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Human Life History Strategies: Calibrated to External or Internal Cues?

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Abstract

Human life history (LH) strategies are theoretically regulated by developmental exposure to environmental cues that ancestrally predicted LH-relevant world states (e.g., risk of morbidity–mortality). Recent modeling work has raised the question of whether the association of childhood family factors with adult LH variation arises via (i) direct sampling of external environmental cues during development and/or (ii) calibration of LH strategies to internal somatic condition (i.e., health), which itself reflects exposure to variably favorable environments. The present research tested between these possibilities through three online surveys involving a total of over 26,000 participants. Participants completed questionnaires assessing components of self-reported environmental harshness (i.e., socioeconomic status, family neglect, and neighborhood crime), health status, and various LH-related psychological and behavioral phenotypes (e.g., mating strategies, paranoia, and anxiety), modeled as a unidimensional latent variable. Structural equation models suggested that exposure to harsh ecologies had direct effects on latent LH strategy as well as indirect effects on latent LH strategy mediated via health status. These findings suggest that human LH strategies may be calibrated to both external and internal cues and that such calibrational effects manifest in a wide range of psychological and behavioral phenotypes.

Keywords

health, life history calibration, life history theory, predictive adaptive response, psychometric assessment

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Multiple studies have shown that environmental factors play a key role in predicting various correlated behaviors and outcomes such as mating strategies, risky behaviors, reproductive development, and health (Belsky, Schlomer, & Ellis, 2012; Belsky, Steinberg, & Draper, 1991; Brumbach, Figueredo, & Ellis, 2009; Ellis, Figueredo, Brumbach, & Schlomer, 2009; Hampson, Andrews, Barckley, Gerrard, & Gibbons, 2016; Kaplan & Gangestad, 2005; McCullough, Pedersen, Schroder, Tabak, & Carver, 2013). From the perspective of life history theory (LHT), a mid-level evolutionary framework, these phenotypic variables are conceptualized as indicators of individual differences along a fast–slow LH continuum (Ellis et al., 2009; Gangestad & Simpson, 2000; Kaplan & Gangestad, 2005; Promislow & Harvey, 1990). Fast LH strategies are theoretically most adaptive under harsh and unpredictable environmental conditions and involve allocating resources toward current reproduction (as opposed to future reproduction) and offspring quantity (as opposed to offspring quality). As such, these individuals employ short-term mating tactics, engage in risky behavior, are less future oriented, and devote less time to their offspring (Griskevicius et al., 2013; Simpson, Griskevicius, Kuo, Sung, & Collins, 2012). Slow LH strategies, on the other hand, are most adaptive in safe and predictable environments and entail the inverse pattern of resource allocation trade-offs. These individuals (and their offspring) tend to have better future prospects for survival and reproduction, which makes it adaptive to expend more effort investing in the quality (as opposed to quantity) of their offspring and in somatic maintenance effort (as opposed to current mating effort; Belsky et al., 1991; Brumbach et al., 2009; Ellis et al., 2009; Figueredo, Vásquez, Brumbach, & Schneider, 2007; McCullough et al.,

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2013; Simpson et al., 2012). Thus, individual differences in rates of maturation, investment in somatic maintenance, mating and parenting strategies, risk-taking, and future orientation are related to the functional trade-offs that occur along the fast–slow LH continuum.

Significant advancements to LHT established by Belsky, Steinberg, and Draper (1991) addressed how stressful ecologies, mediated by parental styles, affect psychological (e.g., attachment styles), behavioral (e.g., opportunistic vs. future oriented), and somatic development (e.g., maturation) as well as reproductive strategies (e.g., sexual activity, mate retention, and parental investment). Chisholm (1993) further characterized cues to parents' stress as an indicator of mortality and poor long-term reproductive prospects that can be monitored by offspring in early development. Since then, research has shown that individuals exposed to economic inequality, neighborhood violence, low parental care, residential changes, or unstable employment will adopt developmental trajectories to enhance immediate reproductive opportunity at the expense of investment in an uncertain future (Belsky et al., 2012; Brumbach et al., 2009; Copping, Campbell, & Muncer, 2013a; Simpson et al., 2012).

Additional evidence suggests that LH-related psychological phenotypes such as anxiety and depression (Norman et al., 2012), high levels of paranoia, and low levels of trust (Nettle, Pepper, Jobling, & Schroeder, 2014; Petersen & Aarøe, 2015) are coordinated in predicted ways with variation in environmental harshness. Within the context of LHT, it is logical that this association between environmental adversity (e.g., aggressive and neglectful parenting) and psychological well-being serves to evoke heightened sensitivity to threat. Vigilance in these conditions may be advantageous because it prepares individuals to respond quickly in threatening situations (Ellis & Del Giudice, 2014; Frankenhuis & Weerth, 2013) and to avoid wasted investments in low-quality social opportunities.

Environmental harshness, as we have been conceptualizing it, is defined by exposure to conditions that increase (or indicate) risks for morbidity, mortality, and interpersonal exploitation (Belsky et al., 2012; Ellis et al., 2009). Researchers have sought to distinguish harshness from the correlated environmental dimension of unpredictability (Belsky et al., 2012; Brumbach et al., 2009; Ellis et al., 2009; Simpson et al., 2012). While we acknowledge that unpredictability could have effects on LH development that are distinct from those of harshness, we concentrate our analysis on the effects of harshness due to the difficulty of disentangling these two dimensions in practice.

Predictive Adaptive Responses (PAR)

The evidence for adaptive coordination of LH strategies with environmental conditions is compelling. However, the developmental mechanisms that generate these associations have not been fully elucidated. Most of this research has proceeded under the assumption that LH calibration can be conceptualized as a "PAR"—a facultative response to external cues, which forecast later environmental conditions that predict the optimal phenotypic strategy (Gluckman, Hanson, & Spencer, 2005). For instance, individuals exposed to cues of high family conflict or neighborhood violence would therefore facultatively respond to these observations by accelerating onset of puberty and sexual activity (Belsky et al., 1991).

Recent quantitative models by Nettle, Frankenhuis, and Rickard (2013; see also Rickard et al., 2014) have made important distinctions between two types of PARs: external and internal. External PARs follow the dominant assumption described above: individuals directly sample external cues and calibrate their LH strategy accordingly (environment → LH strategy). To reiterate, the direct relationship between adverse environments, brought about from economic inequality, low parental investment, and neighborhood discord, can be used as a "weather forecast" to make relatively accurate predictions about the future. In turn, individuals will respond in ways that would have maximized fitness ancestrally. Internal PARs, on the other hand, reflect calibration of LH strategy in response to one's own somatic condition (environment → health → LH strategy). The evolvability of the internal PAR mechanism is based on the idea that one's own somatic condition functions as an index of cumulative lifetime exposure to harsh (vs. safe) environments (or the ability to withstand perturbations imposed by such environments). If so, overall health may provide a better forecast for future morbidity and mortality rates than observations of external cues. Harsh environments may influence health outcomes through multiple causal pathways. For example, low access to resources may simply impose energetic constraints on optimal development and immunocompetence (Hill, Boehm, & Prokosch, 2016; Nettle et al., 2013). Another possibility is that individuals adaptively calibrate their investment in somatic growth and maintenance (immune function, etc.) in response to harsh environmental conditions—in order to avoid making costly investments in an uncertain future (Nettle, 2014). These pathways are not mutually exclusive and both predict that exposure to variably harsh environments will reliably associate with overall health status (which it does; Rickard et al., 2014).

The quantitative models developed by Nettle and colleagues indicate that the evolvability of external and internal PARs hinges on the ancestral validity of the possible cues to which LH strategies might be calibrated (Nettle et al., 2013; Rickard et al., 2014). In general, their models suggest that mechanisms for internal PARs will be more likely to evolve than those for external PARs, given the ancestral relationship between current health status and future morbidity–mortality risk. The evolution of external PARs, on the other hand, only theoretically occurs under the assumption that external cues were, ancestrally, highly reliable indicators of future harshness. Because it is difficult to accurately estimate ancestral cue validities, empirical work on living human participants will likely be crucial for testing between external and internal PARs.

