

This article was downloaded by: [Sefcek, Jon A.]

On: 23 April 2010

Access details: Access Details: [subscription number 921580946]

Publisher Routledge

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Biodemography and Social Biology

Publication details, including instructions for authors and subscription information:

<http://www.informaworld.com/smpp/title~content=t912661267>

A Life-History Model of Human Fitness Indicators

Jon A. Sefcek ^a; Aurelio José Figueredo ^b

^a Department of Psychology, Hamilton College, Clinton, New York, USA ^b University of Arizona, Tucson, Arizona, USA

Online publication date: 23 April 2010

To cite this Article Sefcek, Jon A. and Figueredo, Aurelio José (2010) 'A Life-History Model of Human Fitness Indicators', *Biodemography and Social Biology*, 56: 1, 42 – 66

To link to this Article: DOI: 10.1080/19485561003709214

URL: <http://dx.doi.org/10.1080/19485561003709214>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.informaworld.com/terms-and-conditions-of-access.pdf>

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

A Life-History Model of Human Fitness Indicators

JON A. SEFCEK¹ AND AURELIO JOSÉ FIGUEREDO²

¹Department of Psychology, Hamilton College, Clinton, New York

²University of Arizona, Tucson, Arizona

Recent adaptationist accounts of human mental and physical health have reinvigorated the debate over the evolution of human intelligence. In the tradition of strong inference the current study was developed to determine whether either Miller's (1998, 2000a) Fitness Indicator Theory or Rushton's (1985, 2000) Differential-K Theory better accounts for general intelligence ("g") in an undergraduate university population (N = 192). Owing to the lengthy administration time of the test materials, a newly developed 18-item short form of the Ravens Advanced Progressive Matrices (APM-18; Sefcek, Miller, and Figueredo 2007) was used. A significant, positive relationship between K and F ($r = .31, p < .001$) emerged. Contrary to predictions, no significant relationships were found between "g" and either K or F ($r = -.09, p \geq .05$ and $r = .11, p \geq .05$, respectively). Though generally contrary to both hypotheses, these results may be explained in relation to antagonistic pleiotropy and a potential failure to derive correct predictions for within-species comparisons directly from the results of between-species comparisons.

A Life-History Model of Human Fitness Indicators

Many evolutionary accounts for the emergence of individual differences in human intelligence have been proposed (see Bock, Goode, and Webb 2000, for several examples). Two recent theories are Rushton's (2000) *Differential-K Theory* and Miller's (1998, 2000a) *Fitness Indicator Theory*. The first draws upon somatic selection, exploring the selective pressures that necessitated the development of adaptable, large-brained, intelligent humans (i.e., changing climactic conditions, predictable seasonality due to northern migrations out of Africa). The second is a more direct focus on the reproductive benefits of human intelligence shaped through sexual selection, to serve as an indicator of genetic quality. The purpose of the current research is to apply strong inference (Platt 1964) and the method of multiple working hypotheses (Chamberlain 1890/1965) to determine which best accounts for general intelligence.

General Intelligence ("g") as a Latent Construct

Beginning with Galton (1869/1962), there has been a consensus among intelligence researchers and psychometricians that there is a *general* cognitive ability important to many pursuits in life, including academic and work achievements and developmental (life-history) trajectories. This general dimension, termed Spearman's "g," was empirically validated through factor analytic techniques (Spearman 1904) and has been shown to relate to a variety of psychosocial (e.g., age of school dropout, poverty, unplanned

Address correspondence to Jon A. Sefcek, Department of Psychology, Hamilton College, 198 College Hill Road, Clinton, NY 13323, USA. E-mail: lennonjon@gmail.com

pregnancy, criminality, health risk behavior), and biological/information processing traits (e.g., mass of prefrontal cortex and overall brain mass, nerve conductivity velocity, reaction time, inspection time, glucose metabolic rates, health outcomes, longevity), even when socioeconomic status is controlled in the research design (Murray 1998).

General intelligence is conceptualized as a cognitive ability that allows individuals to tap into, and integrate, various aspects of cognitive functioning (e.g., learning, memory, language, reasoning; Jensen 2000). In its strictest view, variation in this ability is due to an inherited capacity to integrate these various cognitive functions more quickly and with more efficiency than others. However, such variation may also arise owing to environmental influences or the interaction of the two (e.g., Caspi et al. 2007). Theoretical considerations as to the etiology of this ability are as varied as the ability itself. However, the most prominent of intelligence researchers do agree that this ability is the result of evolutionary pressures (Bock et al. 2000).

Fitness Indicator Theory and General Fitness Signaling

Fitness indicator theory, proposed by Miller (1998; 2000a, b) posits that many psychometric, psychosocial, and physical markers of health are linked together in an overarching fitness factor (*F-factor*) that directly taps into an individual's endogenous genetic quality (i.e., mutation load). Each of these variables is theorized to be part of one of four larger constructs in which the individual may allocate its bioenergetic and material resources: (1) somatic investment, the way in which you invest resources in body and brain growth; (2) morpho-developmental stability, or how resistant the genes instructing your bodily development are to the onslaught of negative stressors (e.g., parasites, toxins, malnutrition, and mutation); (3) neuro-developmental stability, how strong the genes instructing your cognitive development are at resisting negative stressors; and (4) immunocompetence, or how well your immune system, as a whole, fends off disease. Each of these constructs is assumed to show some degree of developmental stability or reflect the body's resistance to environmental variation and perturbations, because regardless of environment, those with fewer deleterious genetic mutations will outperform those with more mutations.

