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Environmental Harshness and Unpredictability, Life History, and
Social and Academic Behavior of Adolescents in Nine Countries

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Abstract

Safety is essential for life. To survive, humans and other animals have developed sets of psychological and physiological adaptations known as life history (LH) tradeoff strategies in response to various safety constraints. Evolutionarily selected LH strategies in turn regulate development and behavior to optimize survival under prevailing safety conditions. The present study tested LH hypotheses concerning safety based on a 6-year longitudinal sample of 1245 adolescents and their parents from 9 countries. The results revealed that, invariant across countries, environmental harshness and unpredictability (lack of safety) was negatively associated with slow LH behavioral profile, measured 2 years later, and slow LH behavioral profile was negatively and positively associated with externalizing behavior and academic performance, respectively, as measured an additional 2 years later. These results support the evolutionary conception that human development responds to environmental safety cues through LH regulation of social and learning behaviors.

Keywords: fast and slow life history strategy; environmental harshness; unpredictability; externalizing; academic performance; child and adolescent development

Introduction

One underreported aspect of John Bowlby's attachment theory is his insistent emphasis on predation as a major extrinsic risk in shaping human and other primates' psychological systems (Bowlby, 1972). Other extrinsic risks during evolution include epidemic disease, intraspecific violence, and natural disasters, all of which lead to morbidity and mortality regardless of individuals' survival efforts. These extrinsic threats occurring especially in childhood living environments engender the coordinated tuning of psychological and physiological responses known as fast and slow life history (LH) strategies, which regulate human development and behavior (Chang & Lu, 2017; Del Giudice et al., 2015; Ellis et al., 2009; Stearns, 1992). When extrinsic risks are prevalent, organisms respond by adopting fast LH strategies involving accelerated growth and reproduction before the occurrence of disability and mortality. Accordingly, human cognition and behavior tend to be more present- than future-oriented, more self- than other-serving, and more antagonistic than mutualistic (de Baca et al., 2016; Figueredo & Jacobs, 2010; Zhu, Hawk, & Chang, 2018) as extrinsic risk and unpredictability orient behavioral goals toward immediate survival and away from future planning and long-term conspecific coexistence. Therefore, children who adopt fast LH strategies tend to exhibit externalizing behavioral problems (Del Giudice, Gangestad, & Kaplan, 2015) and academic underperformance (Obradović et al., 2009). A lack of extrinsic risk yields a more predictable living environment, where organisms tend to adopt slow LH strategies involving delayed reproduction and prolonged development. Human cognitive schemata are oriented toward the future, and because of group living, such schemata are more socially affiliative and other centered, supporting long-term coexistence and cooperation with conspecifics (Zhu et al., 2018). Children maturing in safe, predictable environments and following slow LH development are likely to be affiliative, prosocial, and academic achievers (Chang & Lu, 2018). In contrast to socialization theories, the LH account

of behavior constitutes a pancultural process that varies only normatively across cultures as functions of local environmental risks. Existing evolutionary research has primarily relied on single culture samples not best equipped for testing hypotheses about universal evolutionary processes. The present study employed a longitudinal cross-cultural sample from 9 countries to more adequately investigate the pancultural LH developmental process. We tested hypotheses regarding the contingent associations among childhood environments, LH profiles observed in late childhood, and social and academic behavior in early adolescence from 9 countries.

Evolutionary Coupling of LH Strategies and Environmental Conditions

LH is most accurately defined as the process of animals capturing energy from their environments and using it to produce offspring (Ellison, 2017). Some of this energy must be employed for physical growth and development, body repair and maintenance, and learning and socialization, and some must be used for mating and reproduction and raising offspring. Food and safety are essential for this LH process (Chang & Lu, 2017, 2018). However, their acquisition is constrained by varying levels and fluctuations of resources and shifting rates and stochastic variations of extrinsic risks (Ellis et al., 2009). Because such environmental constraints hinder the energy-capturing process, ultimately affecting mortality and life expectancy, amounts of acquired energy are seldom sufficient to meet all aspects of an organism's energy consumption needs. Therefore, tradeoffs are made, mainly between growth and development on one side and mating and reproduction on the other. Calibrated in terms of reproductive success as the ultimate fitness, such tradeoffs can be summarized as that between current or early reproduction and future or delayed reproduction. Early reproduction denotes quicker development, a longer mating tenure, and greater mating effort relative to the organism's life span, resulting in numerous offspring provided with little parental investment. By contrast, delayed reproduction is associated with slower

development, which involves the accumulation of resources, knowledge, and skills that can be subsequently converted into energy-capturing abilities and parental investment for raising few high-quality offspring (Ellis et al., 2009; Stearns et al., 2008).

Specific tradeoffs that form LH strategies adhering to fast–slow and early–late reproductive schedules (Promislow & Harvey, 1990) respond to and are shaped by environmental constraints. One of two overarching environmental constraints is resource limitation or food shortage, which, combined with high competition and low levels of extrinsic risk, drives slow LH strategies (Chang & Lu, 2017; Ellis et al., 2009; MacArthur & Wilson, 1967). However, in human LH studies, resource limitation is not a salient variable because modern day living limits sufficient variation in food supplies, especially at the survival threshold level, where the evolutionary effect is rendered salient (Chang & Lu, 2018). Moreover, resources and resource limitation are not routinely considered in human LH studies because the other environmental constraint—safety in the form of extrinsic risks—is more relevant, especially in shaping human LH strategies (Ellis et al., 2009). For similar reasons, Bowlby centered his attachment theory on perceived security and safety (Bowlby, 1972).

Safety constraints are therefore the main driver of human LH. When extrinsic threats to safety affect the adult population directly or the child population through ineffective parental intervention (Ellis et al., 2009), individuals who grow fast and mature early are more likely than slow growers to escape disability and mortality post-reproductively, and individuals who produce more offspring to unconsciously outnumber juvenile mortality (known as “diversified bet-hedging”; Einum & Fleming, 2004) exhibit improved fitness relative to those who devote heavier parental investment that is rendered ineffective in preventing juvenile mortality. Known as fast LH strategy, these coordinated psychological

and physiological response systems are naturally selected through surviving individuals and continue to respond to the environment and regulate human behavior.

Slow LH strategy prevails when the level or fluctuation of extrinsic risk is low, thereby rendering a habitat more predictable for its inhabitants, and also when resources are limited or competition is intense (Ellis et al., 2009). In such an environment, slow LH strategists who invest more time and energy in development to amass somatic buildup, knowledge, and skills outcompete and outlive fast LH strategists who allocate energy to mating over learning and development or nurturing and training the next generation. The subsequent generation maintains the same fitness differences, with parentally underinvested fast LH offspring being out-selected by slow LH counterparts, who, as children, are well nurtured and taught the skills required to compete for resources. Over generations, nature, which in this case refers to more predictable environments, selects the set of behavioral and physiological response systems known as the slow LH strategy.

Proxies of Environmental Harshness and Unpredictability

The contingent coupling of environmental conditions with fast–slow LH tradeoff strategies that has been selected throughout human evolution continues to respond to current environments (Pepper & Nettle, 2017) and regulate human behavior and development (Del Giudice & Belsky, 2011). An individual’s early childhood environment is especially salient in effecting fast–slow LH strategies (Belsky, Steinberg, & Draper, 1991). Childhood environmental harshness and unpredictability have been represented by microenvironmental proxies such as low familial socioeconomic status (SES) (Belsky, Schlomer, & Ellis, 2012), which in many urban areas is associated with drugs, crime, and dangerous neighborhoods (Chang & Lu, 2018); employment and residential changes (Doom et al., 2016; Zuo, Huang, Cai, & Wang, 2018) or familial mobility (Nettle, Coall, & Dickins, 2011); homelessness (Masten et al., 2014); shorter life expectancy of the local population (Low, Hazel, Parker, &

Welch, 2008); exposure to violence and crime (Brumbach, Figueredo, & Ellis, 2009) as well as rundown neighborhood conditions, including vandalism and the presence of drug addicts or gangs (Upchurch et al., 1999); familial turmoil (Chang & Lu, 2018); harsh parenting (Mell et al., 2018); and parental absence (Belsky et al., 1991). These indicators of early environmental risks have been associated with such fast LH characteristics as early menarche (Belsky et al., 1991); early commencement (Simpson et al., 2012) and high frequency (Baumer & South, 2001) of sexual activity; social deviance and substance use (Brumbach et al., 2009); aggression and externalizing behaviors (Doom et al., 2016; Simpson et al., 2012; Zuo et al., 2018) and other problematic behaviors (Figueredo et al., 2006) and academic underperformance (Obradovic et al., 2009). However, there is also overlapping between fast and slow LH especially in internalizing behavioral manifestations (Del Giudice, 2014, 2018). Child development studies conducted outside the LH framework have supported the same association between indicators of harsh and unpredictable environmental LH-prescribed childhood behaviors. For example, harsh parenting (Lansford et al., 2014), stressful childhood life events (Mesman & Koot, 2001), and low familial SES (Arnold, 1997) have consistently predicted externalizing behaviors and academic underperformance (Gershoff, 2002; Hinshaw, 1992).

Social Behavioral Implementation of LH Strategies

In response to varying extents of mortality risk and in agreement with slow–fast LH strategies, child social behaviors can be classified into two distinct types—affiliative, mutualistic, and more other-centered, and aggressive, antagonistic, and more self-centered, although there is also overlap between the two especially in controlling resources (Hawley, 2003). When extrinsic mortality risk is low, thereby affording predictability and controllability of the future, human social behavior orients toward coexistence, cooperation, and orderly competition to maximize collective resource exploration and acquisition (Zhu et

al., 2018). Such slow LH sociability promotes large and growing social groups in the form of institutions, nations, and societies. Children raised in predictable environments are expected to follow the same slow LH strategy by being sociable and ready to subscribe to group-oriented and other-centered prosocial, mutualistic, and altruistic socialization, although affiliative strategists may also exploit social relationships through deceptive tactics such as free riding (Price, Cosmides, & Tooby, 2002). By contrast, high extrinsic mortality risk beyond human control raises concerns over immediate survival. Under such harsh and unpredictable conditions, humans and other animals pursuing fast LH are likely to adopt opportunistic and antagonistic social behaviors to attend to their immediate survival needs, exhibiting reduced concern for future conspecific coexistence. Disregard for social propriety, crime, and violence — all of which exacerbate environmental unpredictability and perpetuate the cycle of fast LH driving antisocial behavior—are likely to follow. Therefore, early experience of harshness and unpredictability (e.g., familial turmoil, accidents, or parental divorce) or morbidity–mortality threats (e.g., injuries or death) can lead to social deviance during adolescence and young adulthood (Belsky et al., 2012; Brumbach et al., 2009). Similarly, experimentally induced environmental unpredictability elicits present orientation, self-centeredness, and antagonism toward conspecifics (Griskevicius et al., 2011; White et al., 2012; Zuo et al., 2018).

Fast LH driving antagonistic behavior is widely observed in other animals. In harsh and unpredictable environments generated by predation or variations in food supplies, animals are bolder toward heterospecifics and more aggressive toward conspecifics (Réale et al., 2000; Wolf et al., 2007). Boldness and aggression are positively correlated with fast LH characteristics such as faster growth and earlier reproduction, and the correlation is stronger among populations facing many predators than in those with little history of predation (Biro & Stamps, 2008). Populations of the Atlantic silverside living at high latitude (Nova Scotia,

Canada) with more predatory risks and thus following faster LH (e.g., a fast growth rate) were bolder, more aggressive, and more willing to feed in the presence of predators than were those living at low latitude (South Carolina, USA; Billerbeck et al., 2001; Lankford et al., 2001). Similarly, desert spiders exhibited varying degrees of aggressiveness depending on their habitat; in arid habitats characterized by harshness and unpredictability in terms of food supply, spiders were bold and aggressive toward predators and prey, whereas those in riparian habitats were nonaggressive (Riechert & Hall, 2000). Finally, bonnet macaque mothers randomly assigned to unpredictable food conditions engaged in less affiliative mutual grooming and were more aggressive toward other adults than were mothers randomly assigned to predictable foraging conditions (Rosenblum & Andrews, 1994; Rosenblum & Pully, 1984). In addition, mothers assigned to unpredictable conditions were less sensitive and less responsive to their offspring (Rosenblum & Andrews, 1994; Rosenblum & Pully, 1984).

Foraging and Learning in Implementing LH Strategies

Adoption of aggressive or affiliative behaviors is also related to learning styles, which are represented by searching and exploratory behavior in the animal world. Even though this relationship attenuates when averaged across species (Dougherty & Guillette, 2018), species specific findings and trends remain robust. Animals routinely learn where to find food and shelter and how to avoid predators by exploring their environments and by memorization (Reader, 2015). Such exploration can be directed by trial and error (individual learning) or copying conspecifics (social learning) (Chang, Mak, Li, Wu, Lu, & Chen, 2011; Marchetti & Drent, 2000) and can be conducted thoroughly or superficially (Wolf et al., 2007). The coevolution of boldness and aggression as social behaviors and superficial exploration as a learning style has been observed in several animal species including fish (e.g., Bell & Sih, 2007), birds (e.g., Both et al., 2005), and mammals (e.g., Careau et al., 2009). Similar to

boldness and aggression, superficial exploration has been associated with fast LH characteristics such as high growth rate, early initial reproduction, and high mating and low parental investment (Biro et al., 2014; Both et al., 2005; Careau et al., 2009). Superficial explorers search habitats with high predation risk and, consequently, more abundant food sources (Both et al., 2005). Such explorers go to the edges of habitats and often lead a moving group (Beauchamp, 2000). By contrast, thorough explorers exhibit more socially affiliative behavior by collectively foraging in a safer habitat (Kurvers et al., 2010). Among wild and captive great tits, which have been extensively studied, superficial explorers are bolder, faster, and readier to reach new environments and approach unfamiliar objects, and thus appear to be proficient individual learners. However, because their superficial exploration consists mainly of darting from location to location without paying attention to details, they do not acquire new information easily (Verbeek et al., 1994; Merchetti & Drent, 2000). Among captive great tits, superficial learners also show less flexibility in terms of changing food-searching pattern once they have formed one (Verbeek et al., 1994). By contrast, thorough explorers are more exploratory, taking longer to cover a habitat, and spending more time searching each location thoroughly (Merchetti & Drent, 2000). Furthermore, they do not follow a fixed routine and are readier to notice and explore new information (Merchetti & Drent, 2000). These characteristics render slow-LH thorough explorers more successful individual learners than fast-LH superficial explorers. Moreover, thorough explorers are primarily social learners (Reader, 2015) who recognize and utilize the feeding behaviors of conspecifics as a source of information (Merchetti & Drent, 2000).

Other research has shown the linkage between optimal foraging behavior, known as area-restricted search (ARS, Hills, 2006), and goal-directed learning, also referred to as cognitive as compared to physical search (Hills, 2006). Molecular functions involving dopamine and glutamine that initially evolved to modulate ARS were co-opted over evolution

to control goal-directed learning (Hills, 2006). In all eumetazoan clades but especially in vertebrates ranging from fish to mammals, neuroanatomical features in the basal ganglia involved in the control of movement and the involvement of glutamate and dopamine remain unchanged (Salas et al., 2003), supporting a long-standing evolutionary relation between foraging and learning (Hills, 2006). Molecular evidence from prefrontal cortex and the striatum suggests that dopamine modulating goal-directed learning operates much like dopamine increasing spatial focus in ARS (Hills, Brockie, & Maricq, 2004). Specifically, an accelerating-and-decelerating firing pattern of striatal projection neurons in the basal ganglia corresponds to the exploratory and exploitive (evaluative) foraging behavior in completing reinforcement or goal-directed learning (Sheth, Abuelem, Gale, & Eskandar, 2011) with dopaminergic neurons in the midbrain involved in the evaluative phase of the process (Schultz, Tremblay, & Hollerman, 2003). “What was once foraging in a physical space for tangible resources became, over evolutionary time, foraging in cognitive space for information related to those resources” (Hills, 2006, p.4).

Although few studies have approached student learning from an LH foraging perspective, findings from other literature seem to corroborate similar LH predictions related to human learning. For example, several reviews and meta-analyses have identified factors affecting children’s academic performance, including deficits in attention (Jacob & Parkinson, 2015), self-regulated learning and mastery of learning goals (Mega, Ronconi, & De Beni, 2014), and intrinsic motivation and effort (Cerasoli, Nicklin, & Ford, 2014), as well as being distracted by Internet use (Anderson, Steen, & Stavropoulos, 2017). Such learning-impeding factors all seem to portray superficial exploration that is uninterested in, distracted from, or incapable of attending to details. Other studies have highlighted contextual factors such as familial poverty (Hair et al., 2015), low familial SES (Arnold, 1997), residential mobility (Anderson & Leventhal, 2017), homelessness (Masten et al., 2014), parental death

(Berg, Rostila, Saarela, & Hjern, 2014), familial instability (Hampden-Thompson & Galindo, 2015), and antisocial classroom norms (Chang, 2004) in affecting children's academic performance. These factors represent various proxies of environmental harshness and unpredictability that, consistent with the LH prediction, lead to cascade effects of fast LH, antisocial behavior, and superficial or ineffective learning. Finally, non-LH studies have consistently demonstrated comorbidity between externalizing behaviors and academic underperformance among school children (Gershoff, 2002; Hinshaw, 1992), rendering support for a similar coevolution and co-development between antagonistic sociality and superficial learning (Wolf et al., 2007).

Present Study

This study tested LH hypotheses (Figure 1) involving adolescents' externalizing behavior and academic performance as implementations of LH strategies in response to childhood harshness and unpredictability. This evolutionary model was tested on a longitudinal and cross-cultural sample consisting of 1245 children and their parents from 9 countries. Structural invariance across countries was conducted to test this pancultural evolutionary model. Obtained from multiple informants at Time 1 in 2011 when the children were 10 years old on average, childhood harshness and unpredictability was indicated by four proxies, namely unsafe neighborhood, negative life events, family chaos, and family income change. In the direction of slow LH, LH profile was measured based on the children's self-reports at Time 2, when the children were about 13 years old. Externalizing behavior and academic performance were measured based on the parents' and children's reporting at Time 3, by which time the children were 15-year-old adolescents.

Method

Participants

The sample consisted of 1,245 children (51% girls), their mothers ($n = 1,169$), and their fathers ($n = 962$). Most parents (78%) were married. Nearly all were biological parents, with 4% being grandparents, stepparents, or other adult caregivers. In 2011 at the end of Time 1 of the present study, the children were 10 years of age on average ($M = 10.40$ years, $SD = .74$). They were close to 13 ($M = 12.90$ years, $SD = .84$) and 15 years old ($M = 14.60$ years, $SD = .80$) in 2014 and 2016 at the end of Time 2 and 3 of the present study, respectively. Families were drawn from 10 cities of nine countries: Shanghai, China ($n = 103$), Medellín, Colombia ($n = 101$), Naples, Italy ($n = 99$), Rome, Italy ($n = 106$), Zarqa, Jordan ($n = 113$), Kisumu, Kenya ($n = 99$), Manila, Philippines ($n = 107$), Trollhättan/Vänersborg, Sweden ($n = 123$), Chiang Mai, Thailand ($n = 110$), and Durham, North Carolina, United States ($n = 101$ European Americans, $n = 96$ African Americans, $n = 87$ Latin Americans). These are all considered medium to large cities in their respective countries. This sample of countries was diverse on several socio-demographic dimensions, including predominant race/ethnicity, predominant religion, economic indicators, and indices of child well-being. For example, on the Human Development Index, a composite indicator of a country's status with respect to health, education, and income, participating countries ranked from 8 to 145 out of 188 countries with available data (Human Development Report, 2015). The participating countries also varied on psychological constructs such as individualism versus collectivism. Using Hofstede's (2001) rankings, the participating countries ranged from the United States, with the highest individualism score in the world to China, Colombia, and Thailand, countries that are among the least individualistic countries in the world. The purpose of recruiting families from these countries was to create an

international sample that would be diverse with respect to a number of socio-demographic and psychological characteristics.

Participants were recruited from schools serving socioeconomically diverse families in each site. Letters describing the study were sent home with children, which parents were asked to sign and return if they were willing to be contacted (in some countries) and contacted by phone to follow up on the letter (in other countries). Children were sampled from public and private schools serving high, middle, and low income families in the approximate proportion to which these income groups were represented in the local population. Retention rates were high. At Time 3, 92% of the initial sample continued with the study five and a half years after the initial recruitment. Participants who provided complete data across almost six years did not differ from the initial sample with respect to child gender, parents' marital status, or mothers' and fathers' education. Child age and gender did not vary across sites. Data for the present study were drawn from separate interviews conducted with a child and the two adult caregivers, respectively.

Interview Procedures

Measures used in the interviews were administered in the predominant language of each country (Mandarin Chinese in China, Spanish in Colombia and the United States, Italian in Italy, Arabic in Jordan, Dholuo in Kenya, Filipino in the Philippines, Swedish in Sweden, Thai in Thailand, and English in the United States), following forward- and back-translation by translators fluent in English and the target language and after group discussions to resolve any linguistic, semantic, and cultural ambiguities that arose during translation. Interviews lasted 1.5 to 2 hours at each of the three times of data collection and were conducted in participants' homes, schools, or at other locations chosen by the participants. Procedures for the project were approved by the Duke University Institutional Review Board (IRB; Study title: Parenting, adolescent self-regulation, and risk-taking across cultures; Protocol number:

2032), as well as by university IRBs in all of the other participating countries – University of Macau, Macau, China; Universidad San Buenaventura, Medellín, Colombia; Hashemite University, Zarqa, Jordan; University of Naples, Naples, Italy; Università di Roma, Rome, Italy; Maseno University, Maseno, Kenya; Ateneo de Manila University, Quezon City, Philippines; University West, Trollhättan, Sweden; Chiang Mai University, Chiang Mai, Thailand. Mothers and fathers provided written informed consent, and children provided assent. Family members were interviewed separately to ensure privacy. For the present study, adult participants were given the choice of completing the measures in writing or orally, with the interviewer reading the questions aloud and recording the participants' responses (with a visual aid to help the participants understand the response scales). At Time 1, children were administered the measures orally, and, for the two subsequent assessments, they were given the option of completing the measures orally or in writing. To thank them for their participation, children were given small gifts or monetary compensation, parents were given modest financial compensation, families were entered into drawings for prizes, and modest financial contributions were made to children's schools.

Harshness and Unpredictability Measured at Time 1 when Children were 10 Years Old

We used four measures to assess childhood environmental harshness and unpredictability.

Unsafe Neighborhood. Mothers and children separately reported on the 7-item questionnaire measuring the perceived safety and livability of a neighborhood (Murray & Greenberg, 2006; e.g., “My neighborhood is a dangerous place to live,” “My neighborhood is a nice place to live” (reverse coded), and “I feel scared in my neighborhood). Using a 4-point scale ranging from 0 = “almost never true” to 3 = “almost always true,” the items were measured or recoded in the direction of unsafe neighborhood. Internal consistency reliability

estimate was .85 for mother reporting and .76 for child reporting. The correlation between the two ratings was .35. For the structural equation modeling and other analysis reported later, the average of the two ratings was used as an indicator of environmental unpredictability.

Negative Life Events. Using the Social Readjustment Rating Scale (Holmes & Rahe, 1967), mothers reported on whether 10 negative life events happened in the last 2 years in the family to which the child was likely to be exposed (e.g., “severe and/or frequent illness,” “accidents and/or injuries,” and “death of other important person”). The ten items were averaged to create a scale. Internal consistency reliability estimate was .62.

Family Chaos. We adopted 5 items from the Confusion, Hubbub, and Order Scale (Matheny Jr et al., 1995) to measure confusion, chaos, and disorder at home (e.g., “It’s a real zoo in our home,” “The atmosphere in our home is calm” (reverse coded), and “You can’t hear yourself think in our home”). Mothers and children responded to these questions on a 5-point scale ranging from 1 = “definitely untrue” to 5 = “definitely true.” Internal consistency reliability estimate was .67 for mothers and .61 for children. The correlation between the two ratings was .41. In the subsequent analyses, the average of the two ratings formed an indicator of environmental unpredictability.

Family Income Change. Mothers provided two ratings during Time 1 and the following year on how much in the last 12 months the household’s annual income has changed and indicated the change on a 5-point scale (1 = decreased a lot (more than 25%); 2 = decreased a little bit (between 5 and 25%); 3 = did not change at all or it did not significantly change (less than 5%); 4 = increased a little bit (between 5 and 25%); 5 = increased a lot (more than 25%)). The rating was reverse coded so that higher numbers indicate income decrease. The two ratings over two years were averaged to form the final variable. Internal consistency reliability estimate based on the two ratings was .42 and the correlation between the two ratings was .26.

Slow LH Behavioral Profile Measured at Time 2 when Children were 13 Years Old

Life history strategies are measured in the literature by the 199-item Arizona Life History Battery (ALHB, Figueredo et al., 2007), which samples cognitive and behavioral indicators from seven domains of resource allocations – Insight, planning, and control; Mother/father relationship quality; Family social contact and support; Friends’ social contact and support; General altruism; Romantic partner attachment; Religiosity. There are two short versions of the ALHB that are more widely used. The Mini-K (Figueredo et al., 2006) has 20 unique items that are not a subset of the ALHB items. The K-SF-42 (Figueredo et al., 2017) has 42 items selected from the ALHB items with six measuring each of the seven ALHB subscales. All three versions, ALHB, Mini-K, and K-SF-42, measure a single factor in the direction of K selection or slow LH (Figueredo et al., 2017).

We adapted and modified 46 ALHB items to measure five out of the seven subscales; Romantic partner attachment and Religiosity were not measured because of our young adolescent and multicultural sample. Children responded to these questions either on a 6-point or 4-point scale consistent with the ALHB scales. Ten items were used to measure Insight, planning, and control. Sample items included “Once I make a plan to get something done, I stick to it,” “I can do just about anything I set my mind to,” and “I believe that things will always work out no matter how difficult they seem.” Internal consistency reliability estimate was .85. Sixteen items with 8 for each parent were used to assess Parent-child relationship quality. Sample items included “Dad/mom pays attention to me,” “Dad/mom makes it easy for me to confide in him/her,” and “Dad/mom takes real interest in me.” Internal consistency reliability estimate was .91. Family social contact and support was measured by eight items (e.g., “Spend time with grandparents, cousins, aunts and uncles,” “Do things together with brothers and sisters,” and “Do well for the sake of the family”). Internal consistency reliability estimate was .80. Six items were used to measure Friends’

social contact and support (e.g., “I have friends that I really care about,” “When something good happens to me, I have people in my life that I like to share good news with,” and “When I have a problem, I have someone who will be there for me”). Internal consistency reliability estimate was .83. General altruism was assessed by 6 items (e.g., “I try to help others,” “I share things I like with friends,” and “I let others use my things”). Internal consistency reliability estimate was .64. These five subscales form a composite measure of LH in the slow direction which we call Slow LH Behavioral Profile.

Externalizing Behavior and Academic Performance Measured at Time 3 when Children were 15 Years Old

Fathers and mothers completed 33 items of the Achenbach's Child Behavior Checklist (CBCL, Achenbach, 1991) and children completed 30 items of the Youth Self Report to measure child externalizing behavior (e.g., “argues a lot,” “screams a lot,” and “threatens people”). A 3-point scale ranging from 0 = “never” to 2 = “often” registers the frequency a child engaged in each of these behaviors. Internal consistency reliability estimate was .89, .87, and .86 for father, mother, and child reporting, respectively.

Both parents rated their child's academic performance in reading, writing, math, spelling, social studies, and science. These subjects were adapted from the performance in academic subject section of the CBCL, which has demonstrated criterion validity (Achenbach, 1991). Parents rated their child on a 4-point scale (1 = failing, 2 = below average, 3 = average, or 4 = above average). A single scale was computed as the average of the ratings of the 6 school subjects. Internal consistency reliability estimate was .90 for paternal and .89 for maternal ratings. The correlation between the two parental ratings was .73.

Control Variables Used in the Study

Nonverbal IQ. At Time 1, children were administered the Matrix Reasoning Subscale of the Wechsler Abbreviated Scale of Intelligence (WASI, Psychological Corporation, 1999). Given the variability in language across the research sites, we used only this nonverbal component of WASI to estimate children's intellectual ability.

Maternal and Paternal Slow LH Behavioral Profile. At Time 2, parents were given 9 items to measure the Romantic partner attachment dimension of the ALHB (Figueredo et al., 2007). Sample items included "do you enjoy your husband's/wife's company," "do you enjoy doing things together," and "do you enjoy cuddling your husband/wife?" Internal consistency reliability estimates were .93 for mothers and .90 for fathers. Five items were used to measure Insight, planning, and control. Sample items included "I'd rather depend on myself than others," "competition is the law of nature," and "I rely on myself most of the time." Internal consistency reliability estimate was .63 for mothers and .65 for fathers. Four items were used to measure Family social contact and support (e.g., "parents and children must stay together as much as possible," "family members should stick together, no matter what sacrifices are required," and "I think aging parents should live at home with their children."). Internal consistency reliability estimate was .77 for mothers and .77 for fathers. All these measures were based on 4- to 6-point rating scales consistent with the ALHB. To measure the Friends' social contact and support dimension of ALHB, we asked parents to rate on a 6-point scale ranging from 1 = "not available or no support" to 6 = "consistently strong support" the extent of support they received from eight different sources including "friends or neighbors," "other relatives," and "clergy." Internal consistency reliability estimate based on the 8 questions was .89 for mothers and .91 for fathers. We used these four subscales to approximate slow LH behavioral profile, with an internal consistency reliability estimate of .80 for mothers and .79 for fathers. These two control variables were used only in one part of the analyses.

Results

Table 1 presents the means, standard deviations (SD), and correlations of the primary variables used in this study. Some of the correlations were moderate in part because they were based on different informants (i.e., child, mother, and father) and over one to two 24-month time lags. As expected, indicators of environmental harshness and unpredictability (i.e., unsafe neighborhood, negative life event, family chaos, and family income change, which were obtained mainly from mothers) were negatively and mostly significantly correlated with indicators of slow LH behavioral profile (i.e., insight, planning and control, parent-child relationship, family support, social support, and general altruism that were measured two years later from child report). These two sets of indicators were also longitudinally correlated with child externalizing and academic performance in the expected directions. These correlations support our LH theorizing. We also conducted gender comparisons because males are expected to manifest faster LH traits than females in most animals including humans (Hill, Ross, & Low, 1997). Table 2 contains means and SDs of the variables separated by gender. As expected, boys scored lower than girls on some of the slow LH behavioral profiles, whereas there were no other gender differences.

Reported in Table 3, we also computed correlations between the harshness and unpredictability construct and the slow LH behavioral profile construct, between harshness and unpredictability construct and externalizing behavior, between harshness and unpredictability and academic performance, between slow LH behavioral profile and externalizing, and between slow LH profile and academic performance within each of the 10 cities in 9 countries. There were 10 site-specific correlation coefficients for each of the five correlations. As shown in Table 3, for each of the five correlations, the 10 site-specific coefficients were in the same predicted directions. We also conducted z-tests to compare each of the five correlations across 10 locations. Out of 50 z-test comparisons (10 comparisons for

each of five correlations), only three were statistically significant ($p < .05$) after Bonferroni adjustment of Type I error. They involved comparing the lowest ($r = -.05$) with the highest ($r = -.42$) site in the correlation between harshness and unpredictability and slow LH behavioral profile and comparing the lowest ($r = .05$) with two highest ($r = .48$ and $.44$) sites in the correlation between harshness and unpredictability and externalizing. These results suggest that the LH prescribed associations among the constructs were highly similar across locations.

To test the LH model in Figure 1, we conducted structural equation modeling (SEM) tests using Mplus 7.0 (Muthen & Muthen, 2012) and using full information maximum likelihood estimation procedures to treat missing data (Schafer & Graham, 2002). We first examined invariance by conducting the three hierarchically organized invariance tests -- configural invariance (equating model configurations across 10 sites), metric invariance (equating factor loadings plus configuration constraints), and structural invariance (equating path coefficients plus the first two invariance constraints). For configural invariance, 10 free models based on 10 sites separately were each compared to the constrained model constraining model configurations (measurement model and structural model) to be equal across sites. For metric and structural invariance tests, a free model with no equality constraints was compared to a constrained model by constraining the respective parameter estimates (path coefficients and/or factor loadings) to be equal across sites. Following the literature (e.g., Cheung & Rensvold, 2002), if the difference in Comparative Fit Index (ΔCFI) between the constrained and the free model was .01 or smaller, the constrained model was deemed acceptable, supporting invariance. The configural invariance tests met the $\Delta CFI \leq .01$ criterion but the other invariance tests did not. We then conducted partial invariance tests by freeing constrained parameter estimates based on the goodness of fit improvement information (Modification Index) incrementally until we met the $\Delta CFI \leq .01$ criterion. We

achieved metric partial invariance after we freed 14 factor loadings (less than 10%) involving four cities, and we obtained structural partial invariance after freeing 5 path coefficients involving four cities. These invariance tests are based on goodness of fit statistics but do not test differences of the parameter estimates among the sites directly. We conducted multilevel analysis treating sites as Level 2 and examined the variance of each of the 5 path coefficients across sites. The results showed that none of the coefficients had significant between-site variance.

We then tested the model on all participants as one sample. The results are reported in Figure 1. Except for the chi-square test ($\chi^2 = 297.49$, $DF = 65$, $N = 1151$), which is often not considered for goodness of fit evaluation because of its sensitivity to sample size, all of the other goodness of fit statistics (Goodness of Fit Index (GFI) = .98; CFI = .95; Tucker-Lewis Index (TLI) = .93; RMSEA = .056, CI90 = .049 to .062; Standardized Root Mean Square Residual (SRMR) = .044) meet the recommended cut-off values for adequate to excellent model fit (Hu & Bentler, 1999; Schreiber, Stage, King, Nora, & Barlow, 2006). All the parameter estimates were in the expected directions and were statistically significant. Most of the factor loadings were above .50 with an average of .63, suggesting adequate measurement models. The structural model was consistent with our LH theorizing. In the predicted directions, harshness and unpredictability was longitudinally associated with slow LH behavioral profile ($\beta = -.47$, $p < .001$), which was longitudinally associated with externalizing ($\beta = -.33$, $p < .001$) and academic performance ($\beta = .31$, $p < .001$). Also, in the predicted directions, harshness and unpredictability was longitudinally correlated with externalizing ($\beta = .32$, $p < .001$) and academic performance ($\beta = -.23$, $p < .001$).

To rule out possible site differences, we also tested the same model using centered data by removing the city mean from each variable. The results were almost identical (the signs of parameter estimates were identical, the magnitudes of statistical significance were

highly similar, and the magnitudes of the parameter estimates were similar) to those based on the raw data, suggesting little site interference.

Because LH and intellectual ability are heritable and, with respect to academic performance, intellectual ability may also mediate environmental and LH influences (Del Giudice, personal communication), we conducted hierarchical regression analysis to examine the incremental or unique variance explained by our hypothesized LH predictions after controlling for parents' slow LH behavioral profile and children's nonverbal IQ. With academic performance as the outcome variable, we first entered the nonverbal IQ into the regression equation. IQ was a positive and significant predictor of academic performance ($\beta = .21, p < .001$). We then entered harshness and unpredictability. It was still significant ($\beta = -.07, p < .05$), contributing 0.5% unique explained variance after controlling for IQ. We then entered, as control variables, paternal and maternal slow LH profiles, which explained an additional 1.9% of the variance. We finally entered child slow LH profile. It continued to be a robust predictor ($\beta = .27, p < .001$), explaining 6.7% unique variance after controlling all of the other variables. We did the same with externalizing. IQ was entered first as a control variable and explained 2.1% of the variance. Harshness and unpredictability was entered next. It remained a significant predictor ($\beta = .33, p < .001$), explaining 1.1% unique variance. Paternal and maternal slow LH profiles were entered next as controls. They explained an additional 0.9% of the variance, which was statistically significant ($p < .01$). Finally, we entered child slow LH profile. It continued to be a robust predictor ($\beta = -.29, p < .001$), accounting for 7.8% of the unique variance explained after controlling for all of the other variables. These results provide additional confidence in confirming our hypothesized associations among environmental harshness and unpredictability, LH, and social and academic behavior in adolescents.

Discussion

LH tradeoff allocations of limited bioenergy arise from environmental constraints (Kaplan et al., 2000). Patterns derived from such energetic tradeoffs form LH strategies, which are aimed at optimizing survival and reproduction for the individual. One such broad pattern of LH tradeoffs is the fast–slow LH tradeoff continuum (Promislow & Harvey, 1990). A fast LH strategy involves tradeoffs characterized by early maturation, rapid development, high mating frequency, low parental involvement, and behavioral characteristics such as antagonistic sociality and superficial learning to support a present-oriented fast life style. A slow LH strategy involves late maturation, delayed reproduction, prolonged development, high parental involvement, low mating frequency, and related behavioral characteristics such as affiliative sociality and thorough exploration and learning. The fast–slow continuum and other strategic LH tradeoffs are shaped by and respond to environmental constraints involving food and safety; safety is more relevant than food to modern day human living. Fast and slow LH strategies have been selected through evolution and continue to regulate human behavior in response to safety constraints.

The findings of the present study confirm evolutionarily selected contingent responses involving environmental harshness and unpredictability, fast–slow LH strategies, and social and academic behavioral outcomes. Specifically, as represented by such factors as unsafe neighborhood conditions, negative life events, family chaos, and family income change—all measured during childhood—safety constraints were negatively associated with slow LH behavioral profile measured 2 years later. As prescribed by LH theory, slow LH behavioral profile was negatively and positively associated with externalizing behavior and academic performance, respectively, both of which were measured an additional 2 years later, by which time the children had become young adolescents. Moreover, childhood environmental harshness and unpredictability was directly related to adolescents' externalizing and

academics in the predicted directions. This set of longitudinal relations was invariant or relatively invariant across countries. These findings confirm LH predictions regarding development and behavior. Maturing among cues of unreliable environment, children, like other animals, adopt fast LH strategies, are present-oriented and may find little purpose in focusing on academic studies. As fast strategists, they attend to immediate instrumental goals and discount long-term benefits by underperforming academically and adopting externalizing and antagonistic sociality. The opposite is true for children living in a stable environment that fosters slow LH and child development oriented toward long-term socialization goals including affiliative sociality and academic achievement.

Academic and social behaviors that have been investigated in the mainstream developmental literature mainly as contemporary human socialization outcomes veritably represent ancient LH implementations practiced by all animals to adapt to the safety constraints of the living environment. Children do or do not do well in schools and are aggressive or affiliative in social interactions not merely because of the success or failure of the ongoing socialization effort such as parenting, schooling, and peer influence but also because of LH strategic predisposition activated by early environment. In a harsh and unpredictable environment, children, like other animals, may discount the future by engaging in superficial learning and antagonistic sociality even though they are socialized not to do so. The opposite is true about environmental predictability in fostering slow LH and behavior that may be more consistent with human socialization goals. Human socialization is more consistent with slow than fast LH because the human species is among the slowest in LH (Kaplan et al., 2000). Incidentally, the human species exhibits one of the slowest LHs of all animals partially because of its LH strategic tradeoff involving brain development (Aiello & Wheeler, 1995), whereas human sociality, involving complex and large social groups (Dunbar, 1992), and human learning, in the form of extracted and thorough foraging (Aiello

& Wheeler, 1995), are the two drivers of human brain development (Barton, 2000; Humphrey, 1999). The large brain intelligence enhances the predictability and controllability of living environments, thereby activating and accelerating slow LH (Kaplan et al., 2000). Slow LH strategies lead to ever more complex sociality in the form of large-group social interactions and institutions and ever more sophisticated learning in the form of subsistence advancement that extends to science and technology, both of which further enhance human controllability and predictability of living environments, and thus reinforce slow LH. As extended phenotypes in the form of culture and civilization (Dawkins, 2016), slow rather than fast LH-based social and learning behaviors have therefore become core aspects of human socialization. The result is that children are socialized to be affiliative and cooperative and to achieve academically or are otherwise considered deviant and delinquent, representing failures of socialization.

However, there are individual differences resulting from many factors including LH responding to within-species variations of environmental constraints. As shown in the present study, environmental harshness and unpredictability may arise from unsafe neighborhood conditions, familial turmoil, or negative life events, all of which activate fast LH strategies and, consequently, externalizing behaviors and academic underperformance. Such social and learning behaviors are adaptive in environments that diminish the prospect for future cooperation and long-term fitness-enhancing opportunities. One practical implication of the present study is not to rashly judge putatively deviant behavior exhibited by children and adolescents, but to examine the environmental conditions that are associated with such behavior and the evolutionary causes of such associations. Another implication related to education is that instead of steadfast enforcement of socialization or questioning and unfruitfully reforming and reinventing socialization institutions (e.g., parenting or parents, instructional methods or teachers, or school systems or education policies) when socialization

and education do not seem to be achieving the intended objectives, effort should be directed toward improving children's living environments by eliminating or reducing unpredictable elements. Poverty associated with crime and violence generated by economic destitution constitutes a major threat to environmental stability. Other threats include natural and manmade disasters such as famine, wars, and large-scale disease epidemics, all of which cause mortality and morbidity and ignite cascade effects of fast LH, present orientation, and superficial learning and social behaviors aimed at immediate and short-term fitness gains. Efforts should be made to eliminate these elements of unpredictability and render the larger environment supportive of and congruent with the species' chosen slow LH strategy. More tenable efforts may be focused on improving microenvironments; for example, promoting stable family life, safe neighborhoods, and orderly classrooms. Such microenvironments are conducive to slow LH strategies, which engender future orientation and related social and academic behaviors consistent with slow-LH-based socialization.

The present study had several limitations. First, we did not test alternative hypotheses against our LH predictions. However, falsification of evolutionary theories does not rely solely on empirical tests but also on accumulating historical and often interspecific comparative evidence that supports an optimal evolutionary explanation. We believe that we have provided such evidence and explanations with respect to externalizing behavior and academic performance, both of which represent implementations of LH strategies and yielded findings expected to be similar to those obtained from proximate socialization models because human socialization is consistent with and reinforces its slow LH origin. Second, we focused on the environmental influence of LH and our effort to control for the genetic influence of LH was minimal. Genetic confounding may affect developmental research and is a particularly relevant threat to evolutionary studies focusing on distal processes. Future developmental LH research could employ twins or siblings to distinguish between

environmental and potential genetic influences on and of LH. Finally, our results, particularly some of the factor loadings, were moderate, suggesting that we might not have fully or fully accurately represented distal evolutionary processes under investigation. However, this limitation was mitigated by our use of multidimensional, multi-informant, and longitudinal data, which likely yielded more attenuated results less inflated by method variance. Despite these and other limitations, this is one of the first LH studies to examine child and adolescent social and academic development across countries, and represents an earnest effort to use diverse culture samples to test evolutionary predictions about universal fitness functions and processes. The country-invariant findings regarding LH strategies responding to early environment and enacting social and academic behaviors in the fast-slow LH directions provide a new perspective on child development and behavior that helps to explain existing findings based on socialization models. In addition, our findings carry practical implications. If elements of unsafety and unpredictability are removed from living environments, child and adolescent development may follow the species' chosen slow LH trajectory, thereby rendering evolution and socialization more congruent and engendering more effective socialization and education.

References

- Achenbach, T. M. (1991). Integrative guide for the 1991 CBCL 14-18, YSR, and TRF Profiles. Burlington, VT: University of Vermont, Department of Psychiatry.
- Aiello, L. C., & Wheeler, P. (1995). The expensive-tissue hypothesis: The brain and the digestive system in human and primate evolution. *Current Anthropology*, *36*, 19–221. doi: 10.1086/20435
- Anderson, S., & Leventhal, T. (2017). Residential mobility and adolescent achievement and behavior: Understanding timing and extent of mobility. *Journal of Research on Adolescence*, *27*, 328–343. doi: 10.1111/jora.12288

- Anderson, E. L., Steen, E., & Stavropoulos, V. (2017). Internet use and problematic Internet use: A systematic review of longitudinal research trends in adolescence and emergent adulthood. *International Journal of Adolescence and Youth, 22*, 430–454. doi: 10.1080/02673843.2016.1227716
- Arnold, D. H. (1997). Co-occurrence of externalizing behavior problems and emergent academic difficulties in young high-risk boys: A preliminary evaluation of patterns and mechanisms. *Journal of Applied Developmental Psychology, 18*, 317–330. doi: 10.1016/S0193-3973(97)80003-2
- Barton, R. A. (2000). Ecological and social factors in primate brain evolution. In S. Boinski & P. Garber (Eds.), *On the move: How and why animals travel in groups* (pp. 204–237). Chicago, IL: Chicago University Press.
- Baumer, E. P., & South, S. J. (2001). Community effects on youth sexual activity. *Journal of Marriage and Family, 63*, 540–554. doi: 10.1111/j.1741-3737.2001.00540.x
- Beauchamp, G. (2000). Individual differences in activity and exploration influence leadership in pairs of foraging zebra finches. *Behaviour, 137*, 301–314. doi: 10.1163/156853900502097
- Bell, A. M., & Sih, A. (2007). Exposure to predation generates personality in threespined sticklebacks (*Gasterosteus aculeatus*). *Ecology Letters, 10*, 828–834. doi: 10.1111/j.1461-0248.2007.01081.x
- Belsky, J., Schlomer, G. L., & Ellis, B. J. (2012). Beyond cumulative risk: Distinguishing harshness and unpredictability as determinants of parenting and early life history strategy. *Developmental Psychology, 48*, 662–673. doi: 10.1037/a0024454
- Belsky, J., Steinberg, L., & Draper, P. (1991). Childhood experience, interpersonal development, and reproductive strategy: An evolutionary theory of socialization. *Child Development, 62*, 647–670. doi: 10.1111/j.1467-8624.1991.tb01558.x

- Berg, L., Rostila, M., Saarela, J., & Hjern, A. (2014). Parental death during childhood and subsequent school performance. *Pediatrics*, *133*, 682–689. doi: 10.1542/peds.2013-2771
- Billerbeck, J. M., Lankford Jr, T. E., & Conover, D. O. (2001). Evolution of intrinsic growth and energy acquisition rates. I. Trade-offs with swimming performance in *Menidia menidia*. *Evolution*, *55*, 1863–1872. doi: 10.1111/j.0014-3820.2001.tb00835.x
- Biro, P. A., & Stamps, J. A. (2008). Are animal personality traits linked to life-history productivity? *Trends in Ecology and Evolution*, *23*, 361–368. doi: doi.org/10.1016/j.tree.2008.04.003
- Both, C., Dingemanse, N. J., Drent, P. J., & Tinbergen, J. M. (2005). Pairs of extreme avian personalities have highest reproductive success. *Journal of Animal Ecology*, *74*, 667–674. doi: 10.1111/j.1365-2656.2005.00962.x
- Bowlby, J. (1972). *Attachment: Attachment and loss*. Volume 1. New York, NY: Penguin Books.
- Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136–162). Newbury Park, CA: Sage.
- Brumbach, B. H., Figueredo, A. J., & Ellis, B. J. (2009). Effects of harsh and unpredictable environments in adolescence on development of life history strategies. *Human Nature*, *20*, 25–51. doi: 10.1007/s12110-009-9059-3
- Careau, V., Bininda- Emonds, O. R. P., Thomas, D. W., Réale, D., & Humphries, M. M. (2009). Exploration strategies map along fast–slow metabolic and life–history continua in muroid rodents. *Functional Ecology*, *23*, 150–156. doi: 10.1111/j.13652435.2008.01468.x

- Cerasoli, C. P., Nicklin, J. M., & Ford, M. T. (2014). Intrinsic motivation and extrinsic incentives jointly predict performance: A 40-year meta-analysis. *Psychological Bulletin, 140*, 980–1008. doi: 10.1037/a0035661
- Chang, L. (2004). The role of classrooms in contextualizing the relations of children's social behaviors to peer acceptance. *Developmental Psychology, 40*, 691–702. doi: 10.1037/0012-1649.40.5.691
- Chang, L., & Lu, H. J. (2017). Environmental risks. In T. K. Shackelford & V. Weekes–Shackelford (Eds.), *Encyclopaedia of evolutionary psychological sciences*. New York, NY: Springer Meteor.
- Chang, L., & Lu, H. J. (2018). Resource and extrinsic risk in defining fast life histories of rural Chinese left-behind children. *Evolution and Human Behavior, 39*, 59–66. doi: 10.1016/j.evolhumbehav.2017.10.003
- Chang, L., Mak, M. C. K., Li, T., Wu, B. P., Lu, H. J., & Chen, B. B. (2011). Cultural adaptations to environmental variability: An evolutionary account of East-West differences. *Educational Psychology Review, 23*, 99-129. doi: 10.1007/s10648-010-9149-0
- Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling, 9*, 233–255. doi: 10.1207/S15328007SEM0902_5
- Dawkins, R. (2016). *The extended phenotype: The long reach of the gene*. Oxford, UK: Oxford University Press.
- de Baca, T. C., Wahl, R. A., Barnett, M. A., Figueredo, A. J., & Ellis, B. J. (2016). Adversity, adaptive calibration, and health: The case of disadvantaged families. *Adaptive Human Behavior and Physiology, 2*, 93–115. doi: 10.1017/S0954579415001169

- Del Giudice, M. (2018). *Evolutionary psychopathology: A unified approach*. New York, NY: Oxford University Press.
- Del Giudice, M. (2014). An evolutionary life history framework for psychopathology. *Psychological Inquiry, 25*, 261-300. doi: 10.1080/1047840X.2014.884918
- Del Giudice M., Gangestad S. W., & Kaplan H. S. (2015). Life history theory and evolutionary psychology. In D. M. Buss (Ed.), *The handbook of evolutionary psychology* (2nd ed., Vol. 1: Foundations, pp. 88–114). New York, NY: Wiley.
- Del Giudice, M., & Belsky, J. (2011). The development of life history strategies: Toward a multi-stage theory. In D. M. Buss & P. H. Hawley (Eds.), *The evolution of personality and individual differences* (pp. 154–176). New York, NY: Oxford University Press.
- Dougherty, L.R., & Guillette, L.M. (2018). Linking personality and cognition: A meta-analysis. *Philosophical Transaction of the Royal Society B*. doi: 10.1098/rstb.2017.0282
- Doom, J. R., Vanzomeren-Dohm, A. A., & Simpson, J. A. (2016). Early unpredictability predicts increased adolescent externalizing behaviors and substance use: A life history perspective. *Development and Psychopathology, 28*, 1505–1516. doi: 10.1017/S0954579415001169
- Dunbar, R. I. (1995). Neocortex size and group size in primates: A test of the hypothesis. *Journal of Human Evolution, 28*, 287–296. doi: 10.1006/jhev.1995.1021
- Einum, S., & Fleming, I. A. (2004). Environmental unpredictability and offspring size: Conservative versus diversified bet-hedging. *Evolutionary Ecology Research, 6*, 443–455.
- Ellis, B. J., Figueredo, A. J., Brumbach, B. H., & Schlomer, G. L. (2009). Fundamental dimensions of environmental risk. *Human Nature, 20*, 204–268. doi: 10.1007/s12110-009-9063-7

- Ellison, P. T. (2017). Endocrinology, energetics, and human life history: A synthetic model. *Hormones and Behavior, 91*, 97–106. doi: 10.1016/j.yhbeh.2016.09.006
- Figueredo, A. J., & Jacobs, W. J. (2010). Aggression, risk-taking, and alternative life history strategies: The behavioral ecology of social deviance. In M. Frias-Armenta & V. Corral-Verdugo (Eds.), *Bio-psycho-social perspectives on interpersonal violence* (pp. 3–28). Hauppauge, NY: NOVA Science Publishers.
- Figueredo, A. J., Garcia, R. A., Menke, J. M., Jacobs, W. J., Gladden, P. R., Bianchi, J., ... & Jiang, Y. (2017). The K-SF-42: A new short form of the Arizona Life History Battery. *Evolutionary Psychology, 15*, 1474704916676276. doi: 10.1016/j.paid.2005.06.009
- Figueredo, A. J., Vásquez, G., Brumbach, B. H., & Schneider, S. M. (2007). The K-factor, covitality, and personality. *Human Nature, 18*, 47–73. doi: 10.1007/BF02820846
- Figueredo, A. J., Vásquez, G., Brumbach, B. H., Schneider, S. M., Sefcek, J. A., Tal, I. R., ... & Jacobs, W. J. (2006). Consilience and life history theory: From genes to brain to reproductive strategy. *Developmental Review, 26*, 243–275. doi: 10.1016/j.dr.2006.02.002
- Gershoff, E. T. (2002). Corporal punishment by parents and associated child behaviors and experiences: A meta-analytic and theoretical review. *Psychological Bulletin, 128*, 539–579. doi: 10.1037//0033-2909.128.4.539
- Griskevicius, V., Tybur, J. M., Delton, A. W., & Robertson, T. E. (2011). The influence of mortality and socioeconomic status on risk and delayed rewards: A life history theory approach. *Journal of Personality and Social Psychology, 100*, 1015–1026. doi: 10.1037/a0022403
- Hair, N. L., Hanson, J. L., Wolfe, B. L., & Pollak, S. D. (2015). Association of child poverty, brain development, and academic achievement. *JAMA Pediatrics, 169*, 822–829. doi: 10.1001/jamapediatrics.2015.1475

- Hampden-Thompson, G., & Galindo, C. (2015). Family structure instability and the educational persistence of young people in England. *British Educational Research Journal, 41*, 749–766. doi: 10.1002/berj.3179
- Hawley, P. H. (2003). Strategies of control, aggression, and morality in preschoolers: An evolutionary perspective. *Journal of Experimental Child Psychology, 85*, 213–235. doi: 10.1016/S0022-0965(03)00073-0
- Hill, E. M., Ross, L. T., & Low, B. S. (1997). The role of future unpredictability in human risk-taking. *Human Nature, 8*, 287–325. doi: 10.1007/BF02913037
- Hills, T. T. (2006). Animal foraging and the evolution of goal-directed cognition. *Cognitive Science, 30*, 3–41. doi: 10.1207/s15516709cog0000_50
- Hills, T., Brockie, P. J., & Maricq, A. V. (2004). Dopamine and glutamate control area-restricted search behavior in *Caenorhabditis elegans*. *Journal of Neuroscience, 24*, 1217–1225. doi: 10.1523/JNEUROSCI.1569-03.2004
- Hinshaw, S. P. (1992). Externalizing behavior problems and academic underachievement in childhood and adolescence: Causal relationships and underlying mechanisms. *Psychological Bulletin, 111*, 127–155. doi: 10.1037/0033-2909.111.1.127
- Hofstede, G. (2001). *Culture's consequences: Comparing values, behaviors, institutions, and organizations across nations* (2nd ed.). Newbury Park, CA: Sage.
- Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*, 1–55. doi: 10.1080/10705519909540118
- Human Development Report. (2015). *Human development report 2015*. New York, NY: United Nations Development Programme.
- Humphrey, N. (1999). *A history of the mind: Evolution and the birth of consciousness*. New York, NY: Springer.

- Jacob, R., & Parkinson, J. (2015). The potential for school-based interventions that target executive function to improve academic achievement: A review. *Review of Educational Research, 85*, 512–552. doi: 10.3102/0034654314561338
- Kaplan, H., Hill, K., Lancaster, J., & Hurtado, A. M. (2000). A theory of human life history evolution: Diet, intelligence, and longevity. *Evolutionary Anthropology: Issues, News, and Reviews, 9*, 156–185. doi: 10.3102/0034654314561338
- Kurvers, R. H., Prins, H. H., van Wieren, S. E., van Oers, K., Nolet, B. A., & Ydenberg, R. C. (2010). The effect of personality on social foraging: Shy barnacle geese scrounge more. *Proceedings of the Royal Society of London B: Biological Sciences, 277*, 601–608. doi: 10.1098/rspb.2009.1474
- Lankford Jr, T. E., Billerbeck, J. M., & Conover, D. O. (2001). Evolution of intrinsic growth and energy acquisition rates. II. Trade-offs with vulnerability to predation in *Menidia menidia*. *Evolution, 55*, 1873–1881. doi: 10.1554/0014-3820(2001)055[1873:EOIGAE]2.0.CO;2
- Lansford, J. E., Laird, R. D., Pettit, G. S., Bates, J. E., & Dodge, K. A. (2014). Mothers' and fathers' autonomy-relevant parenting: Longitudinal links with adolescents' externalizing and internalizing behavior. *Journal of Youth and Adolescence, 43*, 1877–1889. doi: 10.1007/s10964-013-0079-2
- Low, B. S., Hazel, A., Parker, N., & Welch, K. B. (2008). Influences on women's reproductive lives: Unexpected ecological underpinnings. *Cross-Cultural Research, 42*, 201–219. doi: 10.1177/1069397108317669
- MacArthur, R. H., & Wilson, E. O. (1967). *The theory of island biogeography. Monographs in Population Biology, Vol. 1*. Princeton, NJ: Princeton University Press.

- Marchetti, C., & Drent, P. J. (2000). Individual differences in the use of social information in foraging by captive great tits. *Animal Behaviour*, *60*, 131–140. doi: 10.1006/anbe.2000.1443
- Masten, A. S., Cutuli, J. J., Herbers, J. E., Hinz, E., Obradović, J., & Wenzel, A. J. (2014). Academic risk and resilience in the context of homelessness. *Child Development Perspectives*, *8*, 201–206. doi: 10.1111/cdep.12088
- Matheny Jr, A. P., Wachs, T. D., Ludwig, J. L., & Phillips, K. (1995). Bringing order out of chaos: Psychometric characteristics of the confusion, hubbub, and order scale. *Journal of Applied Developmental Psychology*, *16*, 429–444. doi: 10.1016/0193-3973(95)90028-4
- Mega, C., Ronconi, L., & De Beni, R. (2014). What makes a good student? How emotions, self-regulated learning, and motivation contribute to academic achievement. *Journal of Educational Psychology*, *106*, 121–131. doi: 10.1037/a0033546
- Mell, H., Safra, L., Algan, Y., Baumard, N., & Chevallier, C. (2018). Childhood environmental harshness predicts coordinated health and reproductive strategies: A cross-sectional study of a nationally representative sample from France. *Evolution and Human Behavior*, *39*, 1–8. doi: 10.1016/j.evolhumbehav.2017.08.006
- Mesman, J., & Koot, H. M. (2001). Early preschool predictors of preadolescent internalizing and externalizing DSM-IV diagnoses. *Journal of the American Academy of Child & Adolescent Psychiatry*, *40*, 1029–1036. doi: 10.1097/00004583-200109000-00011
- Michelena, P., Sibbald, A. M., Erhard, H. W., & McLeod, J. E. (2008). Effects of group size and personality on social foraging: The distribution of sheep across patches. *Behavioral Ecology*, *20*, 145–152. doi: 10.1093/beheco/arn126
- Murray, C., & Greenberg, M. T. (2006). Examining the importance of social relationships and social contexts in the lives of children with high-incidence disabilities. *The Journal of Special Education*, *39*, 220–233. doi: 10.1177/00224669060390040301

- Muthén, L. K., & Muthén, B.O. (1998-2012). *Mplus User's Guide*. Seventh Edition. Los Angeles, CA: Muthén & Muthén.
- Nettle, D., Coall, D. A., & Dickins, T. E. (2011). Early-life conditions and age at first pregnancy in British women. *Proceedings of the Royal Society of London B: Biological Sciences*, *278*, 1721–1727. doi: 10.1098/rspb.2010.1726
- Obradović, J., Long, J. D., Cutuli, J. J., Chan, C. K., Hinz, E., Heistad, D., & Masten, A. S. (2009). Academic achievement of homeless and highly mobile children in an urban school district: Longitudinal evidence on risk, growth, and resilience. *Development and Psychopathology*, *21*, 493–518. doi: 10.1017/S0954579409000273
- Pepper, G. V., & Nettle, D. (2017). The behavioural constellation of deprivation: Causes and consequences. *Behavioral and Brain Sciences*, *40*, 1–72. doi: 10.1017/S0140525X1600234X
- Price, M. E., Cosmides, L., & Tooby, J. (2002). Punitive sentiment as an anti-free rider psychological device. *Evolution and Human Behavior*, *23*, 203–231. doi: 10.1016/S1090-5138(01)00093-9
- Promislow, D. E., & Harvey, P. H. (1990). Living fast and dying young: A comparative analysis of life–history variation among mammals. *Journal of Zoology*, *220*, 417–437. doi: 10.1111/j.1469-7998.1990.tb04316.x
- Psychological Corporation. (1999). *Weschler Abbreviated Scale of Intelligence*. San Antonio, TX: Author.
- Réale, D., Gallant, B. Y., Leblanc, M., & Festa-Bianchet, M. (2000). Consistency of temperament in bighorn ewes and correlates with behaviour and life history. *Animal Behavior*, *60*, 589–597. doi: 10.1006/anbe.2000.1530
- Reader, S. M. (2015). Causes of individual differences in animal exploration and search. *Topics in Cognitive Science*, *7*, 451–468. doi: 10.1111/tops.12148

- Riechert, S. E., & Hall, R. F. (2000). Local population success in heterogeneous habitats: Reciprocal transplant experiments completed on a desert spider. *Journal of Evolutionary Biology*, *13*, 541–550. doi: 10.1046/j.1420-9101.2000.00176.x
- Rosenblum, L. A., & Andrews, M. W. (1994). Influences of environmental demand on maternal behavior and infant development. *Acta Paediatrica*, *397*, 57–63. doi: 10.1111/j.1651-2227.1994.tb13266.x
- Rosenblum, L. A., & Paus, G. S. (1984). The effects of varying environmental demands on maternal and infant behavior. *Child Development*, *55*, 305–314. doi: 10.2307/1129854
- Salas, C., Broglio, C., & Rodríguez, F. (2003). Evolution of forebrain and spatial cognition in vertebrates: conservation across diversity. *Brain, behavior and evolution*, *62*, 72–82. doi: 10.1159/000072438
- Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods*, *7*, 147–177. doi: 10.1037//1082-989X.7.2.147
- Schultz, W., Tremblay, L., & Hollerman, J. R. (2003). Changes in behavior-related neuronal activity in the striatum during learning. *Trends in Neurosciences*, *26*, 321–328. doi: 10.1016/S0166-2236(03)00122-X
- Sheth, S. A., Abuelem, T., Gale, J. T., & Eskandar, E. N. (2011). Basal ganglia neurons dynamically facilitate exploration during associative learning. *Journal of Neuroscience*, *31*, 4878–4885. doi: 10.1523/JNEUROSCI.3658-10.2011
- Simpson, J. A., Griskevicius, V., Kuo, S. I., Sung, S., & Collins, W. A. (2012). Evolution, stress, and sensitive periods: The influence of unpredictability in early versus late childhood on sex and risky behavior. *Developmental Psychology*, *48*, 674–686. doi: 10.1037/a0027293

- South, S. J., Haynie, D. L., & Bose, S. (2005). Residential mobility and the onset of adolescent sexual activity. *Journal of Marriage and Family*, *67*, 499–514. doi: 10.1111/j.0022-2445.2005.00131.x
- Stearns, S. C. (1992). *The evolution of life histories*. New York, NY: Oxford University Press.
- Upchurch, D. M., Aneshensel, C. S., Sucoff, C. A., & Levy-Storms, L. (1999). Neighborhood and family contexts of adolescent sexual activity. *Journal of Marriage and the Family*, *61*, 920–933. doi: 10.2307/354013
- Verbeek, M. E., Drent, P. J., & Wiepkema, P. R. (1994). Consistent individual differences in early exploratory behaviour of male great tits. *Animal Behaviour*, *48*, 1113–1121. doi: 10.1006/anbe.1994.1344
- White, A. E., Kenrick, D. T., Li, Y. J., Mortensen, C. R., Neuberg, S. L., & Cohen, A. B. (2012). When nasty breeds nice: Threats of violence amplify agreeableness at national, individual, and situational levels. *Journal of Personality and Social Psychology*, *103*, 622–634. doi: 10.1037/a0029140
- Wolf, M., van Doorn, G. S., Leimar, O., & Weissing, F. J. (2007) Life-history trade-offs favor the evolution of animal personalities. *Nature*, *447*, 581–584. doi: 10.1038/nature05835
- Zhu, N., Hawk, T. S., & Chang, L. (2018). Living slow and being moral: Life history predicts the dual process of other-centered reasoning and judgments. *Human Nature*. doi: 10.1007/s12110-018-9313-7
- Zuo, S., Huang, N., Cai, P., & Wang, F. (2018). The lure of antagonistic social strategy in unstable socioecological environment: Residential mobility facilitates individuals' antisocial behavior. *Evolution and Human Behavior*. doi: 10.1016/j.evolhumbehav.2018.03.002

Table 1. Means, Standard Deviations, and Correlations of Variables used in the Study

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Harshness & Unpredictability														
1 Unsafe Neighborhood	-													
2 Negative Life Event	.28***	-												
3 Family Chaos	.18***	.17***	-											
4 Family Income Change	-.22***	-.25***	-.18***	-										
Slow LH Behavioral Profile														
5 Insight, Planning & Control	-.12***	-.08**	-.25***	.07*	-									
6 Parent-Child Relationship	-.13***	-.04	-.29***	.04	.40***	-								
7 Family Support	.05	.01	-.13***	.01	.34***	.31***	-							
8 Social Support	-.14***	-.07*	-.22***	.09**	.60***	.50***	.28***	-						
9 General Altruism	-.18***	-.16***	-.16***	.07*	.32***	.28***	.21***	.31***	-					
Externalizing Behavior														
10 Mother Rating	.19***	.29***	.26***	-.08**	-.15***	-.27***	-.11***	-.13***	-.15***	-				
11 Father Rating	.20***	.22***	.23***	-.04	-.22***	-.36***	-.15***	-.23***	-.21***	.67***	-			
12 Child Rating	.14***	.14***	.25***	-.09**	-.26***	-.35***	-.18***	-.21***	-.18***	.53***	.59***	-		
Academic Performance														
13 Mother Rating	-.15***	-.14***	-.04	.10***	.23***	.18**	.14**	.21**	.14**	-.31***	-.27***	-.14***	-	
14 Father Rating	-.16***	-.16***	-.05	.08**	.22***	.20***	.16***	.21***	.15***	-.27**	-.30***	-.15***	.82***	-
Mean	0.68	0.15	2.26	2.75	3.74	3.63	4.33	4.31	2.51	0.23	0.22	0.37	3.27	3.29
SD	0.51	0.16	0.56	0.83	0.66	0.37	0.39	0.71	0.35	0.21	0.20	0.26	0.52	0.49

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 2. Gender Comparisons of LH and Other Variables

	Males		Females		t-test
	Mean	SD	Mean	SD	
Harshness & Unpredictability					
1 Unsafe Neighborhood	0.64	0.50	0.69	0.51	-1.76
2 Negative Life Event	0.15	0.17	0.15	0.17	-0.03
3 Family Chaos	2.26	0.53	2.25	0.57	0.36
4 Family Income Change	2.81	0.82	2.72	0.86	1.79
Slow LH Behavioral Profile					
5 Insight, Planning & Control	3.72	0.65	3.76	0.67	-0.87
6 Parent-Child Relationship	3.63	0.37	3.64	0.36	-0.54
7 Family Support	4.30	0.42	4.35	0.37	-2.21*
8 Social Support	4.23	0.71	4.38	0.72	-3.45**
9 General Altruism	2.48	0.34	2.55	0.35	-3.34**
Externalizing Behavior					
10 Mother Rating	0.25	0.22	0.21	0.20	3.33**
11 Father Rating	0.24	0.21	0.20	0.18	3.23**
12 Child Rating	0.37	0.26	0.36	0.26	0.42
Academic Performance					
13 Mother Rating	3.23	0.51	3.32	0.52	-2.87**
14 Father Rating	3.24	0.48	3.33	0.50	-3.17**

* $p < .05$, ** $p < .01$

Table 3. Correlations among Constructs in 10 Locations of 9 Countries

	Harshness & Unpredictability with Slow LH Behavioral Profile	Harshness & Unpredictability with Externalizing	Harshness & Unpredictability with Academic Performance	Slow LH Behavioral Profile with Externalizing	Slow LH Behavioral Profile with Academic Performance
Shanghai, China (<i>n</i> = 90)	-0.31	0.21	-0.31	-0.34	0.25
Medellin, Colombia (<i>n</i> = 89)	-0.42	0.44	-0.16	-0.31	0.24
Naples, Italy (<i>n</i> = 95)	-0.26	0.33	-0.13	-0.29	0.23
Rome, Italy (<i>n</i> = 106)	-0.35	0.48	-0.32	-0.41	0.34
Zarqa, Jordan (<i>n</i> = 104)	-0.12	0.23	-0.13	-0.51	0.53
Kisumu, Kenya (<i>n</i> = 94)	-0.12	0.04	-0.04	-0.25	0.27
Manila, Philippines (<i>n</i> = 97)	-0.05	0.32	-0.27	-0.41	0.16
Trollhättan/Vänersborg, Sweden (<i>n</i> = 106)	-0.30	0.30	-0.03	-0.15	0.33
Chiang Mai, Thailand (<i>n</i> = 101)	-0.27	0.28	-0.27	-0.38	0.39
Durham, North Carolina, United States (<i>n</i> = 269)	-0.27	0.18	-0.21	-0.33	0.18

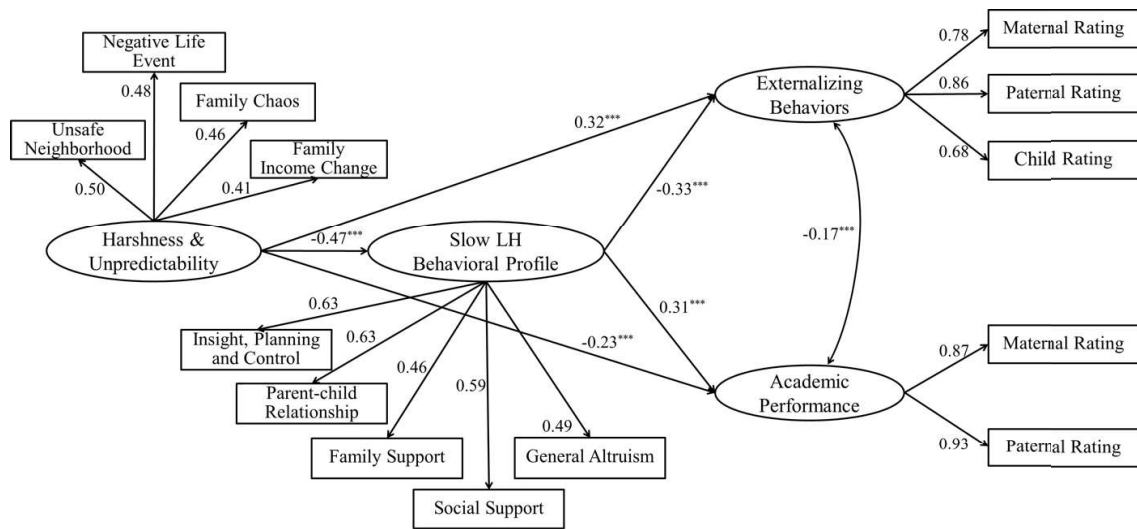


Figure 1. Life History Model of Adolescent Externalizing and Academic Performance.
 *** $p < .001$