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Does Ecology or Character Matter? The Contributions of Childhood Unpredictability, Harshness, and Temperament to Life History Strategies in Adolescence

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As applied to humans, life history theory suggests that harsh and unpredictable childhood environments shape downstream reproductive strategies. Although myriad work provides support for that idea, such work fails to take into account another potentially important childhood contributor to downstream reproductive strategies—temperament. Using data from the Longitudinal Study of Australian Children (LSAC; N = 2,321) and structural equation modeling (SEM), we examined the relative contributions of childhood (age 6/7) temperament, harshness, and unpredictability to reproductive development (i.e., puberty at ages 10/11 and 12/13), and adolescent (age 16/17) romantic relationships, sexual activity, and reproductive intentions. Children who experienced harsh and unpredictable ecologies or who were high in sociability or reactivity engaged in more sexual activity/risk taking. Yet, adolescents who experienced high unpredictability as children explicitly reported wanting fewer children later in life. Additionally, the harsher their environments or the higher their sociability in childhood, the more and earlier romantic relationships adolescents had. Results underscore that both early environmental and individual difference factors may shape adolescent reproductive strategies and add to a growing body of literature suggesting that harshness and unpredictability can have different effects on life history strategies.

Public Significance Statement
This study analyzed data on the development of over 2,000 Australian youth from young childhood to adolescence to understand how different early childhood personality traits and experienced environments affect sexual development and behaviors. We separately measured environmental harshness (i.e., low socioeconomic status, low resources) and unpredictability (i.e., erratic changes in socioeconomic status, resources), which have often been conflated in past work but had some similar and some different effects in the current work.

Keywords: life history theory, harshness, unpredictability, temperament, sexual strategies

Humans' reproductive strategies are sensitive to the affordances of the environment (Belsky et al., 1991; Ellis et al., 2009). Indeed, humans develop flexibly in response to attributes of their childhood ecologies, which presumably represent qualities of the environment across the life span. A growing body of research suggests that sexual development and reproductive behaviors calibrate to the harshness (i.e., high mortality and morbidity, a lack of resources) and unpredictability (i.e., erratic and uncertain presence of threat or resources) of childhood ecologies (Belsky et al., 1991; Ellis et al., 2009). Other work demonstrates that childhood (e.g., Caspi et al., 1997; Raffaelli & Crockett, 2003) and concurrent (e.g., Buss, 1991; Hoyle et al.,

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2000; Markey & Markey, 2007; Schmitt, 2004) personality influences sexual strategies. Nevertheless, most examinations of personality in the context of behavioral ecology focus on personality in adulthood or adolescence, where individual differences are presumably shaped by earlier ecologies (e.g., Carver et al., 2014; Chen et al., 2017). Hence, such studies are unable to discern how early temperament relates to downstream sexual development and behavior when ecological factors are taken into account, and vice versa. The current study aims to close this gap in the literature and uses longitudinal data from more than two thousand children to answer the question: *what are the relative contributions of childhood unpredictability, childhood harshness, and child temperament to sexual development and adolescent reproductive strategies?*

Harshness and Unpredictability Shape Sexual Development and Behavior

Humans' reproductive development and behavior calibrate to early environmental conditions in ways that make the most of limited energy in those types of environments to facilitate optimal production of progeny (Del Giudice, 2016; Neuberg et al., 2010). Some scholars have applied a Life History Theory (LHT) framework to understand the sorts of biological and reproductive tradeoffs human organisms make in response to ecological affordances (e.g., Belsky et al., 1991; Ellis et al., 2009). As applied to humans, LHT proposes that clustered patterns of biological, cognitive, and social strategies emerge from ontogenetic calibration processes (Figueredo et al., 2007). These clusters compose strategies that guide the use of limited energy, facilitate navigation of tradeoffs (i.e., present vs. future reproduction, quality vs. quantity of offspring, and mating vs. parental effort), and fall on a spectrum between *fast* and *slow* endpoints (Kaplan & Gangestad, 2005). Exposure to early harshness and unpredictability cues fast strategies. Fast strategies entail prioritization of earlier (present) reproduction, quantity of offspring, and mating effort—they are characterized by earlier puberty, earlier and shorter-term mating, more romantic partners, sexual promiscuity, and having more numerous but investing less in offspring (Figueredo et al., 2007; Griskevicius et al., 2011; Kaplan & Gangestad, 2005; Nettle, 2010; Quinlan, 2007). At the other end of the spectrum, slow strategies feature later reproduction, quality offspring, and parental effort—including delayed puberty and sexual debut, long-term mating, fewer romantic partners, sexual restrictedness, and having fewer offspring in which the individual invests more (Figueredo et al., 2007; Griskevicius et al., 2011; Kaplan & Gangestad, 2005; Nettle, 2010; Quinlan, 2007).

Although the application of LHT—borne of evolutionary biology to explain *inter*species variation—to humans has received criticism (e.g., Baldini, 2015; Del Giudice, 2020; Nettle & Frankenhuis, 2020; Stearns & Rodrigues, 2020; Zietsch & Sidari, 2020), a large body of work supports the contention that sexual development and behavior are shaped by early environmental conditions (e.g., Belsky et al., 1991; Ellis et al., 2009; Del Giudice, 2009; Simpson et al., 2012). In particular, familial and ecological conditions from ages 5 to 7 years old appear to most strongly shape downstream reproductive strategies (Belsky et al., 1991; Draper & Harpending, 1982). Two important environmental conditions are captured by *harshness* and *unpredictability* (Brumbach et al., 2009).

Harshness is the rate of morbidity-mortality in an organism's environment, largely based on survival resource availability. For humans, harshness linearly scales with *socioeconomic status* (SES)—low monetary resources limit the attainment of essential and nonessential goods (Adler et al., 1994; Belsky et al., 1991; Belsky et al., 2012; Brumbach et al., 2009; Doom et al., 2016; Ellis et al., 2009; Mittal & Griskevicius, 2014; Pepper & Nettle, 2017; Simpson et al., 2012). Unpredictability represents how erratic or uncertain fluctuations in the presence of threat and/or the availability of resources are in an organism's environment (Belsky et al., 1991). Past work has operationalized childhood unpredictability as frequent changes or ongoing inconsistency in presence of caretakers, relationships between parents and step-parents, home and school locations, relationships with and behavior of caretakers and family, and daily routines (e.g., Belsky et al., 2012; Brumbach et al., 2009; Doom et al., 2016; Mittal & Griskevicius, 2014; Simpson et al., 2012). Both harshness and unpredictability mean that an organism may not have the resources to grow its soma, invest in a long-term partner or offspring, such that a faster strategy is optimal—better to have more children sooner. This strategy plays out in

earlier sexual development, romantic and sexual relationships, and intentions to reproduce more.

Indeed, harshness (Belsky et al., 1991; Chisholm et al., 2005; Crockett et al., 2013; Ellis & Essex, 2007; Ellis, 2004 for review) and unpredictability (Ellis & Essex, 2007; Kogan et al., 2015; Moffitt et al., 1992) in childhood are associated with earlier puberty in boys and girls. Earlier puberty predicts earlier dating (Ivanova et al., 2012); first sexual intercourse, pregnancy, and childbirth (Ellis, 2004). Moreover, harshness and unpredictability have been linked directly to earlier sexual behavior (Belsky et al., 1991; Chisholm et al., 2005; Ellis, 2004; Xu et al., 2018); earlier first birth (Low et al., 2008; Wilson & Daly, 1997; Woodward et al., 2001); earlier marriage (Xu et al., 2018); and more numerous pregnancies and offspring (Copping & Campbell, 2015; Dishion et al., 2012). Likewise, a fast strategy correlates with beliefs that casual and promiscuous sex are acceptable or preferred (Figueredo et al., 2007; Patch & Figueredo, 2017; Szepsenwol et al., 2019). Unpredictability, but less often harshness, is associated with risky sexual behavior (e.g., unprotected sex or more partners; Belsky et al., 2012; French et al., 2020; Simpson et al., 2012; Sitnick et al., 2014; Woodward et al., 2001; Xu et al., 2018).

Reproductive intentions also vary by ecological conditions. When their mortality is made salient, people from harsher (lower socioeconomic status) environments report wanting to have children at a younger age, even at the cost of building up their embodied capital in the form of education (Griskevicius et al., 2011). In summary, harsher and more unpredictable environments have been associated with faster life history strategies, characterized by earlier puberty, younger and more numerous romantic and sexual relationships, and younger and stronger reproductive intentions. We expect to replicate this pattern. However, past research applying this framework has rarely considered the contribution of childhood temperament to these processes.

Temperament May Predict Sexual Behavior

Temperament can be understood as developmentally early-emerging personality, presumed to be biologically-based, and represented in traits such as persistence, sociability, and reactivity (Sanson et al., 1994). *Persistence* is the tendency to persevere with tasks or activities and a precursor to the adult personality trait of conscientiousness (associated with orderliness, dutifulness, reliability, and self-control in the pursuit of goals; Goldberg, 1990; McRae & Costa, 1999). *Sociability* is the tendency to seek out and enjoy social interactions, or an early expression of the adult personality trait extroversion (associated with dominance, sociability, positive emotion, exploratory activity, and reward-seeking behavior; Goldberg, 1990; McRae & Costa, 1999). *Reactivity* is the tendency to react with negative emotions, viewed as an early manifestation of the adult personality trait neuroticism (associated with experience of negative emotions such as fear, sadness, anger, anxiety, and guilt; Goldberg, 1990; McRae & Costa, 1999).

With respect to the associations among adult personality and broader psychosocial life history strategies, a general factor of personality consisting of high conscientiousness, extroversion, agreeableness, and low neuroticism was positively associated with slower strategies characterized by higher levels of long-term planning, parental investment, somatic investment, and altruism toward kin and nonkin (Figueredo et al., 2007). That is, relevant here, the adult analogs of persistence and sociability predicted slower strategies, whereas the adult analog of reactivity predicted faster strategies. Next, we turn to the link between temperament/personality and sexual strategies and risk taking more specifically.

Sparse evidence directly links childhood temperament to sexual strategies later in life. One study suggests that undercontrolled, or low in persistence, children (age 3) were more likely to take sexual risks at age 21 than their more controlled peers (Caspi et al., 1997). However, more ample work links temperament to traits and risky behaviors that tend to cluster with components of a faster life history strategy. That is, temperament predicts risk-taking behaviors that covary with sexual activity and sexual risk taking downstream (e.g., Dishion et al., 2012; Simpson et al., 2012). For example, low levels of executive functioning/control (persistence) and high levels of exuberance (sociality) at age 4 interacted to predict higher levels of risk taking at age 5 (Lahat et al., 2012). Looking further downstream, children low in self-control (persistence) at age 3 score higher on measures of impulsivity and risk taking at age 18 (Caspi & Silva, 1995).

Furthermore, prior research demonstrates that the personality traits related to early temperament predict components of sexual strategies. Conscientiousness and self-regulation (persistence) have

been associated with later sex (Khurana et al., 2012), having fewer romantic and sexual partners (Buss, 1991; Raffaelli & Crockett, 2003; Schmitt, 2004); engaging in less risky sexual activity (Caspi et al., 1997; Dir et al., 2014; Lafreniere et al., 2013; Markey et al., 2003; Raffaelli & Crockett, 2003; for quantitative review see Hoyle et al., 2000); and having fewer children (Jokela et al., 2011). Together, these findings suggest that conscientiousness, or persistence, contributes to a relatively slow strategy, as has been noted before (e.g., Del Giudice, 2016; Figueredo et al., 2007). Hence, we predicted that (high) persistence in childhood would predict having fewer romantic partners and less sexual activity/risk taking in adolescence. Highly conscientious people have more planned, versus unplanned, pregnancies (Berg et al., 2013); but it is less clear how that trait predicts reproductive intentions (Kiser & Whelpton, 1958; Westoff et al., 1961). Moreover, achievement personality (analogous to persistence in adults) was unassociated with positive childbearing motives (Miller, 1992). Accordingly, we did not expect childhood persistence to predict adolescent reproductive intentions.

Extroversion and its correlates, including low shyness, high sensation seeking and impulsivity (sociability) are associated with having more romantic (Ivanova et al., 2012) and sexual partners (Cooper et al., 2003; Markey & Markey, 2007; Schmitt, 2004) as well as with more risky sexual activity (Cooper et al., 2003; Hoyle et al., 2000). The temperament traits of sociability and activity level in adolescence and adulthood were positively associated with having more children (Jokela et al., 2009, Jokela et al., 2011). Affiliative personality, or adult sociality, has been tied to positive motivation to have children (Miller, 1992). Hence, we predicted that childhood sociability would be associated with more adolescent romantic relationships, sexual risk taking, and reproductive intentions.

Neuroticism (reactivity) predicts having more sexual, but not necessarily more romantic, partners and taking more sexual risks (Ball & Schottenfeld, 1997; Caspi et al., 1997; Cooper, 2010; Hoyle et al., 2000). Although work on neuroticism and reproductive intentions is lacking, some work suggests that neuroticism is associated with fewer planned and more unplanned pregnancies (Berg et al., 2013) and having fewer children (Jokela et al., 2011). Thus, we predicted that childhood reactivity would be positively associated with adolescent sexual activity, but unrelated or negatively associated with romantic relationships and reproductive intentions.

In sum, there is some direct and myriad indirect evidence that suggests that childhood temperament may shape sexual strategies later in life. Notably, though, few programs of research have examined childhood temperament's contribution to reproductive strategies in the stage before adulthood. Hence, our work moves beyond prior work in linking early temperament to reproductive development as well as reproductive activity and intentions in adolescents.

Summary of Predictions

The current work leveraged longitudinal data to examine the relative contributions of childhood unpredictability, harshness, and temperament to sexual development (i.e., puberty) and adolescent reproductive strategies (i.e., romantic relationships, sexual activity/risk taking, reproductive intentions). We predicted that childhood ecological harshness and unpredictability will be associated with earlier puberty as well as more and earlier romantic relationships, sexual activity/risk taking, and reproductive intentions in adolescence. We predicted that persistence would be negatively associated with romantic relationships and sexual activity/risk taking, but unassociated with reproductive intentions. We also predicted that sociability would be positively associated with romantic relationships, sexual activity/risk taking, and reproductive intentions. Similarly, we predicted that reactivity would be positively associated with sexual activity/risk taking, but, in contrast, would be unrelated or negatively related to romantic relationships and reproductive intentions. Finally, as in prior work (e.g., Brumbach et al., 2009), we predicted that earlier puberty would predict more and earlier romantic relationships and sexual activity/risk taking, but were agnostic as to whether it would predict reproductive intentions.

Method

Participants and Procedure

Participants were drawn from the Longitudinal Study of Australian Children (LSAC; Australian Institute of Family Studies, 2015); a nationally

representative study of children born in Australia. The first wave of LSAC data collection was conducted March 2004 to January 2005; and a follow-up wave has occurred every 2 years. LSAC was approved by the Australian Institute of Family Studies Ethics Committee and each family provided written informed consent before participating. LSAC data can be requested from the Australian Institute of Family Studies (http://growingupinaustralia.gov.au/data/dataaccessmenu.html).

The measures used in these analyses were employed when the children were 6/7 (temperament, childhood harshness and unpredictability), 10/11 (puberty), 12/13 (puberty), and 16/17 years old (reproductive strategies). At 6/7 years old, 4,462 children participated. By 16/17 years old 1,551 children (35%) were no longer involved in the study due to researchers' inability to recontact them or the families' decision not to continue participation. Additionally, 418 children were excluded for missing temperament data, 24 were excluded for missing pubertal development data, and 148 were excluded for missing data on adolescent romantic relationships, sexual activity, or reproductive intentions. Thus, a total of 2,321 children were included in the present analyses. Descriptive statistics of demographic variables are provided in Table 1.

Measures

Childhood Unpredictability

Consistent with prior work's operationalization (e.g., Belsky et al., 2012; Brumbach et al., 2009; Doom et al., 2016; Mittal & Griskevicius, 2014; Simpson et al., 2012), we assessed the unpredictability of children's household environment at 6/7 years old with 9 items that captured absent biological parents, changes in parental relationships, parental employment, household composition, and frequent changes in residence. For all but one of the variables (i.e., frequent moves) the response scale was yes/no and we coded all variables as 0 or 1 with 1 indicating greater unpredictability. For each indicator variable item of this factor, see Table 2.

Childhood Harshness

Consistent with prior work's operationalization (e.g., Belsky et al., 1991; Belsky et al., 2012; Brumbach et al., 2009; Doom et al., 2016; Ellis et al., 2009; Mittal & Griskevicius, 2014; Simpson et al., 2012), we assessed the harshness of children's environment at 6/7 years old with three composite variables capturing low parent education, low parent income, and low neighborhood socioeconomic status (SES) as well as both parents' employment status. For *education*, parents reported two separate

Table 1
Descriptive Statistics for Included Variables

	Descriptives		
Demographics		Childhood temperament	
N	2,321	Sociability	4.02 (1.17)
Female	49.68%	Reactivity	2.36 (0.85)
Indigenous	1.77%	Persistence	4.09 (0.90)
Environmental unpredictability		Pubertal development	
Single parent	10.00%	10/11yo	1.65 (0.49)
Absent bio mother	0.90%	12/13yo	2.30 (0.73)
Absent bio father	11.72%	Change	0.65 (0.55)
Household member change	23.09%	Romantic relationships	
Frequent moves	35.93%	Ever	51.31%
Parent break up	3.19%	Young	0.95 (1.11)
Parent separation	1.34%	Number	0.69 (0.81)
Mother job change	39.72%	Sexual activity	
Father job change	30.50%	Ever	29.56%
Environmental harshness		Young	0.48 (0.87)
Neighborhood SES [R]	−1,017 (58.84)	Unprotected	0.31 (0.50)
Parent log income [R]	−3.03 (0.31)	Reproductive intentions	
Parent education years [R]	−15.89 (2.40)	Ever	1.65 (0.64)
		Young	1.94 (1.28)
		Number	1.91 (1.36)

Note. Values represent a count, percent, or mean (standard deviation). SES = socioeconomic status; [R] = Value reversed by multiplying by −1.

Table 2
Childhood Unpredictability Measure Items

Variable	Item	Coding
1. Single parent	Study child has 2 parents in the home	Yes = 0, No = 1
2. Absent biological mother	Study child has biological mother in the home	Yes = 0, No = 1
3. Absent biological father	Study child has biological father in the home	Yes = 0, No = 1
4. Household member change	Any change in household composition since previous wave (2 years ago)?	Yes = 1, No = 0
5. Frequent moves	How many homes has study child lived in since the last interview (2 years ago)?	1 or 2 = 0, 3+ = 1
6. Parent break up	In the last year, have any of the following happened to you? Broke off a steady romantic relationship	Yes = 1, No = 0
7. Parent separation	In the last year, have any of the following happened to you? You had a separation due to relationship or marital difficulties	Yes = 1, No = 0
8. Mother job change	Are you in the same job/business as you were at two years ago	Yes = 0, No = 1
9. Father job change	Are you in the same job/business as you were at two years ago	Yes = 0, No = 1

education variables: highest year of primary or secondary schooling completed and highest postsecondary qualification. We transformed these two variables into a single estimate of years of education for each parent, utilizing the same method as previous LSAC research (see Blakemore et al., 2009). For those with postsecondary qualifications, our estimate of years of education was: postgraduate degree = 20, graduate diploma or bachelor's degree = 17, advanced diploma or diploma = 16, and certificate or other qualification = 14. For those without postsecondary qualifications, our estimate was: year 12 completed or still in school = 13, year 11 completed = 12, year 10 completed = 11, year 9 completed = 10, year 8 or below completed = 9, Never attended school = 0. We then took the highest value of either parent to obtain maximum parent education and reversed the value so that higher scores indicated greater harshness.

For *income*, parents reported their usual weekly income in Australian dollars. To account for the logarithmic utility of income we transformed income using the function LogIncome = log10 (Income + 1). We then took the highest value of either parent to obtain maximum parent income and reversed the value so that higher scores indicated greater harshness.

For *neighborhood SES*, LSAC staff geocoded the families' addresses and linked them to their statistical local area. These areas were then linked to the Australian Socio-Economic Indexes for Areas —Index of Relative Socio-economic Disadvantage (SEIFA-IRSD, Pink, 2006), which encompasses a broad array of indicators of neighborhood SES. These indicators include having a high percentage of residents with low income, no educational qualifications, who are unemployed or in a low-skill occupation, and live in overcrowded housing, as well as a low percentage of car ownership and home Internet access. The IRSD is scored such that lower values indicate more disadvantaged areas, but we reversed the value so that higher scores indicated greater harshness.

Childhood Temperament

Parents reported the *sociability*, *reactivity*, and *persistence* of their children at 6/7 years old. Each measure included the average of four items with a Likert-type scale from 1 (*almost never*) to 6 (*almost always*). LSAC staff selected the items from the Short Temperament Scale for Children (STSC; Sanson et al., 1994), which can be seen in Table 3.

Puberty and Change in Puberty

Parents reported their child's pubertal development using the Pubertal Development Scale (PDS; Petersen et al., 1988) when their child was 10/11 and 12/13 years old. The scale consists of five items, two of which vary depending on the child's sex. For both boys and girls, items addressed growth spurts, body hair, and acne. The items just for boys addressed voice changes and facial hair, while the items just for girls addressed breast development and menarche. Most of the items had four response options: 1 (*has not yet started*), 2 (*has barely started*), 3 (*has definitely started*), and 4 (*seems complete*). The item asking about girls' menarche (*Has your child ever menstruated?*) had only 2 response options (1 = No, 4 = Yes). We averaged

Table 3
Childhood Temperament Measure Items

Trait	Items	Coding
Sociability	1. This child is shy with strange adults.	Reversed
	2. This child is shy when first meeting new children.	Reversed
	3. When in a park or visiting, this child will go up to strange children and join in their play.	
	4. When unknown adults visit our home, this child is immediately friendly and approaches them.	
Reactivity	1. If this child wants a toy or sweet while shopping, he/she will easily accept something else instead.	Reversed
	2. When this child is angry about something, it is difficult to sidetrack him/her.	
	3. When shopping together, if I do not buy what this child wants (e.g. sweets, clothing), he/she cries and yells.	
	4. If this child is upset, it is hard to comfort him/her	
Persistence	1. When a toy or game becomes difficult, this child quickly turns to another activity.	Reversed
	2. When this child starts a project such as a puzzle or model, he/she works on it without stopping until it is completed, even if it takes a long time.	
	3. This child likes to complete one task or activity before going on to the next.	
	4. This child stays with an activity (e.g. puzzle, construction kit, reading) for a long time.	

across the five items to create overall pubertal development scores at 10/11 and 12/13 years old. To calculate the change in pubertal score from 10/11 to 12/13, we subtracted the 10/11 puberty score from that of the 12/13 wave.

Romantic Relationships

In adolescence (at 16/17yo), participants provided information about their girlfriends/boyfriends that allowed us to derive 3 pieces of information, which we used to create an early romantic relationship factor. Specifically, we derived whether they had *ever been in a romantic relationship* (0 = No, 1 = Yes); *how old were they when they started their first romantic relationship* (0 = Never started, 1 = 16yo or older, 2 = 15yo, 3 = 14yo, 4 = 13yo, 5 = 12yo or younger); and how many *total boyfriends/girlfriends* they have had (observed range: 0–7). Higher scores represent more and earlier relationships.

Sexual Activity

In adolescence (at 16/17yo), participants provided three pieces of information that allowed us to create an early sexual activity and sexual risk-taking factor (following Kogan et al., 2015). Specifically, they responded to the following questions: *Have you ever had sex?* (0 = No, 1 = Yes); *How old were you the first time you had sex?* (coded as: 0 = Never had sex, 1 = 16yo or older, 2 = 15yo, 3 = 14yo, 4 = 13yo, 5 = 12yo or younger); and, *The last time you had sex, what method (if any) was used to prevent pregnancy*? with the options *Birth control pills, Condoms, Morning after pill, Contraceptive implant, Contraceptive injection, Intrauterine device (IUD), Diaphragm, Vaginal ring, Other, None?* (coded as: 0 = Never had sex, 1 = A method was used to prevent pregnancy, 2 = No method was used to prevent pregnancy). Higher scores represent more sexual activity and more pregnancy risk.

Reproductive Intentions

In adolescence (at 16/17yo), participants provided 3 pieces of information that allowed us to create a reproductive intentions factor. Specifically, they responded to the following questions: *Do you hope to have children?* (0 = No, 1 = Haven't considered it, 2 = Yes); *At what age would you like to have your first child?* (0 = Never/Not sure, 1 = 33yo or older, 2 = 28–32yo, 3 = 23–27yo, 4 = 20–22yo, 5 = 19yo or younger); *How many children would you like to have?* (observed range: 0–10 children). Higher scores represent a desire to have more children earlier.

Covariates

All analyses controlled for child sex (0 = male, 1 = female), child indigenous status (1 = Indigenous Australian or Torres Strait Islander, 0 = Other), and child age at the time the dependent variable was collected. These control variables are important given

that women go through puberty earlier than men on average, that indigenous status may be a predictor of harshness and unpredictability, and that children varied from each other in age within a one year window at each wave, respectively.

Statistical Approach

The primary analysis employed structural equation modeling (SEM) to examine the associations between child temperament, environmental unpredictability and harshness at 6/7 years old, pubertal development at 10/11 years old, change in pubertal development by 12/13 years old, and romantic relationships, sexual activity, and reproductive intentions at 16/17 years old. Environmental unpredictability and harshness, romantic relationships, sexual activity, and reproductive intentions were modeled as latent variables composed of three or more observed indicators. Child temperament and pubertal development were based on previously established measures and were hence treated as manifest variables. The covariates of child age, sex, and indigenous status were also treated as manifest variables. All analyses were conducted in R.

The SEM was a full-forward model, with temperament, unpredictability, and harshness at 6/7yo predicting pubertal development at 10/11yo and change in pubertal development from 10/11 to 12/13yo, and all of the variables at 6/7, 10/11, and 12/13yo predicting romantic relationships, sexual activity, and reproductive intentions at 16/17yo. In a preliminary model, we also examined the interactions among temperament, unpredictability, and harshness. None of the interactions were significant, so they were excluded from the final model for parsimony and to improve model fit.

The SEM was computed using the Latent Variable Analysis (lavaan) package for R (Rosseel, 2012). Before conducting the SEM, missing data were imputed using the Multivariate Imputation by Chained Equations (mice) package for R (van Buuren & Groothuis-Oudshoorn, 2011). The parameters were set such that five imputed data sets were generated, and one was chosen at random. Additionally, each of the five imputations consisted of up to five iterations. A predefined random seed was not used. This imputation process was conducted separately for each set of latent variable indicators. Additionally, any missing pubertal development items were imputed separately for boys and girls at 10/11 and 12/13yo before averaging the scale.

The SEM displayed acceptable fit by most indices. The chi-square test indicated that the model was significantly worse than the saturated model ($\chi^2 = 1865.79$, $df = 374$, $p < .001$), but that result is not particularly informative when the sample size is large (Schermelleh-Engel et al., 2003). RMSEA was .041, which is considered good fit (Browne & Cudeck, 1993); SRMR was .034, which is considered good fit (Hu & Bentler, 1995); and CFI was .947, which

Table 4
SEM Results: Confirmatory Factor Analysis

	Factor loadings
Environmental unpredictability	
Single parent	.96 [.95, .97], <.001
Absent bio mother	.14 [.09, .18], <.001
Absent bio father	.90 [.89, .91], <.001
Household member change	.26 [.22, .30], <.001
Frequent moves	.19 [.15, .23], <.001
Parent break up	.45 [.42, .48], <.001
Parent separation	.37 [.33, .40], <.001
Mother job change	.11 [.07, .15], <.001
Father job change	.24 [.20, .28], <.001
Environmental harshness	
Parent education years [R]	.62 [.57, .66], <.001
Parent log income [R]	.63 [.58, .67], <.001
Neighborhood SES [R]	.39 [.34, .44], <.001
Romantic relationships	
Ever	.95 [.94, .96], <.001
Young	.87 [.86, .88], <.001
Number	.87 [.86, .89], <.001
Sexual activity	
Ever	.99 [.98, .99], <.001
Young	.86 [.85, .87], <.001
Unprotected	.98 [.97, .98], <.001
Reproductive intentions	
Ever	.90 [.89, .91], <.001
Young	.92 [.91, .93], <.001
Number	.85 [.83, .86], <.001

Note. Values represent a standardized factor loading [95% CI], *p*-value. SEM = structural equation modeling; [R] = Value reversed by multiplying by −1.

is considered acceptable fit (Hu & Bentler, 1999).

Results

Latent Factors

All the indicators loaded significantly on their latent factors (see Table 4). For the latent factor of environmental unpredictability, the loadings varied substantially among indicators, with single parent and absent biological father as the strongest and mother job change in the last 2 years or absent biological mother as the smallest. For environmental harshness, the loadings were all moderate, with parent education and income being slightly larger than neighborhood SES. For romantic relationships, sexual activity, and reproductive intentions the loadings were all high and similar to each other.

Structural Equation Model

We examined whether childhood (age 6/7) temperament (i.e., sociability, persistence, reactivity), unpredictability, and harshness were associated with early puberty (age 10/11) and change in puberty (age 12/13), and whether all of these were associated with romantic relationships, sexual activity, and reproductive intentions in adolescence (age 16/17). All effects controlled for the other predictors as well as sex, indigenous status, and age. See Table 5 for all associations and Figure 1 for significant pathways. Childhood harshness was associated with both earlier puberty and less change in puberty the following year, as predicted, whereas childhood unpredictability was associated with later puberty, contrary to predictions. Also consistent with predictions, puberty at 10/11 and increase in puberty at 12/13 were positively associated with romantic relationships and sexual activity/risk taking at 16/17. That is, the earlier children went through puberty and the more quickly they developed until age 13, the more likely they were to start dating earlier and to have more boyfriends or girlfriends, and the more likely they were to start having sex earlier and to use fewer precautions to protect themselves against pregnancy.

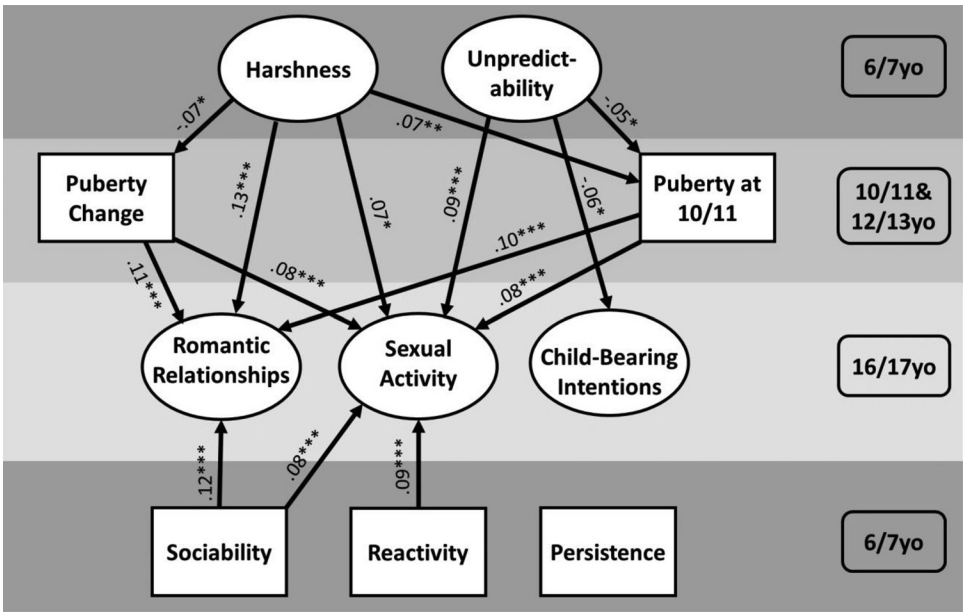
With respect to the links between ecological factors in childhood and sexual strategies in adolescence, harshness and unpredictability had similar effects on sexual activity but dissimilar effects on romantic relationships and reproductive

Table 5
SEM Results: Path Analysis

	Outcomes				
Predictors	Puberty at 10/11yo	Puberty change from 10/11 to 12/13yo	Romantic relationships	Sexual activity	Reproductive intentions
Unpredictability	**−.05 [−.09, −.01], .021**	.01 [−.04, .05], .697	.04 [−.01, .09], .159	**.09 [.05, .14], <.001**	**−.06 [−.11, −.01], .028**
Harshness	**.07 [.02, .12], .010**	**−.07 [−.12, −.01], .022**	**.13 [.07, .19], <.001**	**.07 [.01, .13], .019**	.02 [−.04, .09], .459
Sociability	.03 [−.01, .07], .105	.00 [−.04, .04], .963	**.12 [.08, .16], <.001**	**.08 [.04, .12], <.001**	−.02 [−.06, .02], .389
Reactivity	.01 [−.02, .05], .513	.00 [−.04, .04], .894	.02 [−.02, .07], .264	**.09 [.05, .13], <.001**	.04 [−.01, .08], .095
Persistence	.01 [−.03, .04], .732	−.01 [−.05, .03], .574	−.02 [−.06, .02], .352	−.02 [−.06, .02], .349	.02 [−.02, .07], .292
Puberty 10/11	—	—	**.10 [.05, .15], <.001**	**.08 [.03, .12], <.001**	.03 [−.02, .07], .291
Puberty change	—	—	**.11 [.06, .15], <.001**	**.08 [.03, .12], <.001**	−.02 [−.06, .03], .429

Note. SEM = structural equation modeling. Values represent a standardized regression coefficient [95% CI], *p*-value. Bolded values are statistically significant $\alpha = .05$.

Figure 1
Significant Pathways in Structural Equation Model



Note. Lower-order indicators contributing to each factor are not presented here in order to simplify the presentation of the model. Please see Tables 2 and 4 for details on indicator variables.
* $p < .05$. ** $p < .01$. *** $p < .001$.

intentions. Specifically, as predicted, childhood harshness and unpredictably were positively associated with sexual activity, such that children who grew up with few resources or erratic family environments were more likely to have sex earlier and less likely to use protection. Further, as predicted, childhood harshness was positively associated with romantic relationships; in contrast and contrary to predictions, childhood unpredictability was unassociated with romantic relationships. This suggests that children who experienced high levels of resource scarcity were more likely to have more and earlier romantic relationships as adolescents. Contrary to predictions, unpredictability was associated with lower reproductive intentions and harshness was unrelated. Teenagers who experienced highly unpredictable childhoods wanted fewer children and to have them later compared to teenagers who experienced highly predictable childhoods.

With respect to the links between childhood temperament and sexual strategies in adolescence, we found some evidence for predictions. Highly sociable children had more and earlier romantic relationships and risky sexual experiences than their counterparts low in sociability, as expected. Children high in reactivity grew into adolescents who engaged in more sexual activity/risk taking, as expected. Also consistent with predictions, persistence and reactivity did not systematically predict reproductive intentions. However, contrary to predictions, persistence was not related to romantic relationships or sexual activity/risk taking.

Associations Among Predictors and Among Outcomes

We also examined the latent covariation among predictors in the SEM model, which can be seen in Table 6 and are accounted for in the full SEM model presented above. Childhood harshness and unpredictability were positively associated. Additionally, harshness was negatively associated with persistence; reactivity was negatively associated with sociability and persistence. Finally, we examined the latent covariation among outcomes, which are also accounted for in the model presented above

Table 6
SEM Results: Associations Among Predictors

Predictor	Unpredictability	Harshness	Sociability	Reactivity
Harshness	**.41 [.36, .46], <.001**	—	—	—
Sociability	.00 [−.04, .04], .989	.01 [−.04, .06], .706	—	—
Reactivity	.04 [−.00, .08], .056	.03 [−.02, .08], .287	**−.09 [−.13, −.05], <.001**	—
Persistence	−.03 [−.07, .01], .125	**−.09 [−.14, −.04], .001**	−.01 [−.05, .03], .494	**−.22 [−.26, −.18], <.001**

Note. SEM = structural equation modeling. Values represent a standardized coefficient [95% CI], *p*-value. Bolded values are statistically significant $\alpha = .05$.

(see Table 7). Romantic relationships, sexual activity, and reproductive intentions in adolescence were positively associated.

Discussion

Survival and reproductive success depend on the affordances of the environment. Accordingly, cues from the early ecology prompt adaptive calibration that allows the organism to make the most of limited energy across the life span. Important factors of the environment to which organisms should attend include resource limitations (harshness) and erratic resource availability (unpredictability). There is myriad evidence that this holds true for human animals: children who experience harsh and unpredictable environments develop earlier (i.e., younger puberty) and become adults who have more short-term romantic and sexual relationships, take more sexual risks, and intend to or have more children younger (Belsky et al., 1991; Ellis et al., 2009; Griskevicius et al., 2011; Kaplan & Gangestad, 2005; Nettle, 2010; Quinlan, 2007; Simpson et al., 2012). However, such work failed to consider whether effects hold above and beyond early-emerging personality (i.e., temperament). The current work addressed this gap using longitudinal data and a structural equation modeling approach, demonstrating that both environmental and individual difference factors contribute to adolescent life history strategies.

Our findings complement others in the literature to underscore that not only are harshness and unpredictability dissociable, but their downstream effects differ in adaptive ways (e.g., Belsky et al., 1991; Ellis et al., 2009; Maranges et al., 2021; Simpson et al., 2012)—there is not a uniform "fast" life history strategy (e.g., Baldini, 2015; Nettle & Frankenhuis, 2020; Zietsch & Sidari, 2020). Children who experienced harsh environments went through puberty at a younger age, whereas children who experienced more environmental unpredictability went through puberty at an older age. The former is consistent and the latter is inconsistent with prior work (e.g., Chisholm et al., 2005; Ellis & Essex, 2007; Kogan et al., 2015). Perhaps this difference emerged because our measures of unpredictability picked up on psychosocial stress to a differing degree than that work, and stress may have both accelerating and inhibiting effects on pubertal development (see Ellis, 2004). For example, Ellis and Essex (2007) measured both unpredictability and stress together. As in prior research (e.g., Kogan et al., 2015), earlier puberty was associated with more and earlier romantic relationships and sexual activity/risk taking. However, earlier puberty was not related to reproductive intentions, a novel finding.

It may be that early ecological challenges shape biology and psychology in such a way to maximize reproduction without conscious awareness of reproductive goals. Indeed, children who experienced harsh ecologies had more and earlier romantic relationships and engaged in more sexual

Table 7
SEM Results: Associations Among Outcomes

Outcome	Romantic relationships	Sexual activity
Sexual activity	**.42 [.39, .46], <.001**	—
Reproductive intentions	**.12 [.08, .16], <.001**	**.09 [.05, .14], <.001**

Note. Values represent a standardized coefficient [95% CI], p-value. Bolded values are statistically significant $\alpha = .05$.

activity/risk taking but did not differ from those who experienced resource plentifulness when it came to explicit reproductive intentions. The association between harshness and faster life history strategies as earlier relationships and more sexual activity/risk taking is consistent with some (e.g., Brumbach et al., 2009) but contrasts with other work (e.g., Simpson et al., 2012). Unpredictability was also associated with more sexual activity/risk taking, as in prior work (e.g., Belsky et al., 2012; Simpson et al., 2012), but was unrelated to romantic relationships and was negatively associated with reproductive intentions. Perhaps unpredictability highlights the cost of having more children when one cannot effectively plan for the future given the erratic presence of resources. Past work linking early ecological challenges, namely harshness, to desires to have children at a younger age evoked this response after priming participants with mortality (Griskevicius et al., 2011), suggesting that making limited time and resources salient may bring reproductive goals into awareness. Future work may benefit by examining whether mortality salience interacts with childhood unpredictability also or whether implicit reproductive intentions vary by early ecological conditions.

With respect to temperament, children who were higher in sociability had more and earlier romantic relationships and engaged in more sexual activity/risk taking in adolescence. Likewise, children higher in reactivity engaged in more sexual activity/risk taking in adolescence. These findings accord with past work (e.g., Caspi et al., 1997; Markey & Markey, 2007; Schmitt, 2004). However, persistence was not associated with romantic or sexual involvement, contrary to a large body of work (Hoyle et al., 2000). Finally, none of the childhood temperament traits were associated with reproductive intentions in adolescence. Perhaps the relationship between temperament and reproductive intentions cannot be detected with explicit measures. Alternatively, or additionally, in light of prior work, it could be that the link between temperament and reproductive intentions manifests in young adulthood, versus adolescence (e.g., Jokela et al., 2011), when many of the predictors of childbearing motivations solidify (e.g., total education, occupation, marital relationships, Miller, 1992).

Limitations and Future Directions

The current data come from a large, diverse sample, include information on and from two parents, and allow for clear temporal ordering—this provides confidence in the results presented here. Nonetheless, we consider several limitations to the current work. First, although standard in similar longitudinal work (e.g., Simpson et al., 2012), some of the measures were collected via parents' or children's self-reports, which are susceptible to social desirability, shared method variance, and memory error concerns. Relatedly, some reports, such as those of early puberty, were provided by parents, who may have incomplete knowledge. Including more objective data from other sources can strengthen confidence in results.

Second, although the LSAC sample was diverse (and nationally representative), it was restricted to children in Australia, such that generalizations to other populations may be limited. For example, to the extent that sex education has any effect on sexual strategies in adolescence, we might expect differences between Australian and American youth. Indeed, Australian sex education is much more comprehensive than that of the United States (Bell, 2009). Moreover, other important ecological factors that we did not take into account systematically vary across nations (e.g., Sng et al., 2018). Programs of research focused on behavioral ecology and life history strategies in humans should take into consideration the idiosyncratic nature of data collection locale.

Third, although our operationalizations of harshness and unpredictability follow past work (e.g., Belsky et al., 2012; Simpson et al., 2012), they do not cover the gamut of conceptualizations of these ecological factors. Specifically, our harshness factor captured parental and neighborhood socioeconomic status (e.g., education, income, employment) and our unpredictability factor captured changes in familial and home life (e.g., changes in parental relationships, parental employment, household composition, and home). However, harshness and unpredictability can encompass the mean level and variation of various sources of mortality/morbidity, respectively: for example, measured as stressful life events, subjective levels of stress, or violence. Hence, future work may aim to replicate our findings with alternative operationalizations of ecological harshness and unpredictability.

Last, we cannot account for gene-environment interactions. Genetic factors may help explain the association among childhood harshness and

unpredictability and temperament (Lemery-Chalfant et al., 2013) and downstream behaviors (Belsky et al., 2012). That is, children reside in harsh or unpredictable environments created by their parents, who are also contributing genes associated with reproductive development (Barbaro et al., 2017) and strategies to those children (Rowe, 2000). Hence shared genetics may confound the associations between observed phenotypic characteristics. Future work may benefit by employing behavioral genetic methods to examine the relative contributions of genetic and environmental factors to links between both childhood temperament and environments and adolescent life history strategies.

Conclusion

Humans are sensitive to cues from their early environments, flexibly developing to optimize reproduction across the life span. Ample work has established that the harshness (i.e., high mortality and morbidity, a lack of resources) and unpredictability (i.e., erratic and uncertain presence of threat or resources) of childhood ecologies predict downstream reproductive capacity and activity: earlier and more sexual development, activity, and risk taking (e.g., Belsky et al., 1991; Ellis et al., 2009; Griskevicius et al., 2011; Simpson et al., 2012). Yet, to our knowledge, prior work has failed to take into account the effects of early-emerging personality, temperament—a powerful predictor of behavior later in life (e.g., Caspi et al., 1997; Raffaelli & Crockett, 2003). Hence, the current work addressed this gap via longitudinal data from childhood to adolescence. Children who experienced harsh environments went through puberty at a younger age, whereas children who experienced more environmental unpredictability went through puberty at an older age. Children who experienced harsh or unpredictable ecologies or who were high in sociability or reactivity engaged in more sexual activity/risk taking. Yet, adolescents who experienced high unpredictability as children explicitly reported wanting fewer children later in life. Additionally, the harsher their environments or the higher their sociability in childhood, the more and earlier romantic relationships adolescents had. These results underscore that both early environmental and individual difference factors shape adolescent reproductive strategies, even when taken into account simultaneously. Finally, this work adds to an increasingly clear picture: downstream responses to harshness and unpredictability are not one-life-history-strategy-fits-all.

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