As described by Miller (2000a), fitness indicator theory states that many phenotypic traits used in mate choice, friend choice, competition for access to mates, and predator avoidance serve as honest phenotypic signals of this genetic quality (i.e., mutation load). Operating under Zahavi's (1975, 1995) handicap principle and drawing on the *genetic capture model* of Rowe and Houle (1996), these indicators accurately and reliably express condition to others by tapping into a large portion of underlying genes. This is why fitness indicators do the voodoo they do so well. They are conspicuously wasteful to produce in terms of metabolic energy, time, and risk and because they tap numerous alleles the pleiotropic affect of the alleles (and any associated deleterious mutations) will be expressed phenotypically. Further, because they are condition-dependent (responsive to environmental stressors), the most informative indicators will show the highest phenotypic variation in size, complexity, or quality across individuals within the same environment. Owing to the fitness-enhancing effects of these indicators, they will, over evolutionary time, become genetically and phenotypically correlated with each other.

Miller (2000a, b) has proposed that owing to its large mutational target size (approximately 50 percent of genetic architecture), the phenotypic output of the brain (e.g., behaviors such as creativity, intelligence, psychopathology, and personality) will show off genetic quality. Coupled with its small size (2 percent of body weight) versus high metabolic cost (requiring approximately 15 percent of oxygen, 25 percent of calories, and 40 percent of

glucose), and ease of disruption due to poor nutrition, disease, injury, inbreeding, and social isolation, it is arguably the most interesting and elaborate fitness indicator known to science. This theory also offers an evolutionary explanation for Spearman's (1904) discovery of "positive manifold" (i.e., that many cognitive abilities are positively correlated to each other). Owing to the pleiotropic nature of the genes underlying fitness indicators, mental traits serving this signaling function should all be related to one another and other aspects of fitness such as immune function and health.

In this sexual signaling view, one's life-history strategy (explained further) is not a causal mechanism of intelligence or these other factors. Rather, life-history strategy is another manifestation of general fitness. A related argument has been made by Gottfredson (2004), implying that the systematic differences in general intelligence are the hidden but "fundamental" cause of the observed health differences among social classes, rather than merely an indicator of higher genetic fitness. Either direction that the causal arrow is inferred, both of these models predict that there should be a positive correlation between general intelligence and general health status.

Life-History Theory: An r/K Perspective

Another framework outlining the emergence and maintenance of variation in human intelligence stems from life-history theory (LHT). LHT is a mid-level evolutionary theory that examines the manner in which organisms allocate material (e.g., calories, time) and bioenergetic (e.g., energy) resources among the various demands of survival and reproduction (Figueredo et al. 2006). These allocations may take the form of *somatic effort* (i.e., investing in personal survival and longevity), and *reproductive effort* (i.e., investing in mating, parental, and kin investment; McArthur and Wilson 1967). At its core it is an economic theory that describes how organisms strategically allocate limited resources among the survival of currently existing genes (self, offspring, and genetic relatives) and the potential production of new genes (mating; MacArthur and Wilson).

One recent application of LHT to within-species variation is based on *r/K* selection theory. This perspective describes the tradeoff between two ends of a continuum wherein parental investment is high and fecundity low (*K*-selected), and fecundity is high and there is little to no parental investment (*r*-selected; Figueredo et al. 2005). Associated with these varying patterns of investment/fecundity are a variety of physical and behavioral traits that are argued to aid long-term survival (*K*-selected) or short-term reproduction (*r*-selected; Pianka 1970). It is believed that selective pressures associated with environmental stability and predictability have shaped functional composites of traits associated with increased fitness, which have become phenotypically and genetically correlated to each other in an overarching, observable, behavioral pattern (Figueredo, Vásquez, Brumbach, and Schneider 2004).

Stemming from this, *differential-K theory* (Ruston 1985) posits that the ability to allocate one's resources differentially in response to environmental condition, during ontogenetic time, is an adaptation that will express itself phenotypically as individual within-species variation. Examining this application, a focused research program at the University of Arizona has developed a factor analytic measure of this proposition (i.e., the *K-factor*; Figueredo, Sefcek, Vásquez, et al. 2005; Figueredo, Vásquez, Brumbach, et al. 2005; Figueredo, Vásquez, Brumbach, Schneider, et al. 2006; but see Figueredo, Vásquez, Brumbach, Schneider, Sefcek, et al. 2006). This program owes its original theoretical basis to the argument that environmental shifts associated with human migration out of Africa led to harsher environments that necessitated the development of higher cognitive

abilities (e.g., intelligence, executive function) to help support the need for higher male parental investment to care for altricial young, stronger group cohesion, and enhanced forethought and planning ability to predict seasonal, yet stable, ecological patterns (Miller 1994; Rushton 2000).

Therefore, psychometric traits (e.g., intelligence, personality, psychopathology) and many physiological markers of health and immune function (e.g., negative health symptoms, general physical health, facial and body fluctuating asymmetry) should have been shaped by natural selection to produce meaningful functional composites rather than having a motley assortment of traits that may work in an antagonistic fashion. Indeed, recent research has shown strong positive phenotypic and genetic relationships between the *K-factor* and a global physical and mental health factor (denoted “Covitality”; Figueredo et al. 2004; Figueredo, Vásquez, Brumbach, and Schneider 2007; Figueredo, Vásquez, Brumbach, et al. 2005). Indeed many traits associated with *differential-K theory* have been shown to be heritable in humans. For example, fecundity (Rodgers, Hughes, Kohler, et al. 2001; Rodgers, Bard and Miller 2007); pubertal timing and menarchal age (Rowe 2000); and age of first reproduction and menopause (Kirk et al. 2001) have heritabilities ranging between (.23 and .50). More recently, work examining the *K-factor* has reported broad-sense heritability coefficients of .65 (Figueredo et al. 2004) and narrow-sense heritability coefficients of .43, whereby non-additive (D) components of genetic variance are taken into account (Figueredo and Rushton 2009).