The quantitative models described above, however, were applied only to the calibration of a single LH indicator:

reproductive timing. To the degree that LH strategies reflect coordinated phenotypic variation, the logic should theoretically apply more broadly to the fast–slow LH continuum. Consistent with this hypothesis, recent research described by Hill, Boehm, and Prokosch (2016) preliminarily suggests that overall health and markers of immunocompetence predict various behavioral and psychological LH indicators, such as short-term mating, impulsivity, and temporal discounting.

Overview of the Current Research

In the current research, we aimed to test the external and internal PAR models by examining the associations among environmental harshness, health status, and a wide range of LH indicators. To this end, we modeled variation in LH strategy as a unidimensional latent variable, or higher order LH factor, which manifests as multiple behavioral and psychological traits that should be influenced by one's place along the fast–slow continuum: perceived stress (Belsky et al., 1991; Hanson et al., 2015), anxiety (Ellis et al., 2003; Repetti, Taylor, & Seeman, 2002), depression (Belsky et al., 1991; Ellis et al., 2003; Repetti et al., 2002), temporal discounting (Griskevicius, Tybur, Delton, & Robertson, 2011; Hanson et al., 2015; Hill et al., 2016), trust in others (Nettle et al., 2014; Petersen & Aarøe, 2015), and mating strategies (Belsky et al., 1991; Brumbach et al., 2009; Simpson et al., 2012). This increasingly influential approach to the psychometric assessment of LH variation is based on the empirically supported postulate that a latent variable is the best way to capture an elusive broadband construct encompassing loose correlations among various phenotypic dimensions (see Figueredo et al., 2014, for an overview of this approach). Importantly, although we operationalize latent LH strategy as the variance shared by heterogeneous constructs, we do not suggest that each individual construct is solely (or even primarily) reflective of fast–slow variation.

Across three observational survey studies, we employed structural equation models (SEMs) to test direct effects of self-reported environmental harshness measures on latent LH strategy (as predicted by the external PAR model) as well as indirect effects of environmental harshness on latent LH strategy mediated through health (as predicted by the internal PAR model). The first two studies were very similar, with the primary difference being the nature of the subject sample (mothers vs. undergraduates). In these two studies, three aspects of recalled environmental harshness were assessed: socioeconomic status (SES; Griskevicius, Delton, Robertson, & Tybur, 2011; Hampson et al., 2016; McCullough et al., 2013; Simpson et al., 2012), family neglect (Carver, Johnson, McCullough, Forster, & Joormann, 2014; Hampson et al., 2016; McCullough et al., 2013), and neighborhood crime (Brumbach et al., 2009; Hampson et al., 2016; McCullough et al., 2013). Health status was likewise operationalized via a single latent factor utilizing self-report surveys involving global self-assessments. Study 3 was a conceptual replication that employed relevant variables from a large archival data set.

Study 1

Method

Participants

Participants were 314 mothers recruited through Amazon's Mechanical Turk (MTurk) and compensated US$1.50 upon completion. Participants consisted of Caucasians (67.8%), Asians (12.7%), African Americans (7.6%), Hispanic (6.4%), and Other (5.4%) ranging between 20 and 64 years old ($M =$ 35.3 years). Fathers were not included in the initial recruitment because the original data set strictly assessed pregnancy variables in relation to mother and offspring health. The inclusion criteria identified heterosexual mothers (i.e., have given birth to at least one child) who were 18 years or older, fluent in English, and a citizen of the United States. MTurk masters and workers with an 80% approval rating or higher were selected to participate.

Material and Procedure

All materials and procedures for this study were approved by the institutional review board of Oklahoma State University. Participants completed an online survey. Additional restrictions were set to prevent a high influx of "cheaters." Questionnaires were programmed to only be taken once from a given Internet Protocol (IP) address, participants were guaranteed compensation for answering honestly (even if they did not meet the inclusion criteria), and MTurk masters and workers with an 80% approval rating or higher were selected as they have demonstrated a high degree of accuracy (by Amazon's standards). The focal variables are listed below.

Environmental Harshness

Environmental harshness was assessed using four independent variables to evaluate various factors that contribute to adverse environments: objective and subjective measurements of SES, family neglect, and neighborhood crime. All environmental harshness measures were reported for both early childhood (ranging from birth to 7 years of age) and current adulthood to capture a comprehensive description of overall environmental harshness throughout the life span.

SES. Objective SES was assessed through participants' self-reported annual household income for both time points (sliding scale US$0–US$150,000+). Established subjective SES measures were anchored on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*; Griskevicius, Tybur, et al., 2011). Early childhood items were: (a) "My family usually had enough money for things," (b) "I lived in a relatively wealthy neighborhood," and (c) "I felt that I went to a relatively wealthy and good school compared to the other kids in my town." The last question was modified to clearly distinguish between wealthy and poor schools. Current subjective SES items included: (a) "I don't need to worry too much about being able to pay my bills," (b) "I have enough money to buy things I want," and (c) "I feel relatively wealthy these days." Subjective SES questions were summed with lower scores representing low SES.

Because both subjective and objective SES measures focused on access to monetary resources, it was not surprising to find that they were highly correlated (see Supplementary Table S2). The presence of multicollinearity was resolved by standardizing the SES measures and aggregating them together to obtain one measure of SES. This was done separately for each time point. Descriptives and Cronbach's αs for these measures are listed in Supplementary Table S1.

Family neglect. The Risky Families Questionnaire, adapted from the Adverse Childhood Experience, was used to assess family neglect (Felitti et al., 1998; Taylor, Lerner, Sage, Lehman, & Seeman, 2004). Participants were asked to rate the level of family conflict they experienced during early childhood (e.g., "How often did a parent or other adult in the household make you feel that you were loved, supported, and cared for?"). This scale consists of 13 items anchored on a 5-point scale ranging from 1 (*not at all*) to 5 (*very often*/*very much*). Current family neglect was assessed by modifying the original questionnaire, replacing "parent" with "spouse" and "you/siblings" with "your children" (e.g., "How often would you say there is quarreling, arguing, or shouting between your children?"). Scores were summed with higher scores representing high levels of family neglect.

Neighborhood crime. The exposure to violence subscale from the City Stress Inventory was used to assess neighborhood crime (Ewart & Suchday, 2002). This subscale consists of 7 items that asked participants to rate the occurrence of each statement (e.g., a friend was stabbed or shot) on a 4-point scale ranging from 1 (*never*) to 4 (*very often*). This subscale was not modified for either time point. Scores were aggregated with higher scores representing high levels of neighborhood crime.

Bivariate correlations revealed that the time points (i.e., early and current) within each environmental harshness indicator (i.e., SES, family neglect, and neighborhood crime) were moderately-to-strongly intercorrelated. To resolve the multicollinearity within each indicator, early and current SES scores were standardized and combined, early and current family neglect scores were standardized and combined, and early and current neighborhood crime scores were standardized and combined. Thus, a total of three independent measures of harsh conditions, SES, family neglect, and neighborhood crime, were formed. Supplementary Tables S1 and S2 list the descriptives, reliability values, and the full bivariate correlation matrix for these measures.

Health Outcomes

Two types of measures were incorporated to evaluate general subjective health and grouped together to form a health composite.

Health attitude. Health attitude was assessed through four questions taken from the Research and Development Short Form Health Survey (RAND SF-36) developed by the RAND Corporation (Coons, Alabdulmohsin, Draugalis, & Hays, 1998; Hays & Morales, 2001; Hays & Shapiro, 1992; Ware Jr & Sherbourne, 1992). Participants were asked to endorse each statement: (a) "I seem to get sick a little easier than other people," (b) "I am as healthy as anybody I know (reversed)," (c) "I expect my health to get worse," and (d) "My health is excellent (reversed)." These items were anchored on a 5-point scale ranging from 0 (*definitely true*) to 4 (*definitely false*). Scores were summed with lower scores indicating poorer health.

Sick days. Single-item questions that assessed the number of (school/or work) days missed due to illness during (early childhood/within the past month) were asked in order to obtain a relative measure of overall subjective health. These 2 items used a 5-point scale ranging from 1 (*never*) to 5 (*very often*) with higher scores representing poorer health.

LH Strategy

Several scales were used to measure LH-related psychological and behavioral phenotypes. See Table 1 for details on descriptives and reliability values.

Depression and anxiety. The Depression, Anxiety, Stress Scale 21 (DASS 21) consists of 21 items used to assess the severity of depression, anxiety, and stress symptoms (Antony, Billing, Cox, Enns, & Swinson, 1998). However, because the stress component essentially provided "more cognitive [and] subjective measures of anxiety" rather than a measure of perceived stress, only the depression and anxiety portions were analyzed. The full scale was administered because all stress items overlapped with the other two components. Participants were asked to indicate how often they experienced each symptom (e.g., "I felt I was close to panic.") on a 4-point scale ranging from 0 (*never*) to 3 (*almost always*). Scores were summed and multiplied by two. Multiplying by a factor of two is necessary because the DASS 21 (containing 21 items) is the shorten form of the DASS 42 (containing 42 items). Higher scores indicate higher levels of depression and anxiety.

Perceived stress. The Short Form Perceived Stress Scale developed by Cohen, Kamarck, and Mermelstein (1983) and further validated by Warttig, Forshaw, South, and White (2013) measured the degree to which individuals appraised life events as stressful (i.e., unpredictable, uncontrollable, and overwhelmed) within the past month (e.g., "How often have you felt that you were unable to control the important things in your life?"). This scale consists of 4 items anchored on a 5-point scale ranging from 0 (*never*) to 4 (*very often*). Scores were summed with higher scores representing higher levels of perceived stress.

Paranoia. The Paranoia Checklist was used to assess paranoia levels (Freeman et al., 2005). Participants were asked to

Table 1. Descriptives Among Environmental Harshness, Health, and Life History Strategy Indicators.

	Study 1 (MTurk Mothers)			Study 2 (Undergraduates)		
Variable	*M*	*SD*	Cronbach's α	*M*	*SD*	Cronbach's α
1. Socioeconomic status composite	−.30	2.82	.73	.16	3.09	.78
2. Family neglect composite	−.31	1.39	.90	−.06	1.92	.94
3. Neighborhood crime composite	−.35	1.22	.91	−.06	1.70	.90
4. Childhood sickness	2.46	.84	—	2.22	.71	—
5. Adulthood sickness	1.62	.89	—	1.59	.81	—
6. Health attitude	10.60	3.91	.82	11.37	3.15	.73
7. Paranoia	30.42	14.17	.96	27.07	10.28	.94
8. Depression	16.45	16.55	.94	15.37	14.28	.91
9. Anxiety	17.18	17.26	.95	15.08	13.91	.92
10. Perceived stress	5.75	3.44	.76	5.74	3.01	.71
11. Short-term mating orientation	28.06	15.21	.94	30.49	16.83	.96
12. Long-term mating orientation	43.12	7.82	.92	45.08	6.05	.94
13. General trust	—	—	—	3.56	.62	.82

Note. $N_{\text{Study 1}} = 314$. $N_{\text{Study 2}} = 505$.

indicate how much they believed each statement (e.g., "I need to be on my guard against others."). This scale consists of 18 items on a 5-point scale ranging from 1 (*do not believe it*) to 5 (*absolutely believe it*). Scores were summed with higher scores indicating higher levels of paranoia.

Trust. Trust was assessed using two single-item questions, independent from each other (Nettle et al., 2014). Participants were asked to indicate: (a) "How much do you trust people you meet for the first time?" and (b) "How much do you trust people you know personally?" on a 5-point scale ranging from 1 (*never*) to 5 (*always*).

Mating strategies. The Multidimensional Sociosexual Orientation Inventory evaluated participants' preference toward casual sex anchored on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*; Jackson & Kirkpatrick, 2007). This scale consists of 21 items subdivided into preferences toward short-term mating orientation (e.g., "I can imagine myself enjoying a brief sexual encounter with someone I find very attractive.") and preferences toward long-term mating orientation (e.g., "I hope to have a romantic relationship that lasts the rest of my life."). Scores were aggregated with higher scores indicating a stronger preference for short-term mating and long-term mating, respectively.

Temporal discounting. Temporal discounting, also known as time preference, is a term used in economics to describe the relative value individuals place on present versus future rewards. Established items from Griskevicius et al. (2012) asked participants to choose between receiving a smaller hypothetical monetary reward sooner versus waiting to receive a larger amount later (e.g., "Do you want US$58 tomorrow or US$76 in 33 days?"). The argument is that those in adverse environments may favor receiving the immediate reward particularly when their future is uncertain. Five items were used and aggregated together with higher scores indicating higher temporal discounting or preference toward investing in the future.

Analytic Strategy

The data were evaluated to determine whether they met the distributional assumptions of maximum likelihood. Results indicated that all variables exhibited skewness and kurtosis levels within normal limits, with the exception of the neighborhood crime and mating strategy variables. Based on recommendations by Kline (2016), we used robust maximum likelihood, which does not assume normality, to estimate the models in Mplus 7.4 (Muthén & Muthén, 2015). Additionally, to account for missing data, a listwise deletion was performed because missingness was not extensive and utilizing this method allowed for composites to be created. Missing data for all subsequent studies were handled in the same manner. We used four fit indices to determine model fit: the comparative fit index (CFI), the Tucker–Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Adequate model fit was based on TLI and CFI values of .90 or greater (Bentler, 1992) and RMSEA and SRMR values lower than .10 (MacCallum, Browne, & Sugawara, 1996), whereas excellent fit was indicated by CFI and TLI values close to .95, RMSEA values close to .06, and SRMR values close to .08 (Hu & Bentler, 1999).

Because there has been debate about the best way to estimate LH strategies in the literature (e.g., Copping, Campbell, & Muncer, 2014; Figueredo et al., 2015), the measurement and structural portions of the model were estimated separately (Anderson & Gerbing, 1988; Kline, 2016). Initially, an exploratory SEM (as recommended by Hayduk & Glaser, 2000) was conducted to evaluate whether having two correlated latent variables measuring psychological and behavioral outcomes would provide an adequate fit to the data. The rationale for testing LH strategy as two latent factors were due to the psychological variables being consistent with Figueredo,

Table 2. Bivariate Correlations Among Environmental Harshness, Health, and LH Strategy Indicators in Study 1 (MTurk Mothers) and Study 2 (Undergraduates).

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Socioeconomic status composite	—	−.14*	.03	−.09	−.03	.04	−.07	−.08	−.15**	−.22**	.08	.06	—
2. Family neglect composite	−.39**	—	.48**	.36**	.37**	.06	.51**	.60**	.61**	.44**	.18**	−.31**	—
3. Neighborhood crime composite	−.25**	.48**	—	.29**	.32**	.10	.47**	.48**	.41**	.18**	.11	−.13*	—
4. Childhood sickness	.01	.09*	.03	—	.33**	.09	.27**	.39**	.38**	.29**	.11	−.24**	—
5. Adulthood sickness	−.07	.14**	.11*	.20**	—	−.03	.39**	.43**	.39**	.29**	.01	−.28**	—
6. Health attitude	.12**	−.22**	−.07	−.29**	−.46**	—	.08	.12*	.10	.01	.02	−.06	—
7. Paranoia	−.13**	.25**	.31**	−.01	.15**	−.15**	—	.67**	.63**	.41**	.16**	−.25**	—
8. Depression	−.14**	.27**	.23**	.09	.26**	−.32**	.46**	—	.95**	.62**	.18**	−.27**	—
9. Anxiety	−.18**	.28**	.22**	.07	.25**	−.32**	.45**	.94**	—	.68**	.21**	−.27**	—
10. Perceived stress	−.11*	.25**	.13**	.06	.16**	−.28**	.37**	.56**	.62**	—	.13*	−.20**	—
11. Short-term mating orientation	−.10*	.09	.04	.05	.00	−.04	.12**	.10*	.10*	.08	—	−.31**	—
12. Long-term mating orientation	.11*	−.12**	−.08	.02	−.01	−.05	−.15**	.04	.04	−.06	−.36**	—	—
13. General trust[a]	.17**	−.22**	−.23**	−.07	−.06	.17**	−.24**	−.22**	−.27**	−.20**	−.02	.08	—

Note. $N_{\text{Study 1}} = 314$. $N_{\text{Study 2}} = 505$. Above the diagonal is the bivariate correlation for Study 1. Below the diagonal is the bivariate correlation for Study 2. LH = life history.
[a]Variable included in Study 2.
*p < .05. **p < .01.

Vásquez, Brumbach, and Schneider's (2007) "covitality" LH strategy factor, which appeared to be separate from the behavioral measures of LH strategy. All items were free to load on both factors. If no support for the two latent variables is found, then we would proceed with a two-step approach in estimating the single, hybrid latent variable (Anderson & Gerbing, 1988). In this approach, the first step is to specify the measurement portion of the model, correlating all variables except for the indicators of the latent variables (Kline, 2016). If necessary, substantively justified modifications to the model can be made at this step (Jöreskog, 1993). Once a well-fitting measurement model has been established, the second step is to compare the measurement model to a structural model, where structural paths replace the correlations. If all paths are added, then the structural model will have the same degrees of freedom as the measurement model. This approach allows one to ensure that a model that does not reproduce the covariance matrix is not due to measurement concerns (Kline, 2016).

Results

Descriptive statistics and the bivariate correlation matix for all environmental harshness composites, health, and LH indicators are shown in Tables 1 and 2. The percentage of missingness for the variables ranged from 6.41% to 16.37%. An exploratory SEM revealed that the two-factor model provided an adequate fit, $\chi^2(46) = 170.68$, $p < .001$; CFI = .93, TLI = .89, RMSEA = .09. However, the two factors were correlated at −.91, and only three indicators significantly loaded on the latent variables (short-term mating strategies, long-term mating strategies, and trust—personal). Because there was no support for two latent LH strategy variables, we proceeded with a two-step approach instead. The initial model, examining LH strategy as a single latent factor, did not provide an adequate fit to the data, $\chi^2(83) = 401.11$, $p < .001$; CFI = .78, TLI = .72, RMSEA = .11, SRMR = .08. Evaluating the parameter estimates indicated that temporal discounting and the two trust variables did not load on the latent variable. These variables were therefore dropped iteratively. In addition, modification indices suggested estimating error covariances between the two mating orientation variables as well as depression and stress. After adding these parameters, the model provided a good fit to the data, $\chi^2(45) = 103.03$, $p < .001$; CFI = .95, TLI = .92, RMSEA = .06, SRMR = .05, with one index indicating adequate fit and the others indicating close fit. Parameter estimates indicated that all indicators loaded significantly on their respective latent variables (i.e., LH strategy and health), although there was wide variability in their magnitudes (see Table 3). Next, the correlations between latent LH strategy, health, and the predictors were reestimated as structural paths, with the model fitting the data well, $\chi^2(45) = 84.90$, $p < .001$; CFI =.96, TLI =.94, RMSEA =.05, SRMR = .04. As shown in Figure 1, the final path model displays the relationship between indicators of harsh environments and LH-related traits mediated through health in the MTurk sample of mothers. Path coefficients for direct, indirect, and total effects are listed in Table 4.

Figure 1 indicates that high neighborhood crime, but not high family neglect or low SES, had a significant direct effect on LH-related traits and an indirect effect on LH phenotypes through health. SES did significantly predict the health latent variable. Family neglect did not significantly predict either latent variable.

Discussion

Results revealed that exposure to high neighborhood crime had direct effects on latent LH strategy and indirect effects on latent LH strategy that were mediated via physical health status. Specifically, individuals exposed to harsh conditions displayed

Table 3. Parameter Estimates and Standard Errors for Latent Health and Latent LH Strategy in Study 1 (MTurk Mothers) and Study 2 (Undergraduates).

Latent Variable	Estimate		*SE*		*p* Value	
	Study 1	Study 2	Study 1	Study 2	Study 1	Study 2
Health						
Childhood sickness	.57	.34	.07	.05	.00	.00
Adulthood sickness	.51	.54	.07	.06	.00	.00
Health attitude	.15	−.86	.08	.07	.06	.00
LH strategy						
Paranoia	.62	.54	.05	.05	.00	.00
Depression	.95	.78	.01	.04	.00	.00
Anxiety	.99	.85	.01	.03	.00	.00
Perceived stress	.68	.71	.03	.03	.00	.00
Short-term orientation	.21	.13	.06	.05	.00	.01
Long-term orientation	−.28	−.04	.05	.05	.00	.51
General trust[a]	—	−.35	—	.05	—	.00

Note. $N_{Study\ 1} = 314$. $N_{Study\ 2} = 505$. Standardized parameter estimates shown. LH = life history. [a]Variable included in Study 2.

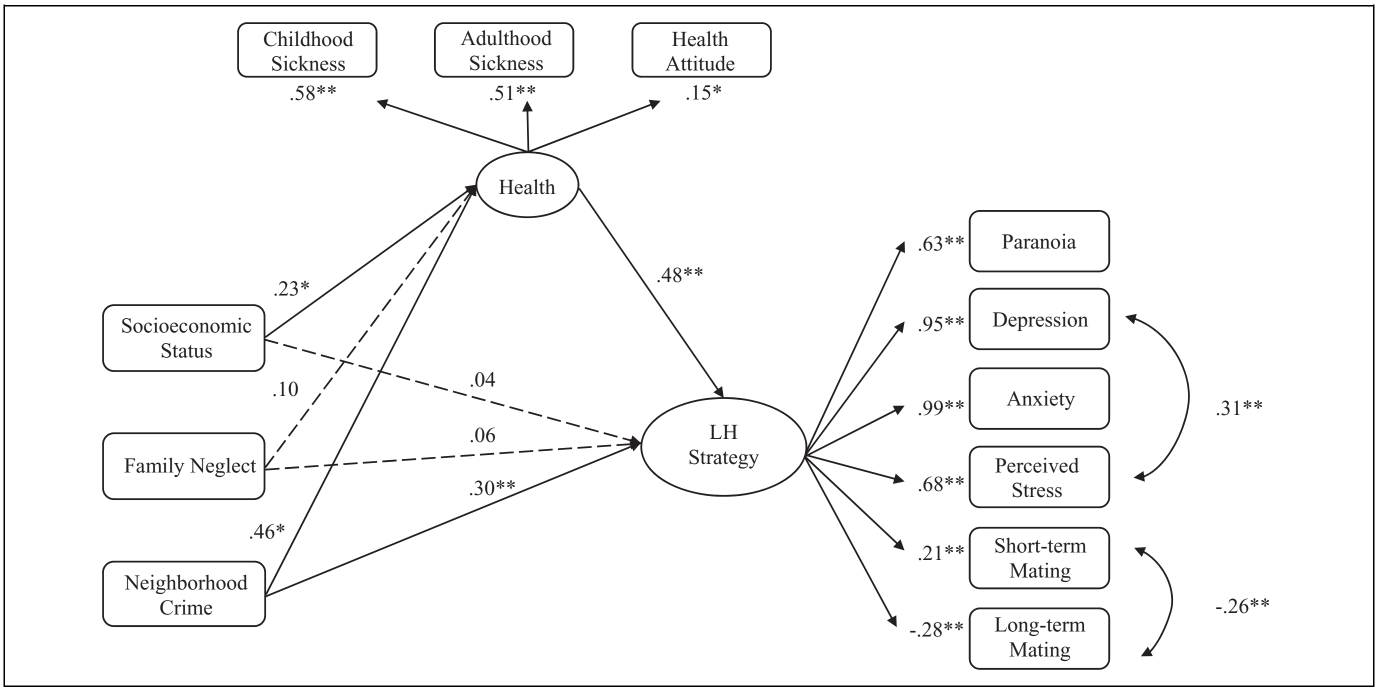

Figure 1. Path model illustrating direct effects of environmental harshness on life history strategy and indirect effects through health for Study 1 (MTurk mothers). Dashed lines represents no significance. Standardized path coefficients for direct paths are shown. Latent variables are represented in ovals, and the observed variables are represented in rectangles. $*p < .05$. $**p < .01$.

higher levels of paranoia, depression, anxiety, perceived stress, higher preference for casual sex, and lower preference for long-term relationships; all of which are in line with fast LH strategies. We thereby provide support for the internal and external PAR models and demonstrate that these findings are consistent with the previous literature stating that health may account for additional variance in the relationship between adverse environments and LH strategy (Brumbach et al., 2009; Figueredo et al., 2007; Nettle et al., 2013).

Results also revealed that health attitude was not correlated to the other health variables. The health attitude measure employs broad self-ratings of overall health relative to others—and it is therefore crucial for validity that individuals compare themselves to similar reference groups. Given that the MTurk mothers were from various demographic groups and geographic regions, they may have been comparing themselves to different groups of individuals. We still included this measure in Study 2 under the assumption that self-perceived health may be more valid among a relatively homogenous subject sample, wherein individuals are comparing themselves to a common reference class.

Table 4. Summary of Path Coefficients and Confidence Intervals for Direct, Indirect, and Total Path Effects for Study 1 (MTurk Mothers) and Study 2 (Undergraduates).

Structural Paths	Path Coefficients		Lower Confidence Interval		Upper Confidence Interval		*p* Value	
	Study 1	Study 2	Study 1	Study 2	Study 1	Study 2	Study 1	Study 2
Direct path								
Socioeconomic status → LH strategy	.04	−.07	−.10	−.18	.18	.03	.56	.17
Family neglect → LH strategy	.06	.16	−.05	.04	.17	.28	.29	.01
Neighborhood crime → LH strategy	.30	.15	.11	.04	.50	.27	.00	.01
Indirect path								
Socioeconomic status → health → LH strategy	.11	−.01	−.02	−.06	.23	.03	.09	.51
Family neglect → health → LH strategy	.05	.10	−.03	.04	.13	.16	.25	.00
Neighborhood crime → health → LH strategy	.22	−.01	.06	−.06	.38	.04	.01	.60
Total path								
Socioeconomic status → LH strategy	.15	−.09	.02	−.19	.28	.02	.02	.10
Family neglect → LH strategy	.11	.25	.00	.13	.22	.37	.05	.00
Neighborhood crime → LH strategy	.52	.14	.42	.01	.62	.27	.00	.03

Note. $N_{\text{Study 1}} = 314$ and $N_{\text{Study 2}} = 505$. Standardized path coefficients and confidence intervals are shown. Lower and upper bounds are at the 95% confidence interval. LH = life history.

While a single latent factor for LH strategy provided the best fit to the data (relative to the two-factor model), both trust variables and temporal discounting were removed from analyses because they failed to load significantly on latent LH strategy. The single-item trust variables may have been limited in their ability to accurately measure trust. Thus, we incorporated a validated trust scale in Study 2 as a means for providing a more psychometrically sound measure of this construct.

It remains unclear why temporal discounting did not share a common factor with the other LH indicators. While the literature suggests that individuals facing high risk of mortality may devaluate the future and focus on immediate rewards (Ellis et al., 2009), others have debated whether temporal discounting stands as a single or multidimensional construct encompassing impulsivity, compulsivity, and inhibition (Copping et al., 2013a; Frederick, Loewenstein, & O'Donoghue, 2002). Temporal discounting may be a more complicated construct than typically portrayed in the LH literature and requires further elucidation (a point to which we return below). Nevertheless, we included temporal discounting in Study 2 to examine whether results would differ in another sample.

Study 1 provides encouraging evidence supporting LH calibration to both internal and external PARs. However, this sample consisted only of mothers, and these findings therefore need to be replicated in another sample in order to establish their external validity. To this end, Study 2 was conducted to test whether the findings would replicate in a different sample containing both male and female subjects.

Study 2

Method

Participants

A test of whether Study 1 results would generalize beyond MTurk mothers was conducted in an undergraduate population. Participants were recruited from Oklahoma State University and received course credit upon completion. A total of 505 participants (33.9% males and 66.1% females) with ages ranging from 18 to 48 years ($M = 19.6$) participated in this study. It was comprised of Caucasian (78.2%), African American (5.9%), American Indian (5.0%), Hispanic (4.4%), and Other (3.4%).

Measures and Procedure

All materials and procedures for this study were approved by the institutional review board of Oklahoma State University. Participants completed an online survey using all of the measures from Study 1 with the addition of the General Trust Scale (Yamagishi & Yamagishi, 1994). The addition of this scale was added to provide a more optimal measure of trust (e.g., "Most people are trustworthy."). Participants were asked to endorse 6 items anchored on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Scores were summed with higher scores indicating higher levels of general trust. See Table 1 for details on descriptives and reliability values.

The Risky Families Questionnaire was not modified in either time point because most undergraduates were not married ($N = 494$). As a result, their level of family neglect was assessed through their immediate family network.

As in Study 1, early subjective and objective SES were highly correlated. Current subjective and objective SES were highly correlated as well. To address the multicollinearity, SES measures were standardized and summed together at each time point to form a composite of SES. A bivariate correlation revealed that early and current SES, early and current family neglect, and early and current neighborhood crime, respectively, were highly correlated. To resolve multicollinearity between these variables, time points within each indicator were standardized and aggregated to form a total of three independent proxies for harshness (i.e., SES, family neglect, and

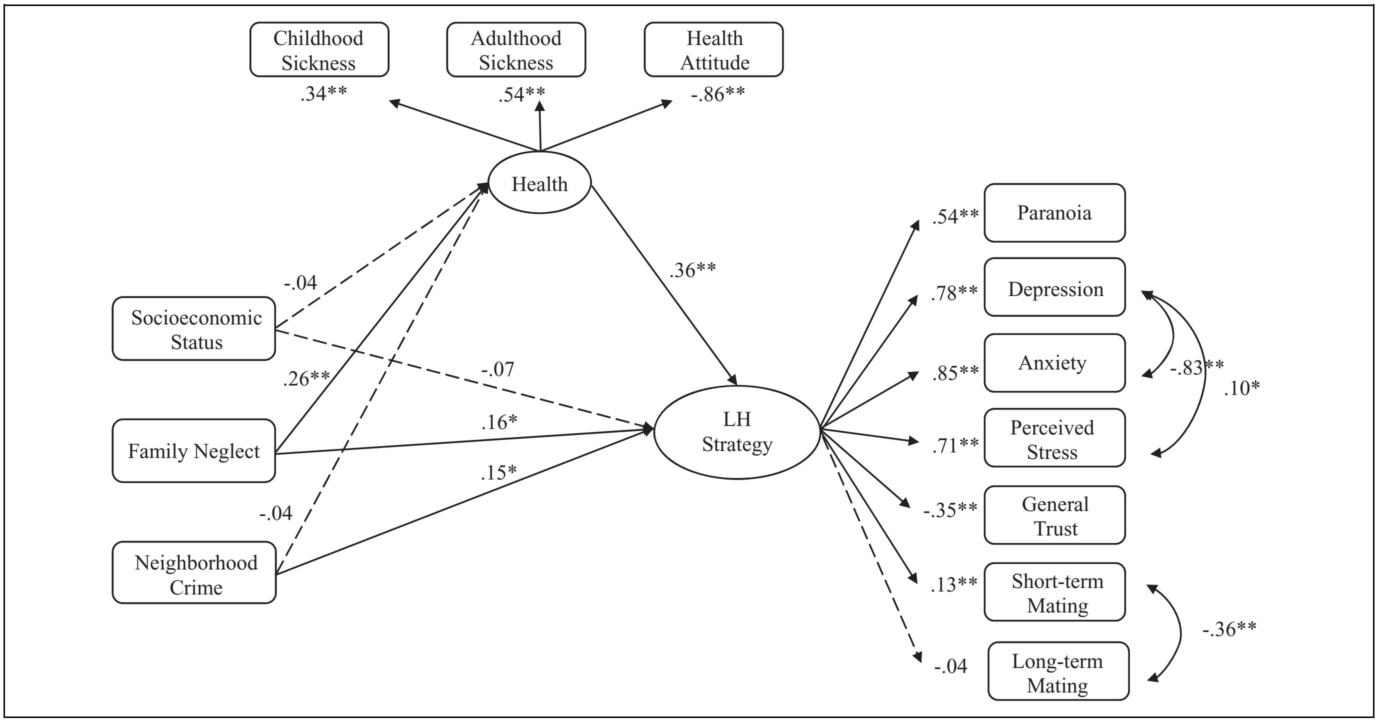

Figure 2. Path model illustrating direct effects of environmental harshness on life history strategy and indirect effects through health for Study 2 (undergraduates). Dashed lines represents no significance. Standardized path coefficients for direct paths are shown. Latent variables are represented in ovals, and the observed variables are represented in rectangles. *$p < .05$. **$p < .01$.

neighborhood crime). See Supplementary Tables S1 and S2 for descriptives, reliability values, and the full bivariate correlation matrix for these measures.

Analytic Strategy

Study 2 sought to confirm the structure found in Study 1. Thus, the analytic strategy was quite similar to Study 1. Missingness was handled through listwise deletion. Because an exploratory SEM failed to sufficiently fit the data in Study 1, we no longer implemented it for Study 2. Rather, we proceeded with the two-step approach. First, the measurement portion of the model was evaluated. Because modification indices were used in Study 1, the same modifications were added to the measurement model in Study 2. Additionally, the new trust measure was included as an indicator of LH strategies. After finding an accurate measurement model, the structural model was evaluated. Finally, models were estimated to evaluate whether the structural paths were invariant to sex.

Results

A bivariate correlation matrix between all environmental harshness composites, health, and LH strategy indicators with descriptive statistics are shown in Tables 1 and 2. The percentage of missingness for the variables ranged from 0.16% to 5.37%. SEM was used to test the direct effects of environmental harshness on LH traits and indirect effects through health. As in Study 1, latent variables were used to create LH personality variation and health outcomes.

The initial measurement model provided a good fit to the data, $\chi^2(56) = 134.05, p < .001$; CFI = .95, TLI = .94, RMSEA = .05, SRMR = .05, although the model had difficulty producing in-bound variance estimates for anxiety. Because of the high zero-order correlation between anxiety and depression in this sample, the model was reestimated with an error correlation between anxiety and depression. This model was a close fit to the data, $\chi^2(55) = 107.34, p < .001$; CFI = .97, TLI = .96, RMSEA = .04, SRMR = .04, and all parameters were in bounds. When the covariances between the variables were reestimated as structural paths, the model still provided a close fit to the data, $\chi^2(55) = 107.34, p < .001$; CFI = .97, TLI = .95, RMSEA = .04, SRMR = .04. All indicators significantly loaded on their respective latent variables, with the exception of long-term mating strategy, with most displaying moderate or high factor loadings (see Table 3).

As shown in Figure 2, both family neglect and high neighborhood crime had direct effects on LH-related traits. Family neglect also displayed indirect effects on LH-related traits through the health latent variable, although high neighborhood crime did not significantly predict health. Low SES failed to show any unique association with LH-related traits. Path coefficients for direct, indirect, and total effects are listed in Table 4.

Next, the model was tested for invariance between the sexes. This was accomplished by comparing a model in which the structural paths were free to vary across the sexes to a model, where the paths were constrained to be equal across the sexes. Results indicated that the unconstrained model did not significantly differ from the constrained model, $\chi^2(7) = 1.71$, $p = .97$. Thus, there was no evidence of sex differences on the structural portion of the model.

Discussion

Study 2 was conducted to determine whether the patterns exhibited among mothers were consistent across the sexes. Thus, a near direct replication of the survey was administered in a college sample allowing both sexes to complete the questionnaire. Analyses showed that exposure to high family neglect had direct effects on latent LH strategy as well as indirect effects on latent LH strategy through health status. Individuals exposed to harsh conditions displayed higher levels of paranoia, depression, anxiety, perceived stress, higher preference for casual sex, and lower levels of general trust. Sex differences were analyzed and demonstrated that patterns were measurement invariant across the sexes.

The same variables were included from Study 1, with the exception of the General Trust Scale. General trust loaded on the latent LH variable, unlike the single-item trust measures employed in Study 1. This likely reflects the greater reliability and validity of the General Trust Scale. As in Study 1, the single-item trust measures and temporal discounting did not load on latent LH strategy and was therefore dropped from the model. Overall, this sample showed similar conceptual patterns as the community sample of mothers, with a few explainable differences.

The first is that, among the environmental variables, only family neglect explained unique variance in health or latent LH strategy. Given the nature of the undergraduate sample, it is likely that these individuals had a restricted range of experiences with crime and disorder. If so, it makes sense that variation in family neglect would explain more unique variance in this sample. Additionally, preferences toward long-term mating did not significantly load on the overall latent variable of LH strategy. Long-term mating is weakly correlated with the other variables, but it is unclear why this was the case. One possibility is that the subject sample was homogeneous in the desire to (eventually) form long-term mateships. Or, perhaps the young adults composing the sample (mean age = 19.6 years) have not yet transitioned to an LH stage entailing long-term monogamous commitment—which could limit this variable's ability to indicate LH strategy among these individuals.

Despite these differences from Studies 1 and 2, they both converge on the same conclusion: aspects of environmental harshness have both direct and health-mediated effects on latent LH strategy. However, given that the samples for these studies were composed of self-selected subjects who exhibited fairly limited variability, it was of interest to establish the generalizability of these findings in a large, diverse, and representative sample. To this end, Study 3 employed a large archival data set to conceptually replicate patterns from the first two studies.

Study 3

Method

A conceptual replication was conducted using data from the European Values Study (EVS): Wave 2, 1990 (2015). Adhering to a set of stringent guidelines, this large-scale longitudinal study received considerable merit for its rigorous methodological standards. The EVS used a cross-sectional design repeated every 9 years to assess European beliefs from citizens all over Europe. However, we analyzed data only from Wave 2 because all relevant LH variables were not asked in the other waves.

Participants

Wave 2 consisted of a total of 26,631 participants, all recruited from various parts of the world ranging between 16 and 93 years old ($M = 43.7$ years) and consisting of 49.2% males and 50.8% females. The questionnaire was distributed via an in-person interview, translated into several languages (i.e., Spanish, German, French, etc.), and conducted in 25 European countries, the United States, and Canada for a total of 27 participating countries. The data are available for online download at the GESIS Data Archive.

Measures and Procedure

All materials and procedures for this study were approved by the European Values project's Council of Program Directors. Participants were recruited using either random sampling or quota sampling. All interviews were anonymously administered using two types of interviewing techniques computer-assisted personal interviewing (CAPI) or paper-and-pen interviewing (PAPI; see Caeyers, Chalmers, & De Weerdt, 2010). Before finalizing the questionnaires, they underwent a series of reviews and critique before approval. The translation process, data collection, and data processing followed strict guidelines and were monitored closely to ensure standardization across all countries. The relevant variables are listed below.

Environmental harshness. Environmental harshness was operationally defined by income level. Participants were asked, "Here is a scale of incomes and we would like to know in what group your household is, counting all wages, salaries, pensions and other incomes that come in . . . " with income level partitioned into 11 categories ranging from 1 (*first* step) to 11 (*highest step*). Other independent measures of environmental harshness were not used.

Health outcome. Self-reported health was assessed using a single question. Participants were asked, "All in all, how would you describe your state of health these days? Would you say it is . . . " on a 5-point scale ranging from 1 (*very good*) to 5 (*very poor*).

LH Strategy

Four items were used to measure LH strategy. Of the 4 items, 3 were similar constructs evaluated in the previous studies such as trust and depression. The remaining item assessing number of children, while not originally included in the previous studies, is central to the overall argument of offspring quantity versus offspring quality and thus, warrants inclusion in the overall model (Ellis et al., 2009).

Depression. A self-reported state of depression was assessed using a single-item. Participants responded to the question, "During the past few weeks, did you ever feel depressed or very unhappy," dichotomized 0 (*no*) or 1 (*yes*).

Trust. Trust was measured using two questions. Items were (a) "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?" dichotomized 1 (*can't be too careful*) or 2 (*most people can be trusted*) and (b) "Could you tell me how much you trust British people (Countries other than UK: Please substitute your nationality for 'British' people in general)?" on a 5-point scale ranging from 1 (*do not trust them at all*) to 5 (*trust them completely*).

Number of children. A single item assessing the number of children participants have was anchored on a 7-point scale ranging from 0 (*no child*) to 6 (*six children or more*). While debate around items focusing on biometric indicators—anthropometric measurements that "highlight fitness outcome (i.e., ends)" rather than "functional processes (i.e., means)"—exist, the inclusion of this item serves as a fundamental indicator of LH strategies. In addition, Figueredo and colleagues (2015) argue that including both types of indicators (i.e., ends and means) allow for a better overall understanding of LH strategy.

Analytic Strategy

Study 3 used a similar analytic strategy as in Studies 1 and 2 (i.e., two-step approach). However, there were no missing data, and the robust weighted least squares estimator was utilized in Mplus (Li, 2015; Muthén, du Toit, & Spisic, 1997). This estimator does not provide the SRMR, and the degrees of freedom and χ^2 represent adjusted values to ensure the p value is correct (Asparouhov & Muthén, 2010). After finding a measurement model with adequate fit, the structural model was evaluated. Finally, models were estimated to evaluate whether the structural paths were invariant to sex.

Results

Descriptive statistics and the bivariate correlation matix for all variables are shown in Table 5. The initial model did not fit the data well, $\chi^2(8) = 1{,}564.38$, $p < .001$; CFI = .78, TLI = .58, RMSEA = .09. Evaluation of modification indices suggested that the ill-fit was due to the measurement portion of the model. Therefore, theoretically justified error covariances were added (i.e., covariance between the two continuous indicators, covariance between the two trust variables), greatly improving model fit, $\chi^2(6) = 230.89$, $p < .001$; CFI = .97, TLI = .92, RMSEA = .04. All four indicators significantly loaded on latent LH strategy, although the factor loadings were small (see Table 6).

Table 5. Bivariate Correlations and Descriptives Among SES, Health, and LH Strategy Indicators for Study 3 (EVS).

Variable	1	2	3	4	5	6
1. SES	—					
2. Subjective health	−.27**	—				
3. Number of children	−.05**	.13**	—			
4. Trust people	.15**	−.17**	.01	—		
5. Trust country	.03**	−.05**	.08**	.21**	—	
6. Depression	−.10**	.22**	.02*	−.08**	−.05**	—
M	5.00	2.28	1.72	1.37	3.74	.20
SD	2.41	.95	1.43	.48	.92	.40

Note. $N = 26{,}631$. LH = life history; SES = socioeconomic status; EVS = European Values Study.
*$p < .05$ **$p < .01$.

Table 6. Parameter Estimates and Standard Errors for Latent LH Strategy for Study 3 (European Values Study).

Latent Variable	Estimate	*SE*	*p* Value
LH strategy			
Number of children	−.13	.01	.00
Trust people	.32	.01	.00
Trust country	.07	.01	.00
Depression	−.37	.02	.00

Note. $N = 26{,}631$. Standardized parameter estimates shown. LH = life history.

Figure 3 represents the final model with the structual paths estimated. Again, the model adequately fit the data, $\chi^2(6) = 223.04$, $p < .001$; CFI =.97, TLI =.92, RMSEA =.04. SES had a significant direct and indirect effect on LH-related traits through health (Table 7). Invariance of the structural paths was tested between sex, with results indicating that the constrained and unconstrained models were significantly different from each other, $\chi^2(3) = 18.50$, $p < .001$. Post hoc analyses indicated that all three paths were significantly different between men and women. The positive association of SES and LH-related traits was stronger among men ($\beta = .31$) than women ($\beta = .24$), $p = .005$. For health predicting LH traits, the effect was stronger among men ($\beta = -.74$) compared to women ($\beta = -.69$). Finally, for the path from SES to health, the β was marginally stronger among men ($\beta = -.26$) compared to women ($\beta = -.26$).

Discussion

Study 3 conceptually replicated the findings from the first two studies in a large archival data set that contained variations of

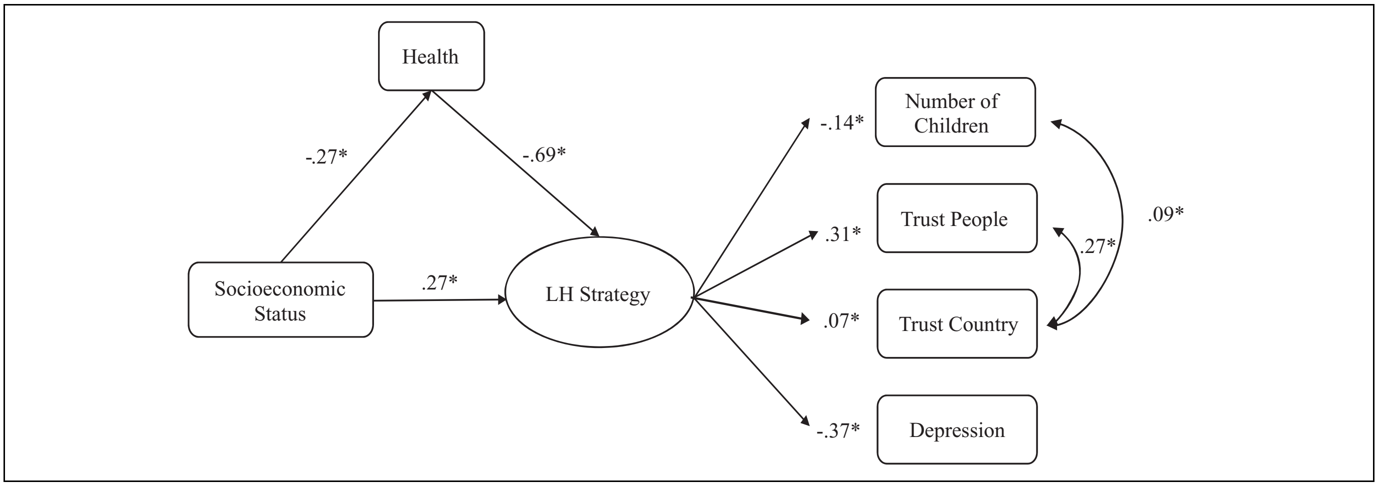

Figure 3. Path model illustrating direct effects of environmental harshness on life history strategy and indirect effects through health for Study 3 (European Values Study). Standardized path coefficients for direct paths are shown. Latent variables are represented in ovals, and the observed variables are represented in rectangles.*p < .001.

Table 7. Summary of Path Coefficients and Confidence Intervals for Direct, Indirect, and Total Effects for Study 3 (European Values Study).

Structural Paths	Path Coefficients	Lower Confidence Interval	Upper Confidence Interval	*p* Value
Direct path				
Socioeconomic status → LH strategy	.27	.24	.31	.00
Indirect path				
Socioeconomic status → health → LH strategy	.19	.17	.20	.00
Total path				
Socioeconomic status → LH strategy	.46	.42	.50	.00

Note. $N = 26{,}631$. Standardized path coefficients and confidence intervals are shown. Lower and upper bounds are at the 95% confidence interval. LH = life history.

the focal theoretical constructs. In this study, SES (the sole indicator of ecological harshness) had a direct effect on latent LH strategy as well as an indirect effect on latent LH strategy that was mediated via subjective health status. Although there were technically sex differences in the exact magnitudes of these paths, this difference may not be meaningful and the statistical significance likely reflects our use of an extremely large sample. Whether these differences are replicable or of theoretical importance are questions for future research.

General Discussion

Three studies were conducted to provide an empirical test of Nettle et al.'s (2013) conceptual distinction between internal and external PARs and to determine whether their hypotheses could be extended to other LH-related facets. In all of the studies, the overall model suggested that exposure to harsh ecologies had a direct association with fast LH-related traits, with individuals exhibiting greater risk proneness and sensitization to potential social threats. This association was statistically mediated by overall health status, lending support to the internal PAR hypothesis. However, exposure to harsh environments also had a direct effect on LH-related traits that was independent of overall health status—which lends support to the external PAR hypothesis. At a broad conceptual level, the patterns of association were remarkably consistent across our three studies wherein exposure to harsh ecologies may have both direct- and health-mediated calibrational effects on variation in LH strategy. We discuss a few notable differences.

The current research assessed multiple components of recalled environmental harshness: family neglect, neighborhood crime, and SES in Studies 1 and 2. In general, all of these components of harshness exhibited the predicted patterns of zero-order correlation with measures of health status and LH-related psychological phenotypes. When these three variables competed to explain variance in health status and latent LH strategy, neighborhood crime in Study 1 and family neglect in Study 2 were the most influential predictors. Within these path models, SES did not show any direct or indirect effects on LH-related traits despite a number of past studies linking SES with various behavioral, health, and psychosocial outcomes (Griskevicius, Delton, et al., 2011; Hampson et al., 2016; McCullough et al., 2013; Simpson et al., 2012). A plausible explanation is that the unique variance that would have otherwise been explained by SES is subsumed by family neglect and neighborhood crime such that these poorer areas harbor more criminal activity and family dissonance (Copping, Campbell, & Muncer, 2013b; Simpson et al., 2012). On the other hand, SES was the only predictor in Study 3 and behaved as predicted. It will be important for future research to include multiple measures of environmental harshness. Discriminating between the factors that make up the construct is informative and relying on SES may be insufficient.

Temporal discounting surprisingly failed to significantly load on latent LH strategy in both Studies 1 and 2. One possibility is that the decision to prioritize smaller immediate rewards over larger delayed rewards sometimes subserves future-oriented goals (e.g., using money to invest in courtship effort for romantic relationship initiation). Without specific information about the intended use of these monetary rewards, financial temporal discounting measures may not precisely reflect a fast/slow LH strategy. Another possibility is that the developmental environment is most influential in regulating within-person shifts in temporal discounting in response to changing situations, such as the appearance of acute mortality threats (Griskevicius, Delton, et al., 2011; Griskevicius, Tybur, et al., 2011). These possibilities are not mutually exclusive. Mishra, Barclay, and Sparks (2016) have recently drawn a crucial distinction between need-based risk-taking (e.g., based on having low resource access) and ability-based risk-taking (e.g., condition dependent). If both of these forms of risk-taking show up in decisions on the future discounting task across individuals, this would be expected to water down the association of this measure with LH strategy. Future research will be required to disentangle these complexities.

There has been recent debate surrounding whether a unidimensional or multidimensional approach to LH strategy is appropriate (Copping et al., 2014; Dishion, Ha, & Véronneau, 2012; Dunkel, Mathes, & Harbke, 2011; Figueredo et al., 2014, 2015). To address these issues, we attempted to fit our data using both approaches. Because many of the highest loading indicators on latent LH strategy appeared to be consistent within the context of Figueredo et al.'s (2007) proposed covitality LH strategy factor (e.g., anxiety, paranoia), we tried a two-factor model with the capacity to separate covitality from other LH indicators. However, the two factors were highly correlated with only a few of the items significantly loading on either factor. Based on both fit to the data and parsimony, it was appropriate to settle on a single factor of LH strategy (Figueredo et al., 2014, 2015). While several error covariances were added to improve model fit, they generally replicated from Study 1 to Study 2. Error covariances added in Study 3 seemed to be due to method effects (i.e., dichotomous vs. continuous variables).

There has also been some debate about whether aspects of psychological functioning (e.g., paranoia) are appropriate indicators of LH strategy. For example, Copping, Campbell, and Muncer (2014) argue that objective measures of LH outcomes (e.g., offspring number, age of pubertal onset), as opposed to psychological indicators, are more optimal for measuring LH strategy. However, others have argued that focusing solely on the behavioral and more objectively quantifiable traits loses invaluable information about the individual as a strategic agent and renders cognition irrelevant to the LH trajectories (Figueredo et al., 2015). Based on the current state of the literature, it seems reasonable to posit that the portion of the variance in psychological indicators that is shared with more direct measures—such as that captured in our latent LH factor—does indeed validly tap components of LH strategy. Future research should include additional indicators of LH strategy to elaborate on these findings. We expect that the debate regarding how to best conceptualize and operationalize human LH strategy will continue, and we hope our findings (as well as other contributions to this special issue) contribute to the discussion.

While the study lends empirical support to the existence of both internal and external PARs in relation to LH strategy, it is not without its limitations. All of the studies used self-reported health measurements. Future studies can work to obtain not only self-reported health but also acquire physiological health indicators or clinical assessments to assay health more directly. Such measurements could include cortisol patterns to assess chronic stress (Kirschbaum & Hellhammer, 1994), immune functioning to assess overall health (Hill et al., 2016; Nettle, 2014), dietary biomarkers to assess risk factors for heart disease (Fung et al., 2001), and telomere length as a marker for somatic health (Rickard et al., 2014). The inclusion of these more objective health measures would permit a more compelling replication of the current findings and also shed light upon the specific components of somatic state that are most influential in LH calibration. Likewise, we measured exposure to environmental harshness exclusively via retrospective self-report measures. Although daunting, it will be important for future research to develop more objective ways to operationalize harshness (and to distinguish it from other relevant ecological dimensions such as unpredictability). Finally, the correlational designs employed in the current research inherently limits our ability to draw strong inferences about the directionality of causal pathways that underpin the observed associations. Although experimental manipulation of developmental exposure to harsh ecologies is not possible, perhaps longitudinal studies can help disentangle the nature and direction of these (potentially reciprocal) causal pathways.

In conclusion, the present studies were among the first, to our knowledge, to provide empirical evidence supporting Nettle and colleagues' (2013) quantitative model of LH calibration via somatic state (i.e., health) and to test its applicability to a wide range of traits beyond reproductive timing (see also Hill et al., 2016). Results were consistent with external and internal PAR mechanisms operating in parallel, which provide a basis for future research on the specific developmental mechanisms involved in calibrating individual differences in human LH strategies.

Declaration of Conflicting Interests

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Supplemental Material

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