ social deviance) predicts earlier age of menarche (Tither & Ellis, 2008). Maltreated girls reach pubertal maturity eight months earlier than non-maltreated girls (Costello, Sung, Worthman, & Angold, 2007), and earlier harsh maternal caregiving forecasts earlier menarche (Belsky et al., 2007, 2010). Taking advantage of a natural experiment, Pesonen and colleagues (2008) observed that young Helsinki girls who were evacuated from their homeland during World War II and sent to other countries reached menarche at a younger age (and also bore more children by late adulthood) compared to young girls who remained at home and avoided the trauma of separation from their families.
In modern Western societies, where nutritional deprivation is not as severe as in underdeveloped countries, lower socioeconomic status accelerates pubertal maturation (Ellis, 2004). When environments are harsh (due to non-food-related factors such as social competition) but calories are sufficient, menarche should and does occur earlier in life (see Ellis et al., 2009). The current research extends prior work by moving beyond the assessment of general stress levels or very specific stressors to examine two fundamental dimensions of environmental variation that many living organisms monitor in the service of fitness goals.

Environmental Stress Dimensions: Harshness and Unpredictability

Ellis and colleagues (2009) proposed that the development of life history strategies is regulated by two environmental dimensions: harshness and unpredictability. Harshness reflects the mean level of extrinsic mortality-morbidity in a population, which in modern populations is closely tied to socioeconomic status (Belsky, Schlomer, & Ellis, 2012; Chen & Miller, 2012; Simpson, Griskevicius, Kuo, Sung, & Collins, 2012). Unpredictability refers to fluctuations in environmental conditions, which relates to frequent residence changes and family instability in modern populations (i.e., having family members, especially paternal figures, move in and out of the home).

According to Ellis et al. (2009), exposure to harsh and/or unpredictable environments early in life should have unique effects on shaping life history strategies, including by accelerating pubertal timing. Recent empirical evidence about the unique effects of harshness and unpredictability on pubertal and reproductive timing, however, is mixed. Several longitudinal studies indicate that exposure to harsher and/or more unpredictable environments early in life does uniquely forecast fast-strategy outcomes in adolescence, such as greater delinquency and more sexual partners (e.g., Belsky et al., 2012; Brumbach, Figueredo, & Ellis,
2009; Simpson et al., 2012), while some other studies find that unpredictability, as measured specifically by father absence, is not uniquely associated with age of menarche (Ryan, 2014) or age at first sex (Carlson, Mendle, & Harden, 2014). Thus, the current study sought to test the unique effects of environmental harshness and unpredictability.

**Moderating Effects of Early Attachment Security**

Is it *inevitable* that exposure to stress early in life accelerates reproductive development? According to both attachment theory (Bowlby, 1973, 1988) and life history approaches (e.g., Belsky et al., 1991; Del Giudice, 2009), the attachment bond reflects a more proximal developmental process than many distal sources of stress (e.g., poverty, father absence). The attachment bond may, therefore, be able to over-ride the distal sources of stress, thereby buffering secure girls exposed to high levels of stress early in life from undergoing earlier menarche.

Children develop secure (versus insecure) attachment relationships with their primary caregiver (usually the mother) primarily in response to receiving responsive, situationally-appropriate parental care. Children are also more likely to be secure if their caregivers have good mental health, if parents have a happy relationship, and if sufficient social support is available (Belsky & Fearon, 2008). Due to these factors, securely attached children have greater confidence than do insecurely attached children that their caregivers will provide safety, comfort, and emotional reassurance, especially in challenging or stressful situations (Ainsworth, Blehar, Waters & Wall, 1978). Because they have received better and more consistent care, securely attached children usually adopt slower reproductive strategies across the lifespan (Belsky et al., 1991; Simpson & Belsky, 2008, 2016). Secure children appear to learn that their caregivers can be reliably counted on for comfort and support when stressed. Accordingly, girls with insecure
attachment histories experienced menarche at a younger age than secure girls (Belsky, Houts, & Fearon, 2010).

The current research extends this prior work that has documented a main effect of attachment to determine whether attachment moderates the effect of stress on pubertal timing. According to Belsky et al.’s (1991) model, the nature and quality of the parent-child attachment relationship early in life should moderate the effect of stress on reproductive strategies and pubertal timing. Consistent with this claim, recent studies have found that high-quality parenting protects individuals against the adverse effects of early-life stress on pro-inflammatory responses (Chen, Miller, Kobor, & Cole, 2010), and externalizing behavior problems (Skopp, McDonald, Jouriles, & Rosenfield, 2007). Thus, we propose that exposure to stress may differentially affect secure and insecure children, potentially buffering secure children from accelerated reproductive maturity.

**The Current Longitudinal Study**

Drawing on data from the National Institute of Child Health and Development Study of Early Child Care and Youth Development (NICHD SECCYD), two questions are addressed: (1) Does exposure to harsher and/or more unpredictable environments during the first five years of life uniquely predict girls’ earlier onset of menarche (controlling for their mother’s age of menarche)? (2) If so, are secure children protected from this stress-accelerating effect? Although it remains unclear which environmental dimension should forecast age of menarche, we predicted that girls with secure attachment histories would be protected from the adverse effects of stress.

**Method**

**Participants**
The NICHD Study of Early Child Care and Youth Development (SECCYD) recruited 1,364 families through hospital visits shortly after the birth of each child in 1991 at 10 U.S. locations. For a detailed description of recruitment procedures and sample, see the NICHD Early Child Care Research Network (2001) and http://www.icpsr.umich.edu/icpsrweb/ICPSR/series/00233.

The analysis sample included 492 females with data on age of menarche. Racial-ethnically, 398 were White (80.9%), 60 were Black (12.2%), 10 were Asian (2.0%), and 24 reported another ethnicity (4.9%). Compared to all other sample members, analysis-sample members were more likely to be securely attached at 15 months of age, \( t(1189) = -2.50, p = .013 \), came from higher-income families (i.e., income-to-needs ratio), \( t(1353) = -2.72, p = .007 \), and experienced fewer paternal transitions during childhood, \( t(1340) = 2.34, p = .020 \), but did not differ on residential or parental job changes.

**Measures**

**Environmental harshness.** Following Belsky et al. (2012) and Simpson et al. (2012), environmental harshness was indexed by the economic resources of each family, which is a prime indicator of socioeconomic status. The economic resources of families were assessed using the income-to-needs ratio, an index of family’s income as a proportion of the federal poverty line for a family of that size. Family income was divided by the poverty threshold, adjusted for total family size. Thus, a ratio of 1 indicates that family income equals the federal poverty threshold for a family of that size. In 1991 (the year that participants were born), the poverty threshold for a family of four was an annual income of $13,812. A higher income-to-needs ratio indicates greater financial resources *per person* in the household. During each participant’s (each child’s) first 5 years of life, the income-to-needs ratio was assessed repeatedly.
(when participants were 1, 6, 15, 24, 36, 54, and 60 months of age), based on his/her mother’s detailed reports of family finances.

To create an index of early environmental harshness during the first 5 years of life, income-to-needs ratios were averaged over time ($\alpha = .95$). They ranged from .17 to 23.79 ($M = 3.63, SD = 2.73$), with a score of 1 reflecting the federal poverty line. Since high income-to-needs ratios indicate less harsh environments, the index was reversed scored (such that higher values $=$ greater resources).

**Environmental unpredictability.** Also consistent with past research (e.g., Belsky et al., 2012; Simpson et al., 2012), environmental unpredictability across the first 5 years of life was assessed using three measures (see Belsky et al., 2012, and the Supplemental Material available online): (1) *paternal transitions*—the number of changes in the male parental figure within the home, based on face-to-face or telephone interviews 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 old; (2) *household moves*—changes in residence, based on whether and when families relocated during the first 5 years of each child’s life; and (3) *parental employment*—the number of changes in the mother’s and the father’s or boyfriend’s employment during each child’s first 5 years, based on reports at the ages mentioned above. To create a scale of early environmental unpredictability, the three scores were standardized and averaged ($\alpha = .54$). The unpredictability scale ranged from -1.00 to 3.39 ($M = -.08, SD = .68$).

**Infant attachment.** When children were 15 months old, infant-mother attachment was assessed using the Strange Situation procedure (Ainsworth et al., 1978). Infant-mother attachment relationships were classified as secure or insecure based on how each infant responded to his or her mother following a series of brief, stressful separations. Upon reunion,
secure infants usually approach their mothers, are soothed by them, calm down quickly, and then resume normal activity (e.g., play, exploration). Insecure infants either do not approach their mothers or display anger toward them, never fully calming down and not resuming normal activity during the assessment. Among our participants (children), 127 (26.8%) were classified as insecure at 15 months, and 347 participants (73.2%) were classified as secure.

**Age of menarche.** Age of menarche was reported between 9-15 years of age. Some participants reported it at more than one assessment, and others reported it just once. When age of menarche was reported multiple times, the reports were averaged. Age of menarche ranged from 9.03 to 15.50 years ($M = 12.40$ years, $SD = 1.13$).

**Maternal age of menarche.** Each participant’s mother also reported her age of menarche, which was used to partially control for shared genetic effects that could account for her child’s menarcheal timing. Maternal age of menarche ranged from 9.00 to 18.00 years ($M = 12.71$ years, $SD = 1.46$).

**Birth weight.** The mother of each participant was interviewed within 24 hours after delivery and reported her baby’s birth weight, which ranged from 2.00 to 5.34 kg ($M = 3.43$ kg, $SD = .49$).

**Results**

**Descriptive Statistics**

Table 1 presents relations between all of the variables.

Table 1

*Correlations between variables*

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ethnicity</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Attachment security</td>
<td>.07</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Maternal age of menarche</td>
<td>.12*</td>
<td>.07</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Note. Ns range from 456-492. * \( p < .05 \)  ** \( p < .01 \)  *** \( p < .001 \).

Ethnicity, which was coded 0 (Non-White) or 1 (White), was significantly associated with most of the variables. Compared to non-whites, White children were heavier at birth, experienced less harsh and unpredictable environments and had their first menstrual cycle later.

Greater harshness (lower income-to-needs ratio) was associated with greater unpredictability and earlier age of menarche. Girls classified as secure at 15 months experienced menarche later (as reported by Belsky et al., 2010). Maternal age of menarche was positively associated with girls’ age of menarche, but not with girls’ environmental harshness, unpredictability, or attachment security. Birth weight was not significantly related to any of the variables.

**Tests of Hypotheses**

To test (a) whether harshness and/or unpredictability uniquely predicted age of menarche, and (b) whether infant-mother attachment security moderated these effects, we conducted a hierarchical regression analysis. The main effects of environmental harshness, unpredictability, and attachment security along with 3 covariates (maternal age of menarche, ethnicity [White or non-White], and birth weight) were entered in the first block, and all 2-way interactions involving the first three predictors in the second. Listwise deletion was used to deal with missing values since Little’s MCAR test indicated that data were missing completely at random (MACR), \( \chi^2(3) = 5.18, p = .16 \). A square root transformation was applied to the environmental harshness and unpredictability measures given their positively skewed distributions.
As shown in Table 2, greater environmental harshness (i.e., lower income-to-needs ratio) ($\beta = -.26$, $p = .003$), but not unpredictability ($\beta = -.10$, $p > .25$), uniquely predicted earlier age of menarche. Additionally, and as previously reported (Belsky et al., 2010), being securely attached at 15 months also forecasted later menarche ($\beta = .10$, $p = .023$).

Table 2

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>$B$</th>
<th>$SE$</th>
<th>$\beta$</th>
<th>95% CI</th>
<th>$\Delta R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.21***</td>
</tr>
<tr>
<td>Constant</td>
<td>11.95</td>
<td>.15</td>
<td>.11</td>
<td>[11.67, 12.24]</td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td>.32</td>
<td>.14</td>
<td>.11</td>
<td>[0.05, 0.59]</td>
<td></td>
</tr>
<tr>
<td>Maternal age of menarche</td>
<td>.28</td>
<td>.03</td>
<td>.36***</td>
<td>[0.22, 0.35]</td>
<td></td>
</tr>
<tr>
<td>Birth weight</td>
<td>.09</td>
<td>.10</td>
<td>.04</td>
<td>[-.11, .29]</td>
<td></td>
</tr>
<tr>
<td>Attachment security</td>
<td>.26</td>
<td>.11</td>
<td>.10</td>
<td>[0.05, 0.48]</td>
<td></td>
</tr>
<tr>
<td>Harshness</td>
<td>-.26</td>
<td>.09</td>
<td>-.15**</td>
<td>[-.43, -.09]</td>
<td></td>
</tr>
<tr>
<td>Unpredictability</td>
<td>.03</td>
<td>.08</td>
<td>.02</td>
<td>[-.16, .18]</td>
<td></td>
</tr>
<tr>
<td>Harshness \times Attachment</td>
<td>-.35</td>
<td>.18</td>
<td>.16</td>
<td>[.00, .70]</td>
<td></td>
</tr>
<tr>
<td>Unpredictability \times Attachment</td>
<td>.18</td>
<td>.17</td>
<td>.09</td>
<td>[-.14, .51]</td>
<td></td>
</tr>
<tr>
<td>Harshness \times Unpredictability</td>
<td>.18</td>
<td>.11</td>
<td>.08</td>
<td>[-.04, .41]</td>
<td></td>
</tr>
</tbody>
</table>

| Step 2              |         |      |         |              | .01*          |
| Constant            | 11.91   | .15  | .12     | [11.62, 12.21] |               |
| Ethnicity           | .35     | .14  | .12     | [0.08, 0.62]  |               |
| Maternal age of menarche | .28      | .03  | .36***  | [0.22, 0.35]  |               |
| Birth weight        | .08     | .10  | .04     | [-.12, .28]   |               |
| Attachment security | .25     | .11  | .10     | [0.04, 0.47]  |               |
| Harshness           | -.46    | .15  | -.26**  | [-.76, -.16]  |               |
| Unpredictability    | -.16    | .15  | -.10    | [-.45, .14]   |               |
| Harshness \times Attachment | .35   | .18  | .16     | [.00, .70]    |               |
| Unpredictability \times Attachment | .18     | .17  | .09     | [-.14, .51]   |               |
| Harshness \times Unpredictability | .18    | .11  | .08     | [-.04, .41]   |               |

Note. $N = 456$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Notably, girls who were exposed to harsher early-life environments but who were securely attached to their mothers were buffered from accelerated reproductive development (see Figure 1). Specifically, the harshness by attachment interaction was significant ($\beta = .16$, $p = .048$). Greater harshness predicted earlier menarche, but only for girls who were insecurely attached to their mothers at 15 months of age, $b = -.51$, $SE = .15$, $p = .003$, and not for girls who were securely attached, $b = -.14$, $SE = .11$, $p > .25$. 
Figure 1. The moderating effect of infant-mother attachment security at 15 months on the effect of early environmental harshness on age of menarche.

Importantly, all of the effects presented here remained significant when we partially controlled for the shared genes between mothers and their daughters (indexed by mothers’ age of menarche), which independently and positively predicted the timing of menarche.

We also conducted a series of additional analyses to examine alternative models and other possible predictions (see the Supplementary Material available online). These analyses revealed that the effects reported above continued to hold when we statistically modeled and controlled for both male presence in the home and maternal sensitivity early in development (Analysis 1 and 2). Further analyses confirmed that the moderating effect of attachment security
on the relation between early harshness and age of menarche was also found when using latent measures of harshness and unpredictability (Analysis 3). Finally, attachment security did not mediate the link between early harshness and age of menarche although it moderated this connection (Analysis 4).

**Discussion**

Drawing on Belsky et al.’s (1991; Belsky, 1997) evolutionary theory of socialization and Ellis and colleagues’ (2009) life history model of environmental stress, this study addressed two questions: (1) Do specific dimensions of environmental stress—harshness and/or unpredictability—uniquely predict the earlier onset of menarche in girls? And (2) Does secure infant-mother attachment protect girls from the developmentally accelerating effect of stress?

Regarding question 1, this is the first study to show that early-life harshness—but not unpredictability—uniquely predicted the timing of menarche in girls in the theoretically-anticipated manner, with greater stress stemming from a harsh environment leading to accelerated reproductive development. It should be noted, however, that the SECCYD sample has few truly impoverished families, and Ellis et al.’s model acknowledges that different life history outcomes may emerge depending on the absolute level of stress to which children are exposed early in life. Future research is needed to test whether in samples containing more families that have experienced extreme unpredictability, results might be different.

Regarding question 2, having a secure infant-mother attachment buffered girls from accelerated reproductive development, even when they grew up in a family with limited economic resources. This finding extends previous research chronicling the stress-protective effect of having a supportive parent-child relationship (see Belsky et al., 1991, 2010; Chen &
Miller, 2012). In so doing, it also suggests that supportive proximal relationship processes might be able to over-ride more distal, stressful environments.

Despite its longitudinal design, reasonably diverse sample, and good measures collected at different points of development, the current research has some limitations. First, our predicted early environmental harshness by infant-mother attachment security interaction effect, although statistically significant, is not large. It needs to be replicated in future longitudinal samples.

Second, our measures of harshness and unpredictability assess these constructs indirectly. We measured them this way to be consistent with prior research (e.g., Belsky, Houts & Fearon, 2010; Belsky et al., 2012; Simpson et al., 2012) in order to facilitate comparisons of findings with earlier studies. In future research, however, different possibilities for operationalizing both constructs should also be examined using methods that are consistent with the way in which harshness and unpredictability have been conceptualized theoretically.

Third, some prior studies have found that harshness and unpredictability both forecast certain life-history outcomes in adolescents (e.g., sexual behavior in girls; Belsky et al., 2012), whereas others have found that unpredictability alone predicts certain life-history outcomes in young adults (e.g., sexual behavior, deviance, and aggression in both sexes; Simpson et al., 2012). These different outcomes might be partly attributable to the demographic characteristics of the samples being studied (e.g., higher vs. lower SES samples), sampling error, or the indirect measurement of harshness and unpredictability. Future research should address and rectify these limitations.

Finally, in relation to the aforementioned demographic characteristics of the sample, the effects of unpredictability may have been obscured by the absence of more impoverished families experiencing extreme household chaos, only some factors that might impact menarche
were examined, and the findings may have been different if other indices of reproductive maturation were studied. Future research is needed to address these limitations.

In conclusion, this research lies at the intersection of and integrates two major theories, attachment theory (Bowlby, 1973, 1988) and evolutionary models grounded in life history theory (Belsky et al., 1991; Ellis et al., 2009). It connects attachment theory to its original theoretical roots in evolutionary biology, a foundation largely neglected over the past four decades (Belsky, 1997; Simpson & Belsky, 2016), by showing how early attachment is related to reproductive development, not just psychological and behavioral development. More specifically, it illuminates conditions under which exposure to harsh environments in infancy does—and does not—accelerate female reproductive development.
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