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Effects of Harsh and Unpredictable Environments in Adolescence on Development of Life History Strategies:

A Longitudinal Test of an Evolutionary Model

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Abstract

The National Longitudinal Study of Adolescent Health data were used to test predictions from life history theory. We hypothesized that (1) in young adulthood an emerging life history strategy would exist as a common factor underlying many life history traits (e.g., health, relationship stability, economic success), (2) both environmental harshness and unpredictability would account for unique variance in expression of adolescent and young adult life history strategies, and (3) adolescent life history traits would predict young adult life history strategy. These predictions were supported. The current findings suggest that the environmental parameters of harshness and unpredictability have concurrent effects on life history development in adolescence, as well as longitudinal effects into young adulthood. In addition, life history traits appear to be stable across developmental time from adolescence into young adulthood.

Keywords

Life history theory; Add Health; Adolescent health; Environmental harshness; Environmental unpredictability

How do developmental experiences and personality processes in adolescence interact to shape quality of life in early adulthood? Life history theory, based in evolutionary biology, provides a powerful framework for addressing this important question. The theory focuses on analyzing individual differences in life history strategies, which constitute overarching patterns of development and behavior that affect many aspects of quality of life (e.g., health, relationship stability, and economic success). The current research tests hypotheses, derived from life history theory, about relations between types of development experience, individual differences in life history strategies, and related life outcomes. Drawing on the National Longitudinal Study of Adolescent Health (Add Health; Udry 2003), we show that

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both harsh and unpredictable environmental conditions contribute to development of life history strategies from adolescence into young adulthood.

Life History Theory

The key units of analysis in life history theory (Charnov 1993; Roff 1992, 2002; Stearns 1992) are life history traits: characteristics that determine rates of reproduction and associated patterns of growth, aging, and parental investment (e.g., size and number of offspring, amount of investment per offspring, age at sexual maturity, time to first reproduction, longevity). Life history theory attempts to explain variation in life history traits in terms of adaptive trade-offs in distribution of resources to competing life functions: maintenance, growth, and reproduction (Roff 2002; Stearns 1992). Each trade-off constitutes a decision node in allocation of resources, and each decision node influences the next decision node (opening up some options, foreclosing others) in an unending chain over the life course. This chain of resource allocation decisions—expressed in the development of a coherent, integrated suite of life history traits—constitutes the individual's life history strategy. These resource allocation decisions are not generally believed to be voluntary, conscious choices but instead are regulated by cascades of conditional developmental switches (West-Eberhard 2003).

Variation in mammalian life history strategies lies on a continuum that can be described as slow to fast (Promislow and Harvey 1990). At the slower end of this continuum are life history traits associated with slow rates of reproduction and population turnover. At any point on the continuum, life history traits cluster together to form coherent, integrated sets. As Kaplan and Gangestad (2005:73) have stated, "mammalian species on the fast end exhibit short gestation times, early reproduction, small body size, large litters, and high mortality rates, whereas species on the slow end have the opposite features." Comparative analysis of primate life history strategies reveals a marked slow-fast continuum (see Kappeler et al. 2003). As one of the great apes, humans are on the slow end of the slow-fast continuum, with a prolonged period of juvenile dependency, late age at onset of reproduction, and greater longevity than any other terrestrial mammal (e.g., Hawkes et al. 2003; Kaplan et al. 2000).

Although this slow life history strategy is a species-typical characteristic, humans also possess mechanisms for condition-dependent adjustment of life history strategies in their own lifetimes. Natural selection has favored mechanisms of phenotypic plasticity that enable individuals, within their species-typical range, to adjust their life history strategies (along the slow-fast continuum) to match local conditions (e.g., Belsky et al. 1991; Chisholm 1999; Ellis 2004; Vigil and Geary 2006; Worthman 2003). The current research tests developmental hypotheses about matching of young adult life history strategies to environmental conditions encountered in adolescence.

An assumption of life history theory is that strategies consist of biological and psychosocial life history characteristics that accumulate non-randomly. This coherent variation underpins a clustering of individual differences in how people approach various adaptive problems presented by the physical and social environment. For example, individuals employing *slower* life history strategies not only have fewer children, invest greater amounts of time and energy per child, and live longer (as posited by traditional life history theory; e.g., Charnov 1993; Roff 1992; Stearns 1992), they also manifest psychosocial traits that facilitate these strategies (Figueredo et al. 2006b). Thus, people pursuing slower strategies tend to be more committed to long-term relationships, think more in terms of long-term benefits rather than short-term gains, plan more for their children's future (e.g., by amassing more resources or providing avenues to enhance their children's social status), adhere more

closely to the social norms of modern industrialized societies, and have better health. Value systems and personality traits are likely to be manifestations of these strategies, as well (see Figueredo et al. 2006a). In total, cognitive and behavioral life history traits are just as essential to the reproductive strategy in humans as purely biological indicators.

A life history strategy can be characterized in humans by means of three primary kinds of life history traits: *biological*, *behavioral*, and *cultural*. To illustrate this conceptual breakdown, consider the traits associated with a slow life history strategy in humans. This strategy might be characterized by *biological* life history traits such as longer lifespan and high-quality offspring. In addition, this strategy could be characterized by *behavioral* traits such as long-term planning and parental investment. Behavioral and biological life history traits are relevant to organisms in general and are not specific to humans. Cultural manifestations of life history traits, however, may be considered more specific to humans, although some nonhuman cultural phenomena have been documented in the animal literature. Slow life history traits that are *cultural* manifestations may include contraception use, skill development, having a savings account, and home ownership. These activities are related to a slow strategy and consistent with longer lifespan, long-term planning, and parental investment. Slow strategists are therefore more likely than faster strategists to be psychologically predisposed to adopt them during their social development from the surrounding cultural milieu (see Lumsden and Wilson 1981). However, these life history traits are culturally acquired and may therefore vary across cultures (for empirical examples and further discussion, see Figueredo et al. 2004, 2006a; Hill and Kaplan 1999; Geary and Flinn 2001).

A body of empirical research has been conducted to test for a multivariate construct indexing individual difference in life history strategy in humans. Employing the National Survey of Midlife Development in the United States (MIDUS; Brim et al. 2000) database, psychometric analyses were conducted on a hypothesized higher-order life history factor (Figueredo et al. 2006a). Scales were constructed based on psychosocial dimensions theoretically related to life history strategy: personal (e.g., ways in which individuals used past knowledge to help plan for the future), familial (e.g., warmth in relationships with spouses, children, and other kin), and social (e.g., how much help one gave and received from friends). Factor analysis of scales based on these general dimensions yielded a single common factor, representing the dimension ranging from fast to slow life history strategies, found to explain 70% of the reliable variance among the scales. In addition to the personal, familial, and social dimensions, a health factor was constructed based on measures of subjective well-being, negative affect, positive affect, general health, and medical symptoms. In sum, these psychometric analyses, together with other related work (Figueredo et al. 2005a,b, 2004), indicate that there is a common underlying life history factor that is the behavioral expression of a life history strategy.

Development of Individual Differences in Life History Strategies

Development of traits, including life history strategies, is a product of both genetic and environmental influences. As a result, the nature/nurture issues that arise with any developmental study are also relevant to this study. Because of the scope and feasibility of the present research, we will only address *environmental* parameters as potential causal mechanisms. However, we acknowledge the possibility of gene-environment correlations in these data. Gene-environment correlations are generated when individuals with different genotypes selectively choose environmental niches to suit their divergent genetic predispositions, as well as when individuals with different genotypes differentially modify their environment (intentionally or unintentionally) by means of their divergent behavior (Buss 1987). Consequently, future research will be needed to disentangle the independent effects of genes.

Many of the constraints that organisms face are imposed by their ecology. Specifically, food supply and mortality hazards will greatly influence how beneficial a particular life history strategy may be (Kaplan and Gangestad 2005). According to contemporary life history theory, two primary environmental parameters (indirectly) influence the evolution of animals' life history strategies: the degree of harshness and the degree of unpredictability (see Ellis et al. 2009; Pianka 1970; Roff 2002; Stearns 1992).

Harshness of environments describes the general physical strain on the organism. Harsh environmental conditions increase morbidity and mortality and can be created by such factors as intrasexual competition, resource scarcity, pathogen prevalence, climate extremes, and predator threat. Absolute levels of morbidity and mortality are the core indicators of environmental harshness. *Unpredictability of environments* describes the degree to which there is unpredictable variability in the outcomes of adaptively significant behavior (Winterhalder and Leslie 2002). In unpredictable environments, the success of alternative strategies is largely random, such as when there is unpredictable variability in energy capture rates that follow from alternative foraging strategies, or in survival rates that follow from alternative predator-avoidance strategies, or in offspring survival rates that follow from alternative parental investment strategies. Unpredictability of environments is a function of the degree of stochasticity (unpredictable variation) in environmental risks (harshness); such risks are inconsistent over time and space and are thus largely unavoidable in unpredictable contexts (Ellis et al. 2009).

Associated with the distinction between harshness and unpredictability is the distinction between *uncontrollable* and *unpredictable* events. Uncontrollable events are aversive and have deleterious effects on both the mental and physical health of the organism. Unpredictable events are even more detrimental because they actually interfere with the ability of the organism to solve the adaptive problem of avoiding or escaping such aversive events in the future. An uncontrollable event is specifically defined as one in which the probability of that event is not related to the organism's behavior: whether an organism responds or not in any particular way is irrelevant to the likelihood of the outcome (Seligman et al. 1971). Although an event can be predictable without being controllable, controllable events are predictable by definition. Controllability can thus be seen as a special case of predictability, and an unpredictable environment is therefore also uncontrollable.

Effects of Harsh Environments

Life history theory and data indicate that humans have the ability to facultatively adjust their life history strategies in response to environmental conditions during development (e.g., Belsky et al. 1991; Chisholm 1999; Ellis 2004). Morbidity and mortality cues are especially relevant sources of information for calibrating life history strategies. Cues in the environment indicating high levels of adolescent and young adult mortality resulting from conspecific violence or predation should cause development of faster life history strategies (Bereczkei and Csanaky 2001; Ellis et al. 2009). These cues signal that it is beneficial to mature quickly and reproduce early (so as to reduce risk of dying prior to reproduction; Stearns 1992), particularly if bioenergetic resources are adequate for growth and reproduction.

There is empirical evidence that these processes operate in modern environments. For example, Daly et al. (2001) have examined homicide rates in Canada and the United States. They have shown that the best predictor of lethal violence is the amount of inequality in resource distribution: the greater the perceived disparity of resources, the higher the homicide rates (Daly et al. 2001). In a different study, Wilson and Daly (1997) found that neighborhoods in which individuals had shorter life expectancies (often due to greater risk of external mortality—e.g., homicide) were also neighborhoods with the youngest median

age of women giving birth. They argue that this is not the result of a lack of family planning, but rather it is a type of strategic planning (Wilson and Daly 1997). Likewise, a large developmental literature has documented reliable associations between involvement in violence (as perpetrator or victim) and faster life history strategies (i.e., early sexual debut, multiple sexual partners, adolescent pregnancy and childbearing; e.g., Fergusson and Woodward 2000; Kotchick et al. 2001; Miller et al. 2001; Serbin et al. 1991; Underwood et al. 1996).

Because the current study was conducted in the United States, we assumed that the sample had adequate levels of health and nutrition to support growth and reproduction; therefore, we focused our measure of environmental harshness on exposure to external mortality cues (of which there is great variation). The environmental harshness variable was operationalized as exposures to violence in adolescence that could potentially cause mortality. For example, the harshness variable included such items as how often you had seen someone get shot within the last year. We hypothesized that individuals who experienced harsher conditions in adolescence would develop faster life history strategies in adolescence and early adulthood (Fig. 1).

Effects of Unpredictable Environments

In an unpredictable environment, as in a volatile stock market, it does not pay to invest heavily in a single option. Rather, in unpredictable environments, individuals should bias life history development toward high offspring number (Stearns 1992) and diversity (often called “spreading the risk” or “bet-hedging”; Roff 2002). Such traits are indicative of a faster life history strategy. High offspring number and diversity increase the probability that at least some offspring will have phenotypes that are well-matched to their future environments. Consequently, we are using the idea of diversified (as opposed to conservative) bet-hedging, where this could be achieved through either genotypic or phenotypic variance (Einum and Fleming 2004). We hypothesized, therefore, that children growing up under unpredictable conditions would bias development toward faster life history strategies in adolescence and early adulthood (Fig. 1).

As conceptualized by Ellis et al. (2009), three basic sources of information about environmental unpredictability are available to the developing person: (1) individuals can directly experience temporally or spatially changing (stochastic) environments during development, (2) individuals can be exposed to the behavior of others that is indicative of environmental unpredictability, and (3) individuals can experience unpredictable variability in the outcomes of adaptively significant behavior (e.g., unpredictable survival rates that follow from alternative predator-avoidance strategies). Given the limitations of the Add Health data set, the current measure of environmental unpredictability indexed these latter two constructs, focusing on the behaviors of family members that are indicative of an unpredictable home life (e.g., unreliable parental care) and environmental contexts linked to unpredictable future outcomes (e.g., homelessness, removal from the family by Social Services).

We hypothesized that (1) in young adulthood an emerging life history strategy would exist as a common factor underlying many life history traits (e.g., health, relationship stability, economic success), (2) both environmental harshness and unpredictability would account for unique variance in expression of adolescent and young adult life history strategies, and (3) adolescent life history traits would predict young adult life history strategy. The model shown in Fig. 1 depicts these hypotheses and the various constructs that were assessed in this research.

Although distinctions between harshness and unpredictability have been well-articulated in the general life history literature (Stearns 1992; Roff 2002; Ellis et al. 2009), extant hypotheses about the effects of harshness and unpredictability on the development of life history strategies run in parallel (i.e., the hypothesized effects are in the same direction). Accordingly, the present research tests whether harshness and unpredictability uniquely predict individual differences in life history strategy but does not advance differential predictions about the effects of these variables.

Methods

Sample

Add Health Design and Data Organization—This research used the National Longitudinal Study of Adolescent Health (Add Health; Udry 2003) to test the life history hypotheses described above (for more detailed information, see: http://www.cpc.unc.edu/projects/addhealth). These data are nationally representative and were collected in three waves. Adolescents were first measured between grades 7–12 in 1994 (Wave I) and then again in 1996 (Wave II). Ages ranged from 11 years old to 20 years old, but most participants were between the ages of 12 and 18. Participants were reinterviewed in 2001–2002 (Wave III) as young adults, ages 18 to 26 years old. The current research used data from Wave I and Wave III.

The primary goal of Add Health was to examine adolescent health and risk behaviors in the many social contexts thought to influence health. These contexts include family, schools, and communities. Adolescent health and social factors relevant to the adolescent were the primary theoretical focus for the questions chosen and the breadth of populations sampled (e.g., parents and school administrators). Data collected included information on adolescents' social environments (e.g., differences in characteristics of families and communities), health-related behaviors (e.g., differences in personality and predispositions), and vulnerabilities/strengths (e.g., differences in degree of susceptibility or genetic endowments) (Harris et al. 2003; Udry 2003).

Wave I (i.e., adolescents) took place in two primary stages. First, a sample was taken from schools. This sample was a stratified random sample from all US high schools. Stratification of schools was based on clusters related to region, urbanicity, school size, school type, percent white, percent black, grade span, and curriculum. Approximately 90,118 adolescents completed the in-school questionnaires (Harris et al. 2003). The second stage in Wave I was an in-home sample. Adolescents were drawn from the core sample in addition to selected oversamples. In total, 20,745 adolescents completed the in-home survey, and their parents were also asked to participate and complete a questionnaire. Wave III (i.e., young adults) consisted of another in-home interview with subjects who could be relocated from Wave I; 15,197 young adults completed these in-home interviews (Harris et al. 2003).

Random Sampling—Since the Add Health database has approximately 20,000 subjects in Wave I and 15,000 subjects in Wave III, we generated several smaller datasets. Random samples were generated by assigning each subject a random number and then assigning subjects to groups based on that number. The created data subsets contained either 500, 1,000, or 2,000 subjects. By generating smaller data sets we were able to optimize the available resources by testing the models in successive stages of exploratory and confirmatory analysis. To avoid capitalizing on chance owing to sampling error, replication of results on statistically independent samples is essential (Gorsuch 1983). In mathematical statistics, a "large" sample is defined as between 300 and 500 subjects; thus a sample of 15,000 to 20,000 is unnecessary for purposes of hypothesis testing because there is a virtually negligible marginal gain of statistical power after a sample size of, say, 500.

Therefore, the optimal use of such a wealth of data is to create a number of statistically independent and mutually representative samples by random assignment to multiple subsamples for the purpose of exploratory model development and confirmatory replication. That way, any Type I errors made in the exploratory phases of analysis (as a result of sampling error) will fail to replicate in another random subsample and can thus be eliminated from the model (Cohen and Cohen 1983). This procedure does not address the generalizability of the findings to other populations, which might be systematically different, but it does address the problem of pure sampling (Type I) error, which is the main focus of statistical significance tests in structural equations modeling.

Measures

Measures were constructed to reflect the major components of life history theory. First, the environment was assessed in two primary ways—harshness indicated by extrinsic mortality risk and unpredictability indicated by unreliable home life. Second, life history strategies were assessed by traits related to somatic effort (e.g., health) and reproductive effort (e.g., romantic/sexual relationships). These domains were indexed by utilizing both behavioral and biological variables available in Add Health data. Finally, we examine the relationship between social deviance and classic life history traits. Some researchers have found that social deviance is often correlated with traits such as adolescent promiscuity (Rowe and Rodgers 1989), parental warmth and academic achievement (Rowe and Flannery 1994), and overall mating effort (Rowe et al. 1997). Others (e.g., Sefcek 2007) have found that deviant or psychopathic attitudes may be independent of life history, as more narrowly defined. Below we describe the measures in detail.

Environmental Conditions in Adolescence: Harshness—According to life history theory, mortality risk is a critical environmental parameter. We have labeled direct mortality risk as Environmental Harshness, which was operationalized as self-reported exposure to violence from conspecifics. There were seven items on this index. Example items included the frequency in which “You saw someone shoot or stab another person,” “Someone shot you,” and “Someone cut or stabbed you.”

Environmental Conditions in Adolescence: Unpredictability—Environmental unpredictability was measured by frequent changes or ongoing inconsistency in several dimensions of childhood environments. There were ten items on this index. Sample items include, “How often had your parents or other adult care-givers not taken care of your basic needs, such as keeping you clean or providing food or clothing?” “Have you ever stayed in a homeless shelter?” and “How often had you actually been taken out of your living situation by Social Services?”

Life History Traits in Adolescence: Health Indicators of Somatic Effort—The first core component of life history strategy is somatic effort: the energy and resources that an organism puts into its own health and well-being. This can come from internal factors such as immune function as well as lifestyle factors such as positive health behaviors (e.g., diet, exercise, utilization of health care). In the present study, somatic effort was indexed by general physical and mental health.

Physical Health: Physical health was measured by one’s general overall health based on a wide range of physical symptoms. This scale contained 24 items. Example symptoms include, “How often have you had a sore throat or a cough?” and “How often have you had dizziness?”

Mental Health: Positive Affect: Positive mental health was measured by self-report of general feelings of well-being. There were eight items in this scale. Example items are, "You enjoyed life" and "You like yourself just the way you are."

Mental Health: Negative Affect: Negative mental health was measured by self-report of general feelings of sadness or unhappiness. This scale contained 15 items, such as "It was hard to get started doing things" and "You felt life was not worth living."

Life History Traits in Adolescence: Sexual Attitudes and Behavior as Indicators of Reproductive Effort—The other core component of life history strategy is reproductive effort: energy and resources put into the acquisition of mates, the production of new organisms, and parental investment in offspring. In the present study, assessment of reproductive effort in adolescence focused primarily on the acquisition of mates (sexual attitudes and behavior), since very few individuals had produced offspring at this time.

Attitudes about Sexual Behaviors: We measured attitudes about sexual behaviors as one's attitude and/or opinion about the consequences of having sexual intercourse. The 13 items used in this scale include, "If you had sexual intercourse, afterward, you would feel guilty." "If you had sexual intercourse, it would relax you." "If you got [someone] pregnant, it would be embarrassing for you."

Pregnancy: Pregnancy was measured by one's report of how often a relationship ended in a pregnancy. This was asked of both males and females. There were six items in this scale. Each item referred to a different type of partner (e.g., first romantic partner, third non-romantic partner) and the following item was asked: "My partner [I] got pregnant."

Attitudes toward Contraception/Contraception Use: Frequency of and attitudes toward use of birth control were assessed through five self-report items, such as "Did you or your partner use any method of birth control the first time you had sexual intercourse?" "Did you or your partner use any method of birth control when you had sexual intercourse most recently?" "In general, birth control is too much of a hassle to use."

Life History Traits in Adolescence: Social Deviance—In addition to the more traditional life history traits, there is a current debate within evolutionary psychology as to whether behaviors related to risk taking, delinquency, and impulsivity are also life history traits relevant to human life history strategy. Therefore, the current study included social deviance items to test how these behaviors are related to the life history traits of somatic and reproductive effort.

Delinquency: Delinquency was measured by behaviors that have destructive consequences or are deemed socially destructive. The 15 items include, "In the past 12 months, how often did you take something from a store without paying for it?" "In the past 12 months, how often did you paint graffiti or signs on someone else's property or in a public place?"

Consequences of Alcohol Use: Consequences of alcohol use were measured by participants' self-report of problems that have occurred as a result of alcohol consumption. There were nine items. Examples are "Over the past 12 months, how many times were you hung over?" and "You got into trouble with your parents because you had been drinking."

Drug Use: Drug use was measured by how frequently the participant reported using cocaine, heroin, and illegal drugs in general. The five items in this index include, "During

your life, how many times have you used cocaine?" and "During the past 30 days, how many times did you use any of these types of illegal drugs?"

Life History Traits in Young Adulthood: Health Indicators of Somatic Effort

Physical Health: Physical health in young adulthood was measured by one's general overall health based on level of function in daily activities. There were 26 items in this scale, such as "Have you had a physical or nervous condition that has kept you from working?" and "In general, how is your health?"

Mental Health: Mental health was defined as the combination of levels of positive and negative affect in one's general overall well-being. The 16 items in this scale include, "Have you ever been diagnosed with depression?" and "You enjoyed life, during the past seven days."

Life History Traits in Young Adulthood: Sexual Activity Indicators of Reproductive Effort

Sex Behaviors: Sex behaviors in young adulthood were measured by whether or not someone had had intercourse, the frequency thereof, and with how many partners. The four items in this scale include, "Have you ever had vaginal intercourse?" and "With how many partners have you ever had vaginal intercourse, even if only once?"

Contraception Use: Contraception use was measured by self-reported use of a method of contraception. There were three items in this scale. Sample items are, "Did you or <PARTNER> use any method of birth control when you had vaginal intercourse?" and "Did you or <PARTNER> use any method of birth control the first time you had vaginal intercourse?"

Life History Traits in Young Adulthood: Resource Accruing Potential as Indicators of Reproductive Effort: Since young adults are in the early stages of producing offspring or preparing to have children, it was important to include a factor related to accrual of resources (parental investment potential). Therefore, for young adulthood, we developed measures of reproductive effort that indexed the person's ability to invest resources in offspring in the future (i.e., measures related to job security, financial stability, and education).

Work History: Work history was measured by three items related to employment history and current employment, such as "Have you ever worked for nine weeks or more at a paying job that was at least 10 hours a week?" and "Are you currently working for pay for at least 10 hours a week?"

Education: Education was measured by how many levels of education were completed. The seven items in this index included whether the person had received a high school diploma or a bachelor's degree.

Government Aid: Government aid was measured by the amount and variety of government aid an individual reported receiving. This scale had nine items; for example, "During any part of {2000/2001} did you receive income from unemployment insurance, workmen's compensation, disability, or social security benefits, including SSI (supplemental security income)?" and "Are you getting food stamps now?"

Financial Responsibilities: Financial responsibilities were measured by a range of financially relevant activities and possessions. The six items in this scale include, "Do you own a car, truck, van, or motor cycle?" and "Do you have a savings account?"

Financial Insecurity: Financial insecurity was indexed by events that result from being financially insecure, such as being unable to pay utilities. This scale consisted of seven items; for example, "In the past 12 months, was there a time when {YOU/YOUR HOUSEHOLD} didn't pay the full amount of a gas, electricity, or oil bill because you didn't have enough money?" and "In the past 12 months, was there a time when {YOU/YOUR HOUSEHOLD} needed to see a doctor or go to the hospital, but didn't go because {YOU/THEY} could not afford it?"

Life History Traits in Young Adulthood: Social Deviance

Delinquency: Delinquency in young adulthood was measured by behaviors that have destructive consequences or are deemed socially destructive. There were 18 items, such as "In the past 12 months, how often did you deliberately damage property that didn't belong to you?" and "In the past 12 months, how often did you deliberately write a bad check?"

Consequences of Alcohol Use: Consequences of alcohol use were measured by participants' self-report of problems that have occurred as a result of alcohol consumption. The nine items included, "Over the past 12 months, how many times did you get into a sexual situation that you later regretted because you had been drinking?" and "During the past 12 months, how many times did the following thing happen? You had problems at school or work because you had been drinking."

Impulsivity: Impulsivity was measured by self-reporting of ability or inability to control certain behaviors or thoughts. This scale had seven items. Examples are, "I often try new things just for fun or thrills, even if most people think they are a waste of time" and "I often do things based on how I feel at the moment."

Machiavellian Beliefs: Machiavellianism is the degree to which an individual employs cunning, sly, or crafty methods to obtain the things he or she desires. This scale was measured by self-reported Machiavellian-like behavior. This scale had three items. Items include, "I can usually get people to believe me, even when what I'm saying isn't quite true" and "I like it when people can do whatever they want, without strict rules and regulations."

Statistical Analyses

All statistical analyses were performed using SAS version 8.2 (SAS Institute 1999).[1]

Item Selection—According to the a priori hypotheses, several content domains were specified. The first author read Wave I and Wave III codebooks and chose items that corresponded to the theoretically specified content domains (e.g., mental health, delinquency, contraception use). This method of scale construction is often used with Add Health items (see Zweig et al. 2001; Galliher et al. 2004). A total of 235 items were chosen to construct the scales. A complete list of items used to construct each scale is available upon request from the first author.

Scale Construction: Internal Consistency Reliability—Table 1 displays a list of computed (aggregated) scales and their alpha reliability coefficients. Each item that was originally chosen for inclusion on theoretical grounds was retained unless (*a*) it substantially reduced the internal consistently of the scales and (*b*) it was of minor theoretical importance. Final scales were calculated by taking the mean of the standardized items that were retained

[1]All Cronbach's alphas and bivariate correlations used PROC CORR. Exploratory factor analyses used PROC FACTOR, with initial communality estimates using squared multiple correlations and principal axis estimation. Scree tests and proportions of variance accounted for determined the optimal number of factors to be retained. Confirmatory factor analyses and Structural Equation Modeling used PROC CALIS.

through this process; reverse-scored items were keyed appropriately.[2] Cronbach's alphas were then computed for each scale. An alpha coefficient of 0.70 or greater is a commonly used cutoff to denote reasonable internal consistency reliability; because some content domains are known to have fairly low reliabilities (e.g., self-reports of sexual behaviors), however, some scales had alphas between 0.60 and 0.70 (Table 1).

Emergent Variables—It was not theoretically logical to make several of the content domains into a scale consisting of a mean of multiple items. These content domains were better represented as emergent variables, in which the indicator variables are thought to cause an underlying construct, rather than the other way around (i.e., the latent variable causing the indictors). Although each indicator (or item) contributes to scores on the emergent construct, these indicators do not necessarily correlate with each other (Kline 2006). Such items can be thought of as risk factors. For example, several things may increase the chance of developing heart disease. Smoking, poor diet, and genetic predispositions are all factors that may contribute to the disease, but they are not necessarily correlated with each other. However, the more risk factors one has, the greater the risk of developing heart disease.[3]

Items selected as indicators for emergent constructs were implicitly weighted based on the standardized score of that item. The reasoning is that the rarer a high score on an item, the more weight it should have. One's exposure to violence, for example, included such items as "how often you had been beaten up" and "how often you had been shot." Presumably being shot should occur less frequently and constitute a more severe or salient exposure to violence than being beaten up. The following variables were conceptualized and constructed as emergent variables: Environmental Unpredictability, Environmental Harshness, Drug Use, Work History, and Education.

Multivariate Analyses

Measurement Model: A measurement model is composed of measured variables and hypothetical constructs (Campbell and Fiske 1959). Exploratory Factor Analysis (EFA) procedures are empirically driven procedures that generate latent constructs, or factors, based on the correlations between manifest variables (Gorsuch 1983). Confirmatory Factor Analysis (CFA) procedures are theory driven, and the relationships between the manifest variables and their respective factors are specified a priori (Loehlin 2004). In the present analyses, each theoretically specified manifest variable was first subjected to an EFA on an exploratory sample and subsequently a CFA on an independent sample. Scree tests and proportions of variance accounted for determined the optimal number of factors to be retained in the EFA. Only the CFA results are reported in this paper (Figs. 2 and 3).

Structural Model: The structural model is the part of the model that tests theoretically specified causal pathways, typically between the latent variables. In the current paper, the

[2]An item was coded as missing data when participants left an item blank, refused to answer a question, had a legitimate skip, did not know the answer, or the question was not applicable. Some items were constructed so that certain responses led respondents to skip over a set of questions, thus leading to systematically missing data. When theoretically appropriate, this problem was addressed for questions conducive to logical imputation of scores. When questions were phrased in both a positive and negative direction, items were reversed so that a high score on one item was theoretically consistent with a high score on another item. Of the items selected, scores varied in metric; for example, items were formatted as yes/no questions, Likert scale rating, and years engaged in a particular activity. Consequently, it was necessary to standardize the items prior to creating scales or examining internal consistency. By standardizing each item, one can compare scores across items that originally had disparate scores. Items that were internally consistent were used for the construction of scales. Each scale was calculated by taking the mean of the standardized items that had previously met the Cronbach's alpha criteria.

[3]Another common example and an emergent construct is socioeconomic status (SES). Indicators such as income and education are thought to cause SES rather than SES causing income and education (Kline 2006).

structural model consists of pathways between latent factors as well as emergent constructs (the environmental conditions in adolescence shown in Fig. 1).

First, an inclusive model was constructed in which all plausible theoretical pathways between the latent constructs and emergent variables were specified, and this model was tested on a random subsample of the Add Health data. Second, a restricted model, in which all of the nonsignificant pathways had been removed, was tested on the same subsample for purposes of model development. Third, this restricted model was cross-validated on a second, independent, random subsample to test for Type I errors that may have been made in the initial exploratory analysis. If any Type I errors had occurred in the respecification of the model tested on the first subsample, then those pathways would be found nonsignificant in the second sample. The replication of the cross-validated model using the second sample is reported below.

Results

Goodness-of-Fit of Factor Analytic Structural Equation Model

Table 2 shows the statistical and practical fit indices of the final restricted structural model (shown in Fig. 4). The path coefficients are the standardized coefficients. Only the standardized path coefficients of the replicated cross-validation model are shown. With only one exception, all coefficients remained significant. The final causal model indicates that we have explained 54% of the variance in the higher-order life history factor. In addition, we have explained 13% of the variance in the young adult social deviance factor. This indicates that our environmental and adolescent life history predictors account for a substantial portion of the variance in our young adult life history factors.

Interpretation of the Fit Indices

The chi-square fit index indicates that our model was significantly different from the saturated model. This might suggest that our model is a poor fit to the data. However, chi-square tests are sensitive to sample size, and this model was tested on a large number of subjects (N=799). With this large a sample size, no model is likely to fit by purely statistical criteria (Schermelleh-Engel et al. 2003). The RMSEA fit index was 0.056, and according to the criterion proposed by Steiger (1989), this indicates that we have a very good fit (Loehlin 2004). The GFI fit index was 0.919. Although Hu and Bentler (1995, 1999) recommend stricter criteria (0.95 or greater) for the designation of a good fit, according to standards discussed by Loehlin (2004), a GFI above 0.90 suggests a good fit of the model to the data. The CFI, on the other hand, was 0.830, which does not meet the 0.90 criterion of a good fit (Bentler and Bonett 1980). Often fit indices may seem to contradict each other; however, different fit indices use different estimation methods and have varying degrees of sensitivity to sample size, model parsimony, and number of indicators per factor (Schermelleh-Engel et al. 2003). Taken together, the authors conclude that these fit indices indicate a moderately good fit of our model to the data. The authors also acknowledge a trade-off that has to be made between precise model fit and model generalizability. We felt that it was important to keep the model theoretically intact, at the cost of a precise model fit, for purposes of generalizability and replicability to other samples. The cross-validation model yielded fit indices essentially identical to the original model, suggesting that while the fit is not perfect, it is robust.

Measurement Model: Life History Traits in Adolescence

Health—Three manifest variables served as indicators for a general health factor in adolescence. These indicators were physical health, mental health: positive affect, and

mental health: negative affect. The factor loadings were moderate to high and are shown in Fig. 2.

Sexual Restrictedness—Three manifest variables were used as indicators of reproductive effort in adolescence: risky sexual behaviors, contraception use, and whether an individual had experienced a pregnancy. These indicators were coded so that higher scores denoted lower adolescent reproductive effort (e.g., less risky sexual behavior); thus, the factor was labeled "sexual restrictedness." The factor loadings were moderate and are shown in Fig. 2.

Social Deviance—The social deviance factor in adolescence is composed of several indicators which include delinquency, drug use, and negative behavioral consequences of alcohol use. The factor loadings ranged from low to high and are shown in Fig. 2.

Measurement Model: Life History Traits in Young Adulthood

Health—There were two indicators of health in young adulthood. Positive and negative affect were measured as just one construct, mental health. The second indicator was physical health. The factor loadings were moderate and are shown in Fig. 3.

Sexual Restrictedness—There were two indicators of sexual restrictedness in young adults: general sexual behaviors and contraception use. Owing to coding problems inherent in the Add Health data, we were not able to include pregnancy information. The factor loadings were low to moderate and are shown in Fig. 3.

Resource Accruing Potential—There were five indicators of resource accruing potential in young adulthood: work history, level of education, amount of reliance on government aid, amount of financial responsibilities, and overall financial insecurity. The factor loadings were moderate and are shown in Fig. 3.

Social Deviance—The social deviance factor in young adulthood consisted of four indicators: delinquency, negative behavioral consequences of alcohol use, impulsivity, and Machiavellianism. The factor loadings were moderate to high and are shown in Fig. 3.

Higher-Order Life History Factor

As predicted, a coordinated higher-order life history factor was found in young adults. The factor loadings for the higher-order factor were moderate to high and are shown in Fig. 4. There was a positive significant loading of health, sexual restrictedness, and resource accruing potential on the higher-order life history factor, providing evidence of a coordinated life history strategy at this life stage. Although social deviance *did not* load on the higher-order factor, it was still significantly associated with important life history variables. Implications for this finding are addressed in the discussion.

Structural Model

Figure 4 displays the path diagram for the structural equations model. All path coefficients shown are standardized regression (β) weights, estimated by maximum likelihood, and are statistically significant ($p<0.05$) when denoted by an asterisk (*).

Environmental Predictors of Adolescent Life History Strategy—In adolescence, environmental unpredictability had a direct negative effect ($\beta=-0.21$) on overall adolescent health, indicating that environmental unpredictability is associated with a faster life history strategy (less somatic effort). Also in adolescence, environmental harshness had a direct

negative effect (β=−0.44) on sexual restrictedness, indicating that exposure to mortality risks was associated with a faster life history strategy (more reproductive effort). In addition, there was a direct positive effect (β=0.61) of environmental harshness on adolescent social deviance. There was no unique effect of environmental harshness, however, on overall adolescent health.

In addition to these effects of the environmental variables on the adolescent life history factors, the life history factors in turn were modestly associated with adolescent social deviance. Specifically, both health (β=−0.22) and sexual restrictedness (β=−0.11) had direct negative effects on adolescent social deviance.

Environmental Predictors of Young Adulthood Life History Strategy—The environmental variables had both direct and indirect effects on life history strategy in young adulthood. Environmental unpredictability had a direct negative effect (β=−0.30) on young adult life history strategy: more unpredictability was associated with a faster life history strategy. In addition, environmental unpredictability had a direct positive effect (β=0.13) on young adult social deviance. Unpredictability also had an indirect effect on young adult life history strategy through adolescent health. Whereas unpredictability in adolescence was associated with relatively poor health in adolescence (β=−0.21), better adolescent health had a direct positive effect (β=0.54) on slower life history strategy in young adulthood. Harshness of the environment in adolescence had no direct effects on young adult factors. However, it did have two indirect effects. The first indirect effect operated through adolescent sexual restrictedness (β=−0.44), which in turn had a positive direct effect (β=0.25) on slow young adult life history strategy. The other indirect effect operated through adolescent social deviance (β=0.61), which in turn had a positive direct effect (β=0.23) on young adult social deviance. All of these findings indicate that environmental unpredictability and harshness in adolescence have direct and indirect effects leading to a faster life history strategy in young adulthood.

Adolescent Life History Predictors of Young Adult Life History—Three main factors were measured in adolescence: sexual restrictedness, social deviance, and health. Adolescent sexual restrictedness had a positive direct effect (β=0.25) on a slow young adult life history strategy and a negative direct effect (β=−0.15) on young adult social deviance. Adolescent social deviance had a positive direct effect (β= 0.23) on young adult social deviance. Adolescent health had a positive direct effect (β=0.54) on a slow young adult life history strategy. These findings suggest that adolescent life history strategy is consistent across developmental time and can predict life history strategy in young adulthood. For example, if one has a faster life history strategy in adolescence, one is more likely to have a faster strategy in young adulthood.

Overview of Findings

The predictions set forth in the introduction were generally supported in the final set of the model. According to life history theory, harshness and unpredictability are predicted to be similar in their effects on life history strategy (see Ellis et al. 2009 for review). Therefore, we did not predict that harshness and unpredictability would be associated with different life history traits. However, unpredictability in adolescence made significant contributions to life history traits associated with health in adolescents but did not make significant contributions to adolescent sexual restrictedness or social deviance. As predicted, unpredictability did have lasting effects that were significantly linked to life history strategy in young adults. As predicted, environmental unpredictability forecast life history traits on the faster end of the life history dimension. Environmental harshness in adolescence also made significant contributions to life history traits associated with sexual restrictedness and social deviance in

adolescents, although harshness did not significantly predict adolescent health. Again, as predicted, harshness of the environment was associated with adolescent life history traits on the faster end of the spectrum. However, we found no subsequent direct contributions of harshness in adolescence on young adult life history strategy.

It was also found, as predicted, that life history traits in adolescence were fairly stable across time and contributed significantly to life history strategy in young adults. Although health, sexual restrictedness, and resource accruing potential yielded loadings from a higher-order factor, social deviance was uncorrelated. However, adolescent environmental predictors had effects on both the higher-order factor and the social deviance factor in young adulthood. We did not find that health, sexual restrictedness, and social deviance could be explained by a single higher-order life history factor in adolescence. This could be due to the fact that social deviance does not appear to be part of a life history factor in general. Consequently, this left only two factors, health and sexual restrictedness, and as a result there may have been too few indicators to make up a higher-order factor.

Additional Statistical Analyses

To test whether the final model fit males and females equally well, we used multisample analyses. First, the structural model was tested on males and females separately and with parameters unconstrained to be equal across the two samples. Second, the model was tested on males and females with parameters constrained across samples. For both cases, the parameters were negligibly different between males and females and the fit indices were essentially the same for both the constrained and unconstrained models (see Table 3). This indicates that our final structural model can explain life history patterns of behavior equally well for both males and females.

We tested whether or not there was a statistical interaction between the environment variables, harshness and unpredictability. To do this we tested the final structural model with the inclusion of the interaction term allowed to correlate with the environment variables, but with no other parameters specified. We then compared the fit indices of this model to the original model. The average standardized residual of the interaction term with the other variables was −0.019 with a standard deviation of 0.053. In addition, the practical and parsimonious fit indices were essentially identical between the two models. The following are the practical and parsimonious fit indices for the purely “additive” model *without* the interaction term included: RMSEA=0.06, GFI=0.92, CFI=0.84. The following are the fit indices for the model *with* the interaction term included, but with no structural pathways specified from the interaction term to any other variables except for unexplained correlations with the constituent main effects: RMSEA=0.06, GFI=0.91, CFI=0.82. Together, the similarity of parameter estimates and fit indices indicate that the interaction between harshness and unpredictability is not correlating with or explaining variance in the other variables in the model, thus suggesting that the environment terms are, in fact, additive in their effects. This is because including the interaction term did not require fitting any additional pathways to any of the other variables in the model, which would have been necessary to achieve an equivalent fit had nonadditive effects actually existed in the data.

Discussion

Past research has shown that health, personal attributes, and social relationships in middle-aged adults could be explained by a higher-order life history factor (Figueredo et al. 2006a). These findings indicated that there is a coherent life history strategy in mid-adulthood. The current research provides an interesting extension of this work. First, we also found a higher-order life history factor in young adulthood. This implies that by the time people reach their mid-twenties, they have formed a coherent life history strategy that is

characterized by their overall health, approach to romantic and sexual relationships, and the amount of effort they have put into education and employment. Second, we found that in adolescence, life history traits were related to each other but *did not* form a higher-order factor, likely for reasons described above. However, life history traits in adolescence *did* predict life history strategy in young adulthood. We found that the harshness and unpredictability of the environment were linked to adolescent life history traits, that environmental unpredictability continued to have lasting direct effects in young adulthood, and that both harshness and unpredictability had indirect effects on young adult life history strategy through the adolescent life history factors.

Other researchers have found that characteristics of neighborhoods and homes are associated with substance abuse, delinquency, and sexual behaviors. For example, Fick and Thomas (1995) found a positive relationship between youths' exposure to violence and their likelihood of cigarette smoking. Barry and colleagues (2005) found an association between maternal stress in the home and delinquent behaviors exhibited in their children. Browning et al. (2005) also found that onset of first sexual intercourse was earlier in adolescents who had lower parental monitoring and exposure to low socioeconomic neighborhood factors (see also Ellis et al. 2003). Nevertheless, the present research does more than simply report how adolescent environments and life outcomes are related: it has provided a theoretical framework—life history theory—for understanding the interrelatedness across an entire array of environmental factors and life outcomes. In addition, we have specified specific aspects of the environment that are theoretically predicted to be the primary contributing factors influencing life outcomes. Our research suggests that it is not just general stress in neighborhood or home environment that influences the development of life history strategy, but specifically harshness (mortality risk) and unpredictability (stochasticity) of the environment that are the primary influences on the development of a slow or fast life history strategy.

Contributions

A major strength of this research was the analytic rigor under which the model was developed. Cross-validation and replication of findings were employed at every major level of analysis. First, we took advantage of our large initial sample size (approximately 15,000 participants) and randomly selected and assigned participants to many smaller subsamples. Doing this allowed us the advantage of having many random samples at our disposal for purposes of cross-validation. Second, individual factors (e.g., health, sexual restrictedness) were individually constructed on one subsample and then cross-validated on a separate subsample using confirmatory factor analytic techniques. Second, the final structural equations model was tested and modified on one subsample and then cross-validated on an independent subsample. This level of replication is necessary to achieve confidence that one's factors and path models are stable and not obtained by chance. These intensive cross-validation methods are rarely done and should be implemented more often.

In addition to cross-validating the general model, we were able to show that the same structural model fit equally well for males and females. This suggests that the *structure* of life history strategy operates similarly for both sexes. This does not, however, imply that males and females have identical strategies. There may be mean-level differences in life history strategy (e.g., males on average pursue faster strategies that females), while the dynamics of the strategies pursued are similar.

Another strength of this research was our explicit measurement and testing of environmental harshness versus unpredictability. Life history theory posits that organisms pursue strategies that best help them allocate energy toward different survival and reproductive activities. The ecology is a major factor in determining the optimal allocation of energy. Based on life

history theory and data, unpredictability and harshness should be measured as separate aspects of the ecology (Stearns 1992; Roff 2002; Ellis et al. 2009). Each should have unique effects on the development of life history strategies along the slow-fast continuum. Slow life histories should be associated with low environmental harshness and low environmental unpredictability. In these environments, long-term planning pays off because it is likely that the organism will survive into late adulthood. Specific patterns of resource allocation will optimize the organism's fitness, including putting more energy into growth, investment in offspring, and body maintenance. Fast life history strategies should be associated with high environmental harshness and high environmental unpredictability. In these ecologies, there is less certainty that the organism will live until late adulthood, and so long-term planning does not necessarily pay off. These organisms better maximize their fitness through resource allocation that produces many offspring, less investment in each offspring, quicker maturation, and reproduction at an earlier age. The present study empirically tested (*a*) whether environmental unpredictability and harshness predicted life history strategies on a slow-fast continuum (as described above) and (*b*) whether each environmental parameter made unique contributions to life history strategy. We found support for both of these predictions, indicating the importance of incorporating these environmental parameters separately when testing life history in humans.

Additionally, the present study tested longitudinal hypotheses about the stability of life history traits across developmental time. Previous models have only been based on cross-sectional data and have not provided evidence for stability of life history strategy over time (Figueredo et al. 2004, 2006a). This research indicates that life history strategy is persistent over at least part of the lifespan. In addition, it appears that over developmental time individual life history traits become more coherent and constitute a coordinated strategy.

Limitations and Future Directions

The most fundamental limitation of this research is that it was a naturalistic, observational study and, therefore, could not determine causation. For the two primary environmental variables—harshness and unpredictability—to have causal traction, they must, to a meaningful degree, be "extrinsic" or "exogenous" to the developing person. By this reasoning, the person is "placed" in environments falling along these continua and responds accordingly. However, it is likely that the current environmental variables were not fully exogenous in adolescence. That is, adolescents' own behaviors, including genetically influenced personality dispositions, may have influenced that extent to which they were exposed to harsh and possibly even unpredictable environments. Moreover, these same personality dispositions may affect variation in life history strategies, which past research has shown is substantially heritable (Figueredo et al. 2004). Thus, the reported effects of environmental harshness and unpredictability may not have been fully causal. Environmentally informative studies that control for genetic confounds (e.g., Rutter 2005) are needed to address this issue.

Another limitation of the current research is that Add Health was not designed to test life history evolution. The present analyses relied on secondary analyses of variables that were present in the Add Health database. Because of this, we were unable to measure several domains important to life history theory. For example, variables measuring investment from parents in offspring were sparse.

We also acknowledge that our data are self-reported and therefore carry all the known validity problems associated with this type of data. However, we believe that utilizing the rich data source that Add Health provides, as a starting place for model development, is justified. As our research progresses, it will be important to find ways of measuring life history traits that do not rely solely on self-reporting.

The present research was also limited in its ability to explain why social deviance was not part of the higher-order life history factor in young adulthood. Social deviance was predicted to be associated with an overall life history strategy; however, in the present study it was not directly related to the other life history traits in young adulthood. This finding is in contradiction to past theoretical work in which it was strongly suggested that social deviance variables could be interpreted as constituting part of a larger life history construct (e.g., Figueredo et al. 2006b). There could be several reasons why the present data did not support this prediction. Perhaps social deviance is not yet incorporated into a life history strategy in young adulthood but becomes part of an overall strategy later, in middle adulthood. A second reason could simply be that social deviance is related to life history strategy but should not be considered indicative of actual life history traits. The present research was not able to answer this question, and future work will need to more closely address this discrepancy.

Ultimately, we believe that this paper has made an important step in understanding the structure of life history development in humans. There may be much value for future researchers in distinguishing between harsh and unpredictable childhood environments and examining their relative impacts on life history strategy.

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References

Barry TD, Dunlap ST, Cotten SJ, Lochman JE, Wells KC. The influence of maternal stress and distress on disruptive behavior problems in boys. Journal of the American Academy of Child and Adolescent Psychiatry 2005;44(3):265–273. [PubMed: 15725971]

Belsky J, Steinberg L, Draper P. Childhood experience, interpersonal development, and reproductive strategy: an evolutionary theory of socialization. Child Development 1991;62(4):647–670. [PubMed: 1935336]

Bentler PM, Bonett DG. Significance tests and goodness of fit in the analysis of covariance structures. Psychological Bulletin 1980;88:588–606.

Bereczkei T, Csanaky A. Stressful family environment, mortality, and child socialisation: life-history strategies among adolescents and adults from unfavourable social circumstances. International Journal of Behavioral Development 2001;25(6):501–508.

Brim, OG.; Baltes, PB.; Bumpass, LL.; Cleary, PD.; Featherman, DL.; Hazzard, WR., et al. National survey of midlife development in the United States MIDUS), 1995–1996. Ann Arbor, MI: Inter-University Consortium for Political and Social Research [distributor]; 2000. [Computer file]. ICPSR version. Ann Arbor: DataStat, Inc./Boston: Harvard Medical School, Dept. of Health Care Policy [producers], 1996

Browning CR, Leventhal T, Brooks-Gunn J. Sexual initiation in early adolescence: The nexus of parental and community control. American Sociological Review 2005;70:758–778.

Buss DM. Selection, evocation, and manipulation. Journal of Personality and Social Psychology 1987;53:1214–1221. [PubMed: 3320336]

Campbell DT, Fiske DW. Convergent and discriminant validation by the multitrait-multimethod matrix. Psychological Bulletin 1959;56:81–105. [PubMed: 13634291]

Charnov, EL. Life history invariants: some explorations of symmetry in evolutionary ecology. New York: Oxford University Press; 1993.

Chisholm, JS. Death, hope and sex: Steps to an evolutionary ecology of mind and morality. New York: Cambridge University Press; 1999.

Cohen, J.; Cohen, P. Applied multiple regression/correlation analysis for the behavioral sciences. Hillsdale, NJ: Lawrence Erlbaum; 1983.

Daly M, Wilson M, Vasdev S. Income inequality and homicide rates in Canada and the United States. Canadian Journal of Criminology 2001 April;:219–236.

Einum S, Fleming IA. Environmental unpredictability and offspring size: conservative versus diversified bet-hedging. Evolutionary Ecology Research 2004;6:443–455.

Ellis BJ. Timing of pubertal maturation in girls: an integrated life history approach. Psychological Bulletin 2004;130(6):920–958. [PubMed: 15535743]

Ellis BJ, Bates JE, Dodge KA, Fergusson DM, Horwood JL, Pettit GS, et al. Does father absence place daughters at special risk for early sexual activity and teenage pregnancy? Child Development 2003;74:801–821. [PubMed: 12795391]

Ellis BJ, Figueredo AJ, Brumbach BH, Schlomer G. Fundamental dimensions of environmental risk: The impact of harsh versus unpredictable environments on the evolution and development of life history strategies. Human Nature 2009;20 in press.

Fergusson DM, Woodward LJ. Educational, psychosocial, and sexual outcomes of girls with conduct problems in early adolescence. Journal of Child Psychology and Psychiatry 2000;41:779–792. [PubMed: 11039690]

Fick AC, Thomas SM. Growing up in a violent environment: Relationship to health-related beliefs and behaviors. Youth and Society 1995;27(2):136–147.

Figueredo AJ, Vásquez G, Brumbach BH, Schneider S. The heritability of life history strategy: The K-factor, covitality, and personality. Social Biology 2004;51:121–143. [PubMed: 17019827]

Figueredo, AJ.; Sefcek, J.; Vásquez, G.; Brumbach, BH.; King, JE.; Jacobs, WJ. Evolutionary personality psychology. In: Buss, DM., editor. Handbook of evolutionary psychology. Hoboken, NJ: Wiley; 2005a. p. 851-877.

Figueredo AJ, Vásquez G, Brumbach BH, Sefcek JA, Kirsner BR, Jacobs WJ. The K-Factor: Individual differences in life history strategy. Personality and Individual Differences 2005b;39(8): 1349–1360.

Figueredo AJ, Vásquez G, Brumbach BH, Schneider S. The K-factor, covitality, and personality: A psychometric test of life history theory. Human Nature 2006a;18:47–73.

Figueredo AJ, Vásquez G, Brumbach BH, Schneider S, Sefcek JA, Tal IR, et al. Consilience and life history theory: from genes to brain to reproductive strategy. Developmental Review 2006b; 26:243–275.

Galliher RV, Rostosky SS, Hughes HK. School belonging, self-esteem, and depressive symptoms in adolescents: an examination of sex, sexual attraction status, and urbanicity. Journal of Youth and Adolescence 2004;33(3):235–245.

Geary DC, Flinn MV. Evolution of human parental behavior and the human family. Parenting: Science and Practice 2001;1:5–61.

Gorsuch, RL. Factor analysis. Hillsdale, NJ: Erlbaum; 1983.

Harris KM, Florey F, Tabor J, Bearman PS, Jones J, Udry JR. The National Longitudinal Study of Adolescent Health: Research Design. 2003 Available online at http://www.cpc.unc.edu/projects/addhealth/design.

Hawkes, K.; O'Connell, JF.; Blurton-Jones, NG. Human life histories: Primate trade-offs, grandmothering, socioecology, and the fossil record. In: Kappeler, PM.; Pereira, ME., editors. Primate life histories and socioecology. Chicago: University of Chicago Press; 2003. p. 204-227.

Hill K, Kaplan H. Life history traits in humans: theory and empirical studies. Annual Review of Anthropology 1999;28:397–430.

Hu, L-T.; Bentler, P. Evaluating model fit. In: Hoyle, RH., editor. Structural equation modeling: Concepts, issues, and applications. London: Sage; 1995. p. 76-99.

Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural Equation Modeling 1999;6:1–55.

Kaplan, HS.; Gangestad, SW. Life history theory and evolutionary psychology. In: Buss, DM., editor. The handbook of evolutionary psychology. Hoboken, NJ: Wiley; 2005. p. 68-95.

Kaplan HS, Hill K, Lancaster JB, Hurtado AM. A theory of human life history evolution: diet, intelligence, and longevity. Evolutionary Anthropology 2000;9:156–185.

Kappeler, PM.; Pereira, ME.; Van Schaik, CP. Primate life histories and socioecology. In: Kappeler, PM.; Pereira, ME., editors. Primate life histories and socioecology. Chicago: University of Chicago Press; 2003. p. 1-24.

Kline, RB. Formative measurement and feedback loops. In: Hancock, GR.; Mueller, RO., editors. Structural equation modeling: A second course. Greenwich, CT: Information Age; 2006. p. 43-68.

Kotchick BA, Shaffer A, Forehand R, Miller KS. Adolescent sexual risk behavior: A multi-system perspective. Clinical Psychology Review 2001;21:493–519. [PubMed: 11413865]

Loehlin, JC. Latent variable models: An introduction to factor, path, and structural analysis. 4th ed. Mahwah, NJ: Lawrence Erlbaum; 2004.

Lumsden, CJ.; Wilson, EO. Genes, mind, and culture: The coevolutionary process. Cambridge, MA: Harvard University Press; 1981.

Miller BC, Benson B, Galbraith KA. Family relationships and adolescent pregnancy risk: a research synthesis. Developmental Review 2001;21:1–38.

Pianka ER. On r- and K-selection. American Naturalist 1970;104:592–596.

Promislow DEL, Harvey PH. Living fast and dying young: a comparative analysis of life-history variation among mammals. Journal of Zoology (London) 1990;220:417–437.

Roff, D. The evolution of life histories: Theory and analysis. New York: Chapman and Hall; 1992.

Roff, D. Life history evolution. Sunderland, MA: Sinauer; 2002.

Rowe DC, Flannery DJ. An examination of environmental and trait influences on adolescent delinquency. Journal of Research in Crime and Delinquency 1994;31:374–379.

Rowe, DC.; Rodgers, JL. Behavior genetics, adolescent deviance, and “d”: Contributions and issues. In: Adams, G.; Montemayor, R.; Gullotta, T., editors. Advances in adolescent development. Newbury Park, CA: Sage; 1989. p. 38-70.

Rowe, DC.; Vazsonyi, AT.; Figueredo, AJ. Personality and Individual Differences. Vol. 23. 1997. Mating effort in adolescence: conditional or alternative strategy?; p. 105-115.

Rutter M. Environmentally mediated risks for psychopathology: research strategies and findings. Journal of the American Academy of Child and Adolescent Psychiatry 2005;4(1):3–18. [PubMed: 15608539]

SAS Institute, Inc. SAS/STAT User’s Guide, Version 8, Volumes 1, 2, and 3. Cary, NC: SAS Institute; 1999.

Schermelleh-Engel K, Moosbrugger H, Müller H. Evaluating the fit of structural equation models: tests of significance and goodness-of-fit measures. Methods of Psychological Research 2003;8(2): 23–74.

Sefcek, JA. A life-history model of human fitness indicators. Tucson: University of Arizona; 2007. Unpublished Ph.D. dissertation

Seligman, MEP.; Maier, SF.; Solomon, RL. Unpredictable and uncontrollable aversive events. In: Brush, FR., editor. Aversive conditioning and learning. New York: Academic Press; 1971. p. 347-400.

Serbin LA, Peters PL, McAffer VJ, Schwartzman AE. Childhood aggression and withdrawal as predictors of adolescent pregnancy, early parenthood, and environmental risk for the next generation. Canadian Journal of Behavioural Science 1991;23:318–331.

Stearns, SC. The evolution of life histories. Oxford: Oxford University Press; 1992.

Steiger, JH. EzPATH: Causal modeling. Evanston, IL: SYSTAT Inc; 1989.

Udry, JR. The National Longitudinal Study of Adolescent Health (Add Health), Waves I II, 1994–1996; Wave III, 2001–2002. Chapel Hill, NC: Carolina Population Center, University of North Carolina at Chapel Hill; 2003. [machine-readable data file and documentation]

Underwood MK, Kupersmidt JB, Coie JD. Childhood peer sociometric status and aggression as predictors of adolescent childbearing. Journal of Research on Adolescence 1996;6:201–223.

Vigil JM, Geary DC. Family and community background and variation in women's life-history development. Journal of Family Psychology 2006;20(4):597–604. [PubMed: 17176194]

West-Eberhard, MJ. Developmental plasticity and evolution. New York: Oxford University Press; 2003.

Wilson MI, Daly M. Life expectancy, economic inequality, homicide, and reproductive timing in Chicago neighbourhoods. British Medical Journal 1997;314:1271–1274. [PubMed: 9154035]

Winterhalder B, Leslie P. Risk-sensitive fertility: the variance compensation hypothesis. Evolution and Human Behavior 2002;23:59–82.

Worthman, CM. Energetics, sociality, and human reproduction: life history theory in real life. In: Wachter, KW.; Bulatao, RA., editors. Offspring: Human fertility behavior in biodemographic perspective. Washington, DC: The National Academies Press; 2003. p. 289-321.

Zweig JM, Lindberg LD, McGinley KA. Adolescent health risk profiles: the co-occurrence of health risks among females and males. Journal of Youth and Adolescence 2001;30(6):707–728.

Biographies

Barbara Hagenah Brumbach is an assistant professor in the Department of Psychology at Northern Arizona University. Her research examines individual differences in life history strategy and ecological predictors of the development of life history strategy over the life course.

Aurelio José Figueredo is a professor of psychology at the University of Arizona and serves as director of the Graduate Program in Ethology and Evolutionary Psychology. His major area of research interest is the evolutionary psychology and behavioral development of life history strategy, sex, and violence in human and nonhuman animals, and the quantitative ethology and social development of insects, birds, and primates.

Bruce J. Ellis is a professor in the Division of Family Studies and Human Development and the John & Doris Norton Endowed Chair in Fathers, Parenting, and Families at the University of Arizona. He seeks to integrate evolutionary and developmental perspectives in his research on family environments, child stress reactivity, and sexual development.

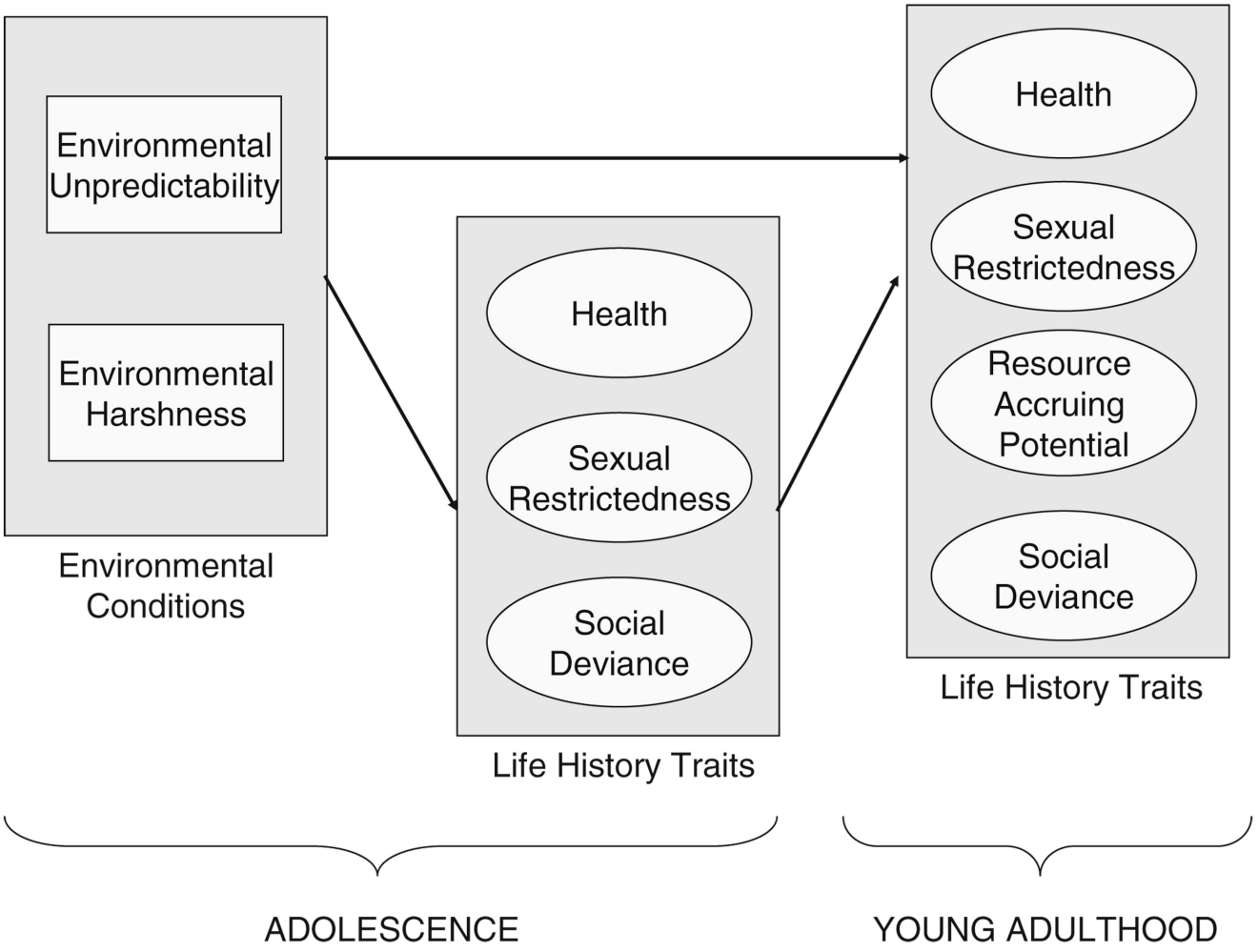

Fig. 1.
Conceptual path model

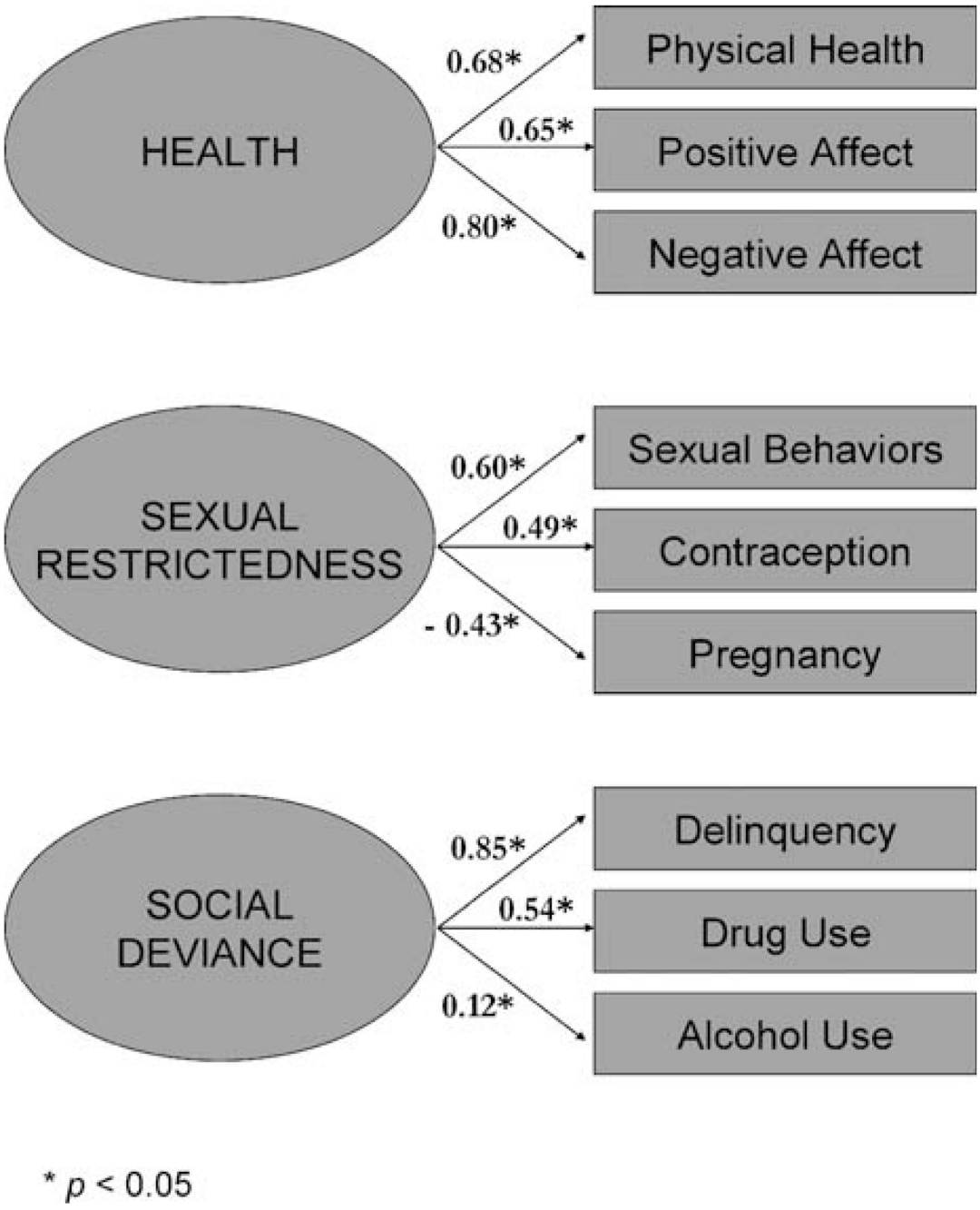

Fig. 2.
Measurement model factor loadings for adolescent life history factors

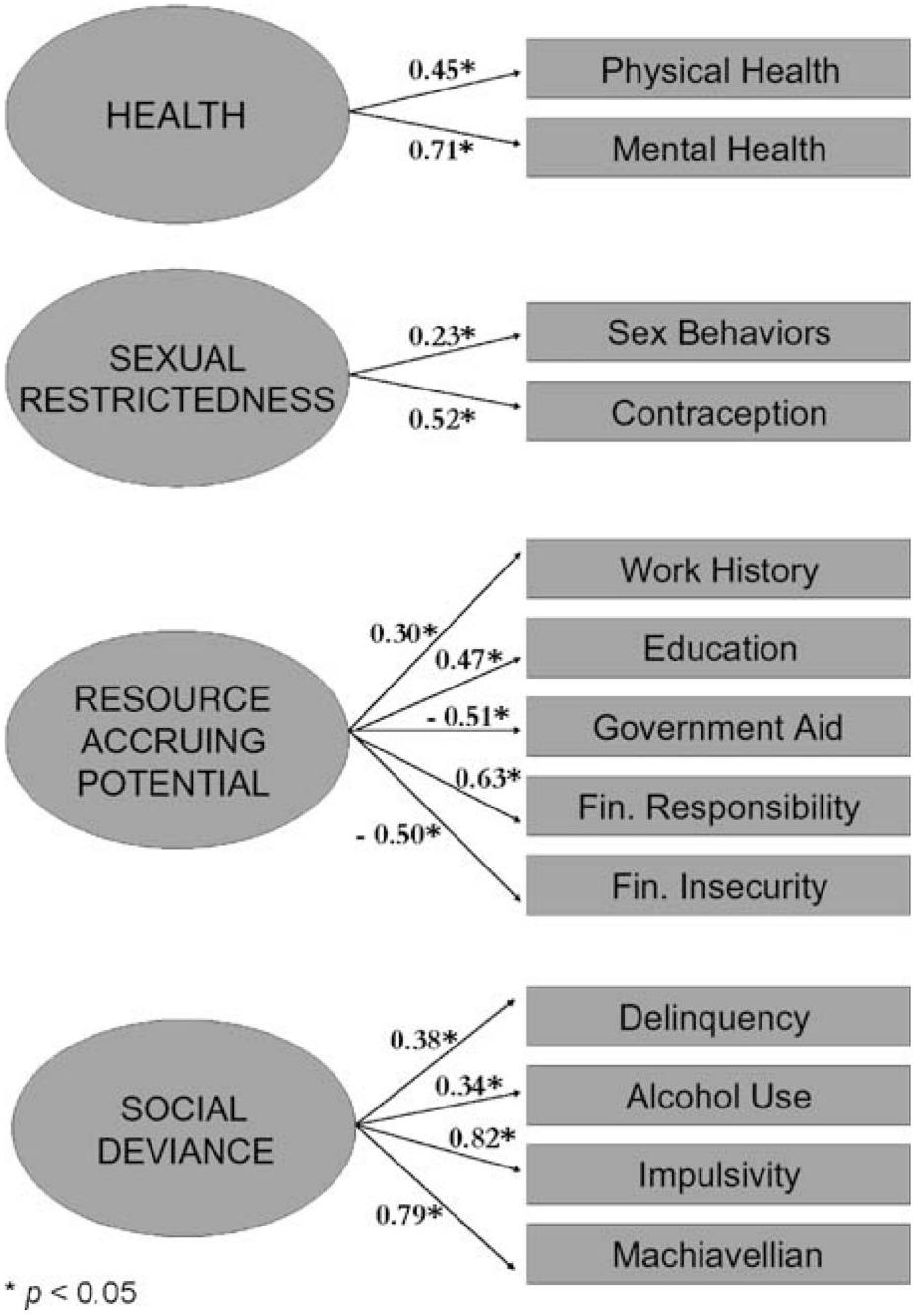

Fig. 3.
Measurement model factor loadings for young adult life history factors

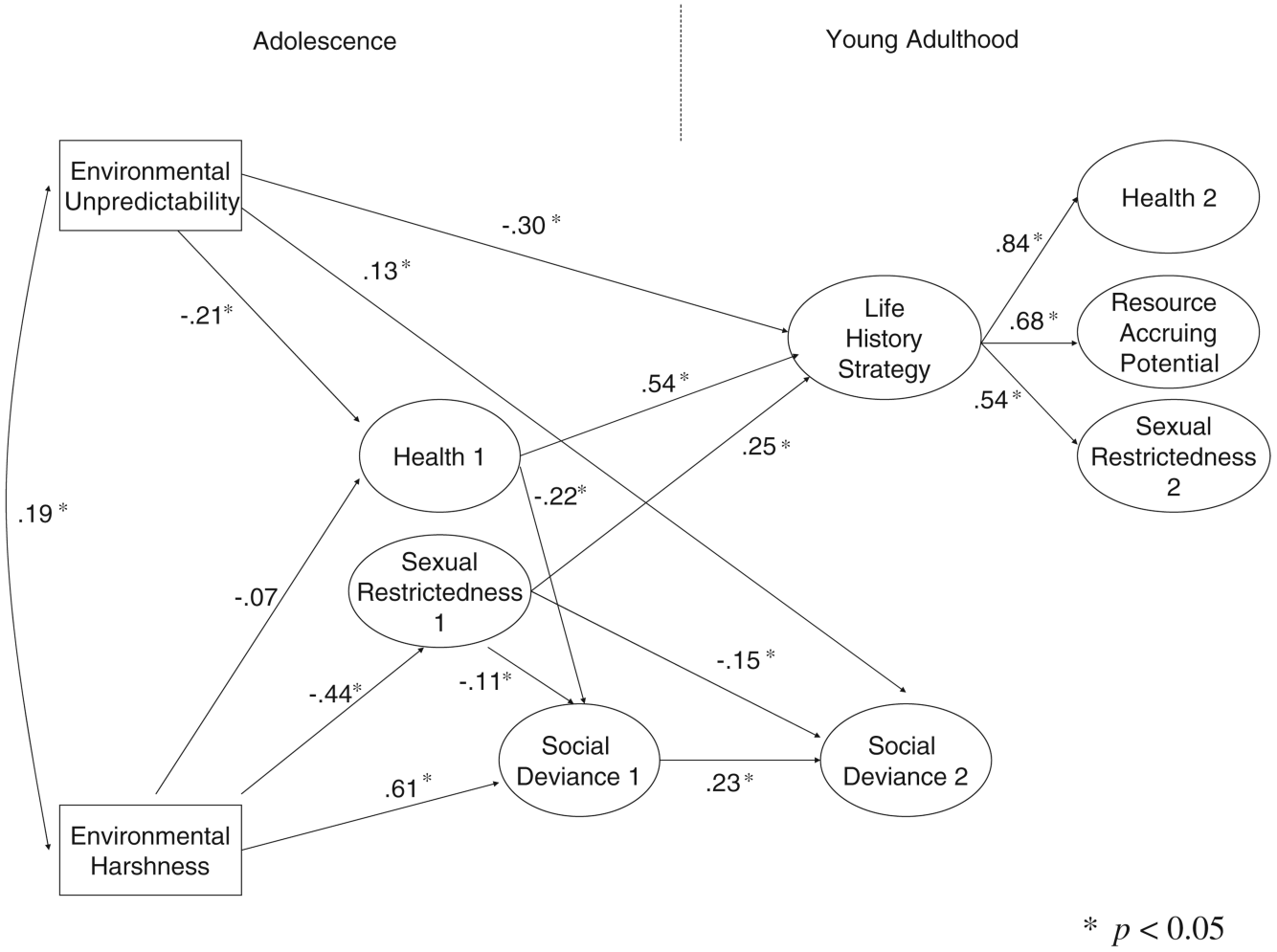

Fig. 4.
Cross-validated structural equations model for the environmental predictors of adolescent and young adult life history strategy

Table 1

Inter-item consistencies (Cronbach's alphas) for all scales used

Constructed scales	Cronbach's alpha
Physical health 1	0.85
Positive affect	0.80
Negative affect	0.86
Attitudes about sexual behaviors	0.74
Pregnancy	0.87
Attitudes toward contraception/contraception use.	0.72
Consequences of alcohol use 1	0.84
Delinquency 1	0.85
Physical health 2	0.77
Mental health	0.81
Sex behaviors	0.65
Contraception use	0.74
Delinquency 2	0.77
Consequences of alcohol use 2	0.81
Impulsivity	0.81
Machiavellian beliefs	0.70
Government aid	0.66
Financial responsibilities	0.65
Financial insecurity	0.68

Table 2

Statistical and practical fit indices for the factor analytic structural equation model

Model	χ^2	df	*p*	RMSEA	GFI	CFI
Combined sample	833.695	238	<0.001	0.056	0.919	0.830

Table 3

Statistical and practical fit indices of cross-sample equality-constrained and unconstrained models for males and females

Model	χ^2	df	*p*	RMSEA	GFI	CFI
Constrained	13,763.22	512	<0.001	0.06	0.93	0.78
Unconstrained	12,028.93	476	<0.001	0.06	0.94	0.81
Difference	1,734.29	36	<0.001	0.00	0.01	0.03