Literature on psychosocial behaviors and social deviance also supports a relationship to *differential-K theory* (Ellis, 1988; but see Figueredo et al. 2006 for review). A variety of research has shown that criminal and delinquent behaviors (e.g., substance abuse, gang involvement, risky sexual behavior, violence, teen pregnancy, sexual and physical abuse, poor parental supervision) tend to cluster together in an observable behavioral pattern with genetic covariance (“*d*,” Rowe and Rodgers 1989; *delinquency proneness*, Rowe and Flannery 1994). Rowe, Vazsonyi, and Figueredo (1997) later reported the possibility that heritable differences in life-history strategy accounted for significant correlations between juvenile delinquency and life-history traits within individuals and across siblings. More recently, moderate heritability coefficients have been reported for various different indices of self-reported delinquency, using sibling data from the National Longitudinal Survey of Youth, and these coefficients have been shown to be quite comparable between races (White, Black, and Other) and between same-sex male siblings, same-sex female siblings, and opposite-sex siblings (Rodgers, Buster, and Rowe 2001), with substantially lower heritability coefficients reported only for the non-white samples on a specially constructed index of non-aggressive delinquency. Furthermore, these latest estimates show negligible effects of either non-additive genetic variance or shared environmental influence.

An Integrated Evolutionary Model

To our knowledge, no single research endeavor has explored which of these two models best accounts for phenotypic variation in human mental, physical, and health traits. Both theories suggest that the use of multivariate correlational techniques will be able to detect underlying functional latent constructs and behavioral signatures. *Differential-K theory* predicts that each of the constructs outlined earlier—somatic investment, morpho-developmental stability, neuro-developmental stability, and immunocompetence—should be positively related, producing individuals who are high-*K*, healthy, symmetrical, and cognitively adept. Fitness indicator theory (*F*) predicts that underlying genetic quality should be driving somatic investment,

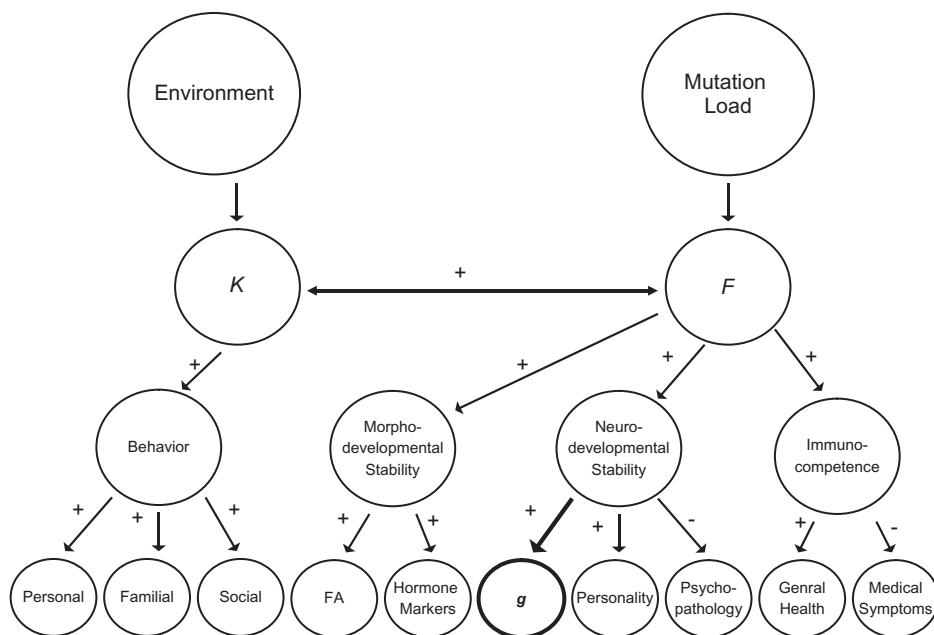


Figure 1. Hybrid model of the relationships among F , K , and g .

morpho-developmental stability, neuro-developmental stability, and immunocompetence; therefore, high-quality indicators of these should all be positively related.

The simple fact is that these models are not mutually exclusive (Figure 1). Rather they examine human traits from two different perspectives (e.g., survival and parental investment versus sexual selection), both of which have strong evolutionary effects. Therefore the current study was developed to examine whether either model better accounts for variation in human mental capacities or whether the two of them are themselves related. This will be examined partially by extending research that established the validity of measuring life-history strategy via self-report measures of family configuration and support, kin and friend altruism, adult romantic attachment, reproduction, mating effort, and risk taking (Figueredo, Sefcek, et al. 2005; Figueredo et al. 2006).

Research Population and Methods

One-hundred ninety-two (99 female, 93 male) introductory psychology students at the University of Arizona participated in this study. All participants were given the option of fulfilling a course requirement through research participation or writing a research-oriented paper. The mean age of participants was 19.11, $SD = 1.62$ ($M_{female} = 19.01$, $SD_{female} = 2.00$; $M_{male} = 19.23$, $SD_{male} = 1.07$). Owing to lengthy administration times of all materials, several individuals did not complete one or more measures of the study (see Table 1 for sample size of specific measures).

Scales and Measures

This study utilized a variety of measures devised to tap into the three, of four, different hypothesized areas of "general fitness": (1) somatic investment, (2) neuro-developmental

Table 1
Sample size comparisons and cronbach's alpha across measures

	<i>N</i>	Cronbach's α
Mini- <i>K</i>	172	.71
Parental investment	190	.86
Family support	191	.89
Friend support	191	.84
Altruism	189	.79
Romantic attachment	188	.88
Psychopathic personality inventory	182	.76
Risk taking questionnaire	191	.89
Mating effort scale	191	.70
APM-18	194	.71
Mill-Hill vocabulary scale	183	.88
ShIPLEY abstractions	193	.89
ShIPLEY vocabulary	193	.91
GPA	177	n/a
SAT	145	n/a
SWB	188	.79
Beck depression inventory	190	.92
Hopkins depression index	188	.90
Hopkins anxiety index	188	.81
SF-36	192	.89
General health scale	192	.73

stability (mental health and intelligence), and (3) physical health (as a proxy for immuno-competence). Internal consistency estimates were calculated for each scale through the use of the Cronbach's alpha coefficient (see Table 1 for complete list of scale reliabilities).

Measures of Somatic Investment

Arizona Life-History Battery. This life-history battery (Figueredo, Sefcek et al. 2005) was developed at the University of Arizona to measure individual differences in life-history strategy. It contains several scales measuring parental attachment and support, support towards and from friends, romantic partner attachment, mating effort, Machiavellianism, and risk taking.

Though this battery previously contained a Machiavellianism scale, the Psychopathic Personality Inventory (see further) was substituted for the Machiavellianism scale in the present study for two reasons. First, one of the main subscales of the battery is specifically related to Machiavellian egocentricity, allowing for this direct test, if needed. Second, several lines of research based on evolutionary perspectives (e.g., Figueredo, Brumbach, Jones, Sefcek, Vásquez, and Jacobs 2007; Mealey 1995) suggest that psychopathy may be an adaptive cheater strategy focused on short-term, opportunistic mating. As such, this scale should show a negative relationship to the *K-factor*.

The Mini-K Short Form. The mini-K short form (Figueredo et al. 2006) was also added to the Arizona Life History Battery in the present study. The mini-K is a 20-item, self-report short form of the *K-battery*. It was developed to be used in situations wherein time constraints made use of the complete *K-battery* prohibitive. It was added to the battery in part as a test of convergent validity and in part to enhance the measurement of the common factor.

The Psychopathic Personality Inventory: Short Form. The Psychopathic Personality Inventory: Short Form (Lilienfeld and Andrews 1996), a 56-item scale, was derived as a shortened version of the Lilienfeld and Andrews 187-item self-report questionnaire of non-criminal population psychopathy. This scale was developed to measure personality traits rather than antisocial behavioral propensities. Each item is endorsed on a 1 to 4 scale and tallied to produce either a total PPI score or one of eight subscale-scores: (1) Machiavellian Egocentricity (manipulativeness), (2) Social Potency (charm and influence), (3) Coldheartedness (callousness and guiltlessness), (4) Carefree Nonplanfulness (lack of forethought), (5) Fearlessness (risk taking), (6) Blame Externalization (blaming others for mistakes), (7) Impulsive Nonconformity (a disregard for social norms), and (8) Stress Immunity (lack of anxiety).

Measures of Morpho-Developmental Stability

General Health Scale. The General Health Scale (Brim et al. 2000) was derived from the MIDUS Life Satisfaction Scale as a global measure of mental and physical health. It is composed of five items rated on either a 0 to 4 (items 1–3) or 0 to 5 (items 4 and 5) scale. Sample items include “In general, would you say your physical health is . . .” and “In general, compared to most (men/women) your age, how would you say your health is?”

Medical Symptoms Scale. The Medical Symptoms Scale (Brim et al. 2000) measures medical symptoms through reports of the endorsement of 28 possible medical conditions. Examples include the endorsement of items including “Thyroid disease,” “High blood pressure or hypertension,” or “Ulcer.”

The RAND 36-Item Health Survey: Version 1. The 36-item RAND 36-Item Health Survey: Version 1 scale (Ware and Sherbourne 1992) can be used both as a global index of physical and emotional health and broken down into eight subscales (based on health concepts): physical functioning, bodily pain, role limitations due to physical health problems, role limitations due to personal or emotional problems, emotional well-being, social functioning, energy/fatigue, and general health perceptions. Subscales may be combined to produce a physical health summary score (mean of the physical functioning, bodily pain, role limitations due to physical health problems, and general health subscales) and a mental health summary score (role limitations due to personal or emotional problems, emotional well-being, social functioning, energy/fatigue).

Measures of Neuro-Developmental Stability (Mental Health)

Subjective Well-Being Scale. The three-item Subjective Well-Being Scale (Figueredo, Vásquez, et al. 2005) was derived by combining one item from the MIDUS (National Survey of Midlife Development in the United States) Life Satisfaction Scale (Brim et al. 2000) and two items created specifically to measure general life-happiness. It was developed to assess general subjective well-being (i.e., general satisfaction with one’s life.)

The Beck Depression Inventory: Second Edition. The Beck Depression Inventory (Second Edition; Beck, Steer, and Brown 1996) is a 21-item self-report instrument that measures the existence and intensity of depression (as outlined by the DSM-IV) for both general and clinical populations. Nineteen of the items consist of a list of four statements arranged in increasing severity (measured 0–3) about a corresponding symptom of depression. Two items, 16 and 18, have seven options associated with increases/decreases in appetite and sleep. Total score of 0 to 13 is considered minimal range, 14 to 19 is mild, 20 to 28 is moderate, and 29 to 63 is severe, although it is recommended that these categories be adjusted based on the mean of the specific sample. This instrument is designed for use across a variety of age-groups, from 13 to 80.

The Hopkins Symptom Checklist 25. The Hopkins Symptom Checklist 25 (Derogatis, Lipman, Rickels, Uhlenhuth, and Covi 1974) is a short version of the original 90-item Hopkins Symptoms Checklist designed for quick assessment of general anxiety and depression. It is composed of 25 items: 10 items anxiety, 15 items depression. Two scores are calculated: The total score is the average of all 25 items, whereas the depression score is the average of the 15 depression items.

Measures of Neuro-Developmental Stability (Intelligence)

The Raven's Advanced Progressive Matrices 18-item. The Raven's Advanced Progressive Matrices (Sefcek, Miller, and Figueredo 2007) is an 18-item scale, a medium-length form of the 36-item Raven's Advanced Progressive Matrices (APM; Raven, Court, and Raven 1998). It was developed for use in time-constrained and classroom settings, wherein the use of the complete 40-minute APM would be unreasonable. By choosing one of eight possible answers, participants are asked to complete a series of 18 visual patterns in which a piece of each pattern is missing. Items are arranged in order of increasing difficulty with a time limit of 25 minutes.

The Mill-Hill Vocabulary Scale Senior Multiple Choice Form, Sets A & B. The Mill-Hill Vocabulary Scale Senior Multiple Choice (Raven, Raven, and Court 1997) is a two-set, 68-item, multiple-choice vocabulary test developed as a measure of reproductive (storage and retrieval) ability to be used in conjunction with the Raven's Matrices tests. The purpose of this scale is to record one's ability to recall acquired information. To this extent it is related to one's education, cultural background, and familiarity with the administration language.

The Shipley Institute of Living Scale. The Shipley Institute of Living Scale (Zachary 1986) is composed of two timed (10-minute) subscales:; vocabulary (40 items) and abstraction (20 items). This test is predominantly used in English-speaking countries and is appropriate for average individuals from 14 years to adult, who are motivated test takers. Interpretation of the score can be based either on individual subscales or on a total SILS score [Subscale 1 + (Subscale 2*2)].

Academic Performance. Academic performance was measured through two self-report measures: grade-point average and Scholastic Aptitude Test scores. A variety of studies have identified moderate-to-strong correlations between these measures and a variety of other cognitive abilities including intelligence, personality, physical health, and psychopathology (Barton, Dielman, and Cattell 1971; Brown 1994; Dyer 1987; Mouw and Khanna 1993).

Statistical Analyses

All statistical analyses, without power analyses, were conducted using SAS version 8.2 for Windows (SAS Institute 1999). Cronbach's alphas and bivariate correlations were computed using the *PROC CORR* procedure. Exploratory factor analyses were conducted by using the *PROC FACTOR* procedure. Parallel analyses were conducted through use of the *PROC IML* procedure. Multiple regression analyses aimed at testing each of the theoretical models were conducted using *PROC REG*. Power analyses were conducted using G*Power 3.0 (Buchner, Erdfelder, and Faul 1997).

Common Factor Modeling

Previous research utilizing the *K-factor* and *F-factor* (denoted *Covitality*) used theoretically derived standardized regression coefficients to define factors (see Figueredo et al. 2006 for review). These factors were determined by constructing each factor based on the correlation of each scale to a theoretically defined factor model. To determine how these data fit the theoretical models, exploratory factor analyses (EFAs) were conducted for each of the hypothesized higher-order factors (*F-factor*, *K-factor*, and *g-factor*).

Results

Exploratory *F-factor* Loadings

First, a principal-factors procedure with promax rotation was used as an exploratory measure of the *F-factor*. One eigenvalue (3.85) meeting the subjective scree test indicated that a one-factor solution best fit these data (Cattell 1978). To determine whether the one-factor solution was indeed the best "objective" solution, a parallel analysis procedure was conducted (PROC IML: SAS Institute 1999). The parallel analysis (Horn 1965) estimated the sampling distribution of the eigenvalues with a Monte Carlo procedure. A large number (e.g., 1,000) of random data sets is created with the same sample size and the same number of items as the real data set. Observed factors with eigenvalues exceeding the statistically significant eigenvalues of the estimated sampling distribution were retained. This analysis indicated that indeed a single-factor solution should be retained.

Shown in Table 2 are the factor loadings for this single-factor solution. This factor accounted for 55 percent of the unique and 83 percent of the common variance. Retained

Table 2

Factor loadings for single-factor solution of *F-factor*

F-factor (83%)

General health scale	.48
SF-36	.77
Subjective well-being scale	.72
Medical symptoms scale	-.61
Hopkins anxiety index	-.77
Hopkins depression index	-.89
Beck depression inventory	-.87

in this factor are seven items that loaded on the factor in their theoretically predicted way positive health aspects: general health, SF-36, and SWB, and negative aspects: anxiety, depression, and negative health symptoms.

Exploratory K-factor Loadings

An exploratory principal-factors procedure with Promax rotation was used to explore the *K-factor*. Two eigenvalues (1.66 and 1.53) meeting the subjective scree test indicated that a two-factor (rather than the theoretically predicted single-factor) solution best fit these data. A parallel analysis was conducted to objectively test this decision. This parallel analysis also indicated that two factors should be retained.

Shown in Table 3 are the factor loadings for this two-factor solution. These factors accounted for 41 percent of the unique and 85 percent of the common variance, with an inter-factor correlation of $-.06$. Factor 1 (accounting for 44 percent of the common variance) is composed of all the “prosocial” scales theoretically associated with the *K-factor* (i.e., mini-*K*, parental investment, family and friend support, altruism, and romantic attachment) and has thus been named *K-factor*. Factor 2 (accounting for 41 percent of the common variance) is composed of scales that are associated with self-endorsed attitudes related to psychopathy (i.e., psychopathic personality, mating effort, and risk taking) and has therefore been named *psychopathic attitudes*. A Varimax rotation retained these factors, with the same scales loading on each. The similarities between the orthogonal and oblique rotation suggested that the orthogonal solution offered a good fit for these data (Pedhazur and Schmelkin 1991).

Owing to the results of these analyses, the psychopathic personality inventory, mating-effort scale, and risk-taking measure were dropped as indicators of *K* from subsequent analysis utilizing the *K-factor*. Rather, they were included in subsequent analyses as a *Psychopathic Attitudes* factor (*P-factor*).

Exploratory g-factor Loadings

The general intelligence, *g-factor*, was explored through a principal-factors procedure. One eigenvalue (1.70) was retained through the use of the subjective scree test. A parallel analysis likewise indicated that one factor should be retained.

Table 3
Factor loadings for two-factor solution of *K-factor*

<i>K-factor</i> (44%)	<i>P-factor</i> (41%)
Mini- <i>K</i>	.64
Parental investment	.57
Family support	.63
Friend support	.54
Altruism	.25
Romantic attachment	.35
Psychopathic personality inventory	.89
Risk taking questionnaire	.79
Mating effort scale	.70

Table 4Factor loadings for single-factor solution of *g-factor**g-factor* (70%)

APM-18	.64
Mill-Hill vocabulary	.57
Shipley vocabulary	.63
Shipley abstractions	.54
GPA	.25
SAT	.35

Shown in Table 4 are the factor loadings for this *g-factor*. This factor accounted for 23 percent of the unique and 70 percent of the common variance. Overall, this factor represents a strong *g-factor* with positive factor loadings on all measures of intelligence.

Unit-Weighted Higher-Order Factors

Owing to the results of the various EFAs, four higher-order factors were created by defining the factors based on direction of their factor loadings from the EFAs. These were the *F-factor*, *K-factor*, *P-factor*, and *g-factor*. Shown in Table 5 are the factor loadings (reported as standardized regression coefficients) for each of the items comprising the latent constructs. These factors were the ones used in all subsequent analyses.

Relationships among Higher-Order Factors

Bivariate correlations among the higher-order factors of interest were calculated by the PROC CORR procedure (SAS Institute 1999) and are displayed in Table 6a. As can be seen, the only significant relationship to emerge was between the *F-factor* and *K-factor* ($r = .31, p < .001$). However, as with the pilot data, this relationship is weaker than with previous samples (e.g., Figueredo et al., 2004). As an exploration of this finding, the correlation between each pair of factors was calculated separately for males and females. Shown in Table 6b are these correlations. Again, the only significant correlation to emerge was between the *F-factor* and *K-factor* but only for females ($r_{female} = .45, p < .001$; $r_{male} = .14, p > .05$). This suggests that at least for males, there is no relationship between life-history strategy and health. Theoretical implications of this are explored later.

To further explore the lack of correlation between either the *F-factor* or *K-factor* and the *g-factor*, bivariate correlations were calculated in relation to each of the specific measures comprising the *g-factor*. Shown in Tables 7a and 7b are these correlations. As can be seen, grade-point average was significantly related to both the *F-factor* and *K-factor* ($r = .15, p < .05$; and $r = .17, p < .05$, respectively). The magnitude of this correlation, however, is not impressive and no other significant correlations were identified in relation to either the *F-factor* or *K-factor*.

Table 5
Unit-weighted factor pattern

	Factor Loading
<i>F-factor</i>	
SWB	.74
BDI	-.85
Hopkins depression index	-.88
Hopkins anxiety index	-.80
SF-36	.79
General health scale	.58
Medical symptoms scale	-.48
<i>K-factor</i>	
Mini-K	.70
Parental investment	.63
Family support	.68
Friend support	.59
Altruism	.59
Romantic attachment	.39
<i>P-factor</i>	
Psychopathic personality inventory	-.61
Risk taking questionnaire	-.43
Mating effort scale	-.41
<i>g-factor</i>	
APM-18	.63
Mill-Hill	.67
Shibley abstractions	.70
Shibley vocabulary	.57
GPA	.52
SAT	.66

Table 6a
Correlations among higher-order factors

	<i>K-factor</i>	<i>P-factor</i>	<i>F-factor</i>	<i>g-factor</i>
<i>K-factor</i>	1.00			
<i>P-factor</i>	-.01	1.00		
<i>F-factor</i>	.31*	.12	1.00	
<i>g-factor</i>	-.09	-.15*	.12	1.00

Note: With $N = 192$, $1 - \beta = .95$, and $\alpha = .05$, the smallest bivariate r that can be found significant = .25 (Buchner et al. 1997). However, as with any power analysis, this is a probabilistic estimate based on the parameters specified for α and β , and we did indeed find one smaller correlation statistically significant in our sample in spite of this prediction. Nevertheless, this power calculation might be used to evaluate the most likely maximum magnitudes in the population of many of the effects that we did *not* find statistically significant in the present sample.

* $p < .001$.

Table 6b
Correlations among higher order factors, by sex

	<i>K-factor</i>	<i>P-factor</i>	<i>F-factor</i>	<i>g-factor</i>
Females (<i>n</i> = 99)				
<i>K-factor</i>	1.00			
<i>P-factor</i>	.03	1.00		
<i>F-factor</i>	.45*	.18	1.00	
<i>g-factor</i>	-.12	-.13	-.12	1.00
Males (<i>n</i> = 93)				
<i>K-factor</i>	1.00			
<i>P-factor</i>	-.00	1.00		
<i>F-factor</i>	.14	.02	1.00	
<i>g-factor</i>	-.05	-.20	-.12	1.00

Note: **p* < .001.

Table 7a
Correlations of *K* and *F* with particular 'g' measures (*n* = 192)

	<i>K-factor</i>	<i>P-factor</i>	<i>F-factor</i>
APM-18	-.09 (-.11)	-.04 (-.05)	-.11 (-.14)
Mill-Hill	-.06	-.20**	-.06
Shiely Abstractions	-.10	-.02	-.02
Shiely Vocabulary	-.06	-.14	-.07
GPA	.15*	-.20**	.17*
SAT	.02	.11	-.01

Note: Numbers in parentheses represent disattenuated correlations.

p* ≤ .05; *p* < .01.

Disattenuation for Restriction of Range

One potential reason for the lack of relationship between the *K-factor*, *F-factor*, and our measures of intelligence (e.g., APM-18) might have been low variance in intelligence scores in college student samples. As it is generally found that scores of intelligence in college samples suffer from such range restriction, we performed a check for such restriction of range in our sample by using the APM-18 as the standard measure of *g*. Because the APM-18 is a newly developed measure of general intelligence, there are no normative data yet available for the general population. To circumvent this problem, we instead used published norms for Scholastic Aptitude Test scores to estimate the predicted population variance of APM-18 scores, as convergent indicators of general mental ability. Using Cohen, Cohen, West, & Aiken's (2003) formula for disattenuation of the correlation coefficient under restriction of range, we calculated the correlation estimates had our sample been more representative of the general population. Shown in parentheses on Tables 7a and 7b are the results of these analyses. No new significant correlations emerged using this statistical procedure.

Table 7b
Correlations of K and F with particular 'g' measures, by sex

	<i>K-factor</i>	<i>P-factor</i>	<i>F-factor</i>
Females (<i>n</i> = 99)			
APM-18	-.14 (-.17)	-.02 (-.02)	-.11 (-.13)
Mill-Hill	-.03	-.11	-.15
Shipley abstractions	-.05	.08	.05
Shipley vocabulary	-.15	-.20*	-.03
GPA	.19	-.10	.22*
SAT	.11	-.04	.02
Males (<i>n</i> = 93)			
APM-18	-.02 (-.02)	-.17 (-.21*)	-.14 (-.17)
Mill-Hill	-.10	-.27**	.01
Shipley abstractions	-.15	-.06	-.07
Shipley vocabulary	.02	-.08	-.10
GPA	.09	-.23*	.15
SAT	-.04	.13	-.09

Note: Numbers in parentheses represent disattenuated correlations.

* $p < .05$; ** $p < .01$.

Multiple Regression Models

Multiple regression analyses (PROC REG) were conducted to explore each of the alternative theoretical models. Because there is a large body of literature supporting gender differences in each of the higher-order factors of interest; general fitness, life-history strategy, psychopathic attitudes and behavior, and intelligence, the gender variable was entered as a predictor in each model. Each test was conducted so that the criterion variable was predicted by a higher-order factor, gender, and the higher-order factor by gender interaction. Interaction terms were named *F-sex*, *K-sex*, *P-sex*, and *g-sex*. Results, reported as ordinary least squares, standardized regression (β) weights, their associated *t* tests, and significance levels are reported in Table 8.

Multiple Regression Tests of Fitness Indicator Theory

The first two regression analyses were conducted to explore Miller's (1998, 2000a) fitness indicator theory. The first one examined the proposition that the *F-factor* would be predictive of life-history, under the supposition that a *K-selected* life-history strategy might be condition-dependent upon phenotypic fitness. The *K-factor* was entered as the criterion variable, with the ordered predictor variables being *F-factor*, gender, and the *F-factor* \times gender interaction. The overall model was significant ($R^2 = .13$; $F(3, 187) = 9.29$, $p < .001$), as were the *F-factor* and *F-factor* \times gender interaction terms ($t(189) = 5.02$, $p < .001$; and $t(189) = -2.40$, $p < .05$, respectively). This analysis suggests that though general fitness is related to higher *K-factor* scores, there is a stronger effect for females than males.

Table 8
Multiple regression statistics for the theoretical models

Predictor	Criterion Variable											
	<i>K-factor</i>			<i>F-factor</i>			<i>P-factor</i>			<i>g-factor</i>		
	β weight	<i>t</i> test	p ($\beta > 0$)	β weight	<i>t</i> test	p ($\beta > 0$)	β weight	<i>t</i> test	p ($\beta > 0$)	β weight	<i>t</i> test	p ($\beta > 0$)
<i>K-factor</i>				0.44	4.90	.001	0.02	0.32	.751	-0.06	-0.61	.545
Sex				0.23	1.71	.089	0.56	5.14	.001	-0.01	-0.05	.962
<i>K-sex</i>				-0.20	-2.18	.030	-0.02	-0.22	.823	-0.01	-0.08	.937
<i>F-factor</i>	0.46	5.02	.001							-0.04	-0.42	.674
Sex	-0.19	-1.36	.175							0.00	0.01	.989
<i>F-sex</i>	-0.22	-2.40	.017							-0.03	-0.27	.787
<i>K-factor</i>										-0.05	-0.45	.651
<i>F-factor</i>										0.02	0.19	.852
<i>KF</i>										0.09	0.89	.376
Sex										0.02	0.15	.877
<i>K-sex</i>										-0.03	-0.26	.795
<i>F-sex</i>										-0.09	-0.85	.397
<i>KF-sex</i>										0.05	0.59	.558

Note: With $N = 192$ ($df = 3, 188$), $I-\beta = .95$, and $\alpha = .05$, the smallest r^2 that is likely to be found significant would be .08 (Buchner et al. 1997).

The second regression analysis for fitness indicator theory examined the prediction that phenotypic fitness would predict general intelligence, as per Miller's (2000) predictions. The *g-factor* was entered as a criterion variable to examine the relationship between the *F-factor*, gender, and *F-gender* interaction. This model ($R^2 = -.02$; $F[3, 188] = 0.59$, $p > .05$) and all individual predictors were found to be non-significant (see Table 8). This is a further confirmation that fitness indicator theory does not account for variation in general intelligence.

Multiple Regression Tests of the Differential-K Theory

A regression analysis was used to examine the relationship between the *K-factor* and *P-factor*, as predicted by the *differential-K* life history model. The *P-factor* was used as the criterion variable with the ordered predictors of *K-factor*, gender, and the *K-gender* interaction. The overall model was significant ($R^2 = .12$; $F(3, 188) = 8.83$, $p < .001$), with the only significant predictor of this model being sex ($t(190) = 5.14$, $p < .001$). This is further support for the results of the EFA leading to a two-factor solution for the theoretically derived *K-factor*. The fact that gender predicts the *P-factor* is not surprising, as there is a large body of literature showing that males exhibit both more psychopathic behavior and attitudes (see Hare 1993, for review).

A second regression analysis examined the prediction that life-history would drive somatic effort, as indicated by the relationship between the *K-factor* and the *F-factor*, under the supposition that greater somatic effort invested and greater amounts parental and nepotistic effort received would contribute to phenotypic fitness. The *F-factor* was entered as the criterion variable with the ordered predictors of *K-factor*, gender, and the *K-gender* interaction. The overall model was significant ($R^2 = .13$; $F[3, 187] = 9.27$, $p < .001$), as were the *K-factor* and *K-factor* \times gender interaction terms ($t[189] = 4.90$, $p < .001$; and $t[189] = -2.18$, $p < .05$, respectively). This model suggests that though life-history is itself a significant predictor of somatic effort, there is something special about females in this relationship. Theoretical reasons for this finding are explained later in relation to Williams' (1957) theory of antagonistic pleiotropy.

The third regression analysis tested the prediction that life-history strategy is predictive of general intelligence, as per Rushton's (2000) predictions. The *g-factor* was entered as the criterion variable, with *K-factor*, gender, and the *K-gender* interaction. This model ($R^2 = .00$; $F[3, 188] = 0.26$, $p > .05$) and all individual predictors were non-significant (see Table 8). This is a further confirmation that the *differential-K theory* does not seem to account for general intelligence, as measured by the *g-factor*.

Multiple Regression Test of the Hybrid Model

A regression analysis was conducted to examine whether life-history strategy and general fitness jointly account for the variance in human general intelligence. The *g-factor* was defined as the criterion, with *K-factor*, *F-factor*, *K-factor* \times *F-factor*, gender, *K-gender*, *F-gender*, and the *K-factor* \times *F-factor* \times gender interactions as the predictors. This model was not significant ($R^2 = .02$; $F[5, 185] = .63$, $p > .05$), nor were any of the predictor variables (see Table 8). These results suggest that life-history strategy and general fitness do not jointly account for general intelligence, either additively or multiplicatively.

Discussion

Using the method of multiple working hypotheses, this study was developed to examine several predictions stemming from Rushton's (1985, 2000) *differential-K theory*, Miller's (1998, 2000a) fitness indicator theory, and a complementary hybrid model. Primarily, these predictions examined the relationships among the latent constructs of the *K-factor*, *F-factor*, and *g-factor*, with secondary analyses examining the subcomponents comprising each factor. Results here suggest only minimal support for any of the models. Specifically, there was a significant relationship between the *K-factor* and *F-factor*. However, even this relationship was less robust than previous findings (see Figueredo et al. 2004). Other results indicated no relationship between either (1) the *K-factor* and the *g-factor*, (2) the *F-factor* and the *g-factor*, or (3) the *K-factor* \times *F-factor* interaction and *g-factor*. Explanations for these findings are presented next.

Differential-K and Delinquency

The *differential-K theory* predicts that behaviors deemed "socially deviant" or delinquent in nature should have a negative relationship to the *K-factor* (load negatively on *K*). In this study, three scales (Mating Effort Scale, Risk Taking Questionnaire, and The Psychopathic Personality Inventory) were used to measure this prediction. Rather than showing a single robust *K-factor* with negative loadings on these scales, an EFA revealed two uncorrelated factors ($r = -.06, p > .05$) accounting for 85 percent of the common variance. The first factor retained the prosocial items of the original *K-factor* and has thus retained its name. Owing to the nature of the questions contained in the three other antisocial scales, the second factor has been named *psychopathic attitudes* (or *P-factor*).

Research on life-history has revealed that a long list of behaviors deemed socially unacceptable and deviant are positively related to a low-*K*, fast reproductive strategy (and being negatively related to a high-*K*, slow strategy). For example, Charles and Egan (2005) found that mating effort (as measured by the mating effort scale; Rowe et al. 1997) was positively related to self-reported delinquency in a large sample of adolescents; whereas Egan et al. (2005) found a relationship between mating effort and sensational, or macabre interests. Other researchers have identified a relationship between delinquency and promiscuity (Rowe and Rodgers 1989), and mating effort (Rowe et al. 1997). These findings show correlations among different single measures of life-history (e.g., mating effort) and what has been considered as socially deviant behavior.

However, consistent with the current results, Brumbach, Figueredo, and Ellis (2009) found that social deviance, as a latent factor, was not related to life-history in a large sample of nationally represented young adults. They suggested that young adults may not yet have incorporated socially deviant behaviors into their life-history strategy but that they might do so by middle adulthood. This argument may be based on the concept of *heterochrony*, which refers to the differential timing in the maturation of phenotypic traits that lead to changes in sizes and shape. For example, an abundance of testosterone in young males influences them to engage in high levels of mating effort, which may lead to risky displays (Wilson and Daly 1985). At the same time, the brain's frontal lobes have not yet fully myelinated, which results in lowered inhibition of such behaviors. As males age, frontal-lobe white matter increases and may continue into their fifth decade (Bartzokis et al. 2001). Such delayed development may be a partial cause of the risk-prone behavior of younger versus older men and a general "mellowing" of behavior as they age.

An alternative explanation might account for the current findings (i.e., the construct validity of the measures used). Rather than measuring behavior, the scales used here were measures of attitudes, asking questions about how one believes one acts, or would act, in a specific context. A long history of research spanning several decades has shown that attitudes do not necessarily predict behavior (e.g., LaPiere 1934; Wicker 1969) unless they are strongly held (Bassili 1995) and vitally affect the holder's interest (Sivacek and Crano 1982). In this sample, it is unlikely that any of the participants are extremely delinquent, psychopathic, or socially deviant. Therefore, simply because they may have attitudes directed toward social deviance their behavior may not follow suit. Further research needs to be conducted using a more representative sample of humans.

Relationship between the K-factor and the F-factor

As with previous studies (e.g., Figueredo et al. 2004), a significant positive relationship between the *K-factor* and the *F-factor* was found. This relationship is, however, weaker than previously reported. Further, when examined as a function of gender, the relationship between these factors disappears for males but becomes stronger in females. Two complementary explanations may account for these findings. First, owing to the young age of this sample, there may simply be very little phenotypic variation in general health and psychopathology. Such variation may become more apparent with increasing age. This coupled with the gender differences noted here are not surprising when we look at the *theory of antagonistic pleiotropy* (Williams 1957).

The *theory of antagonistic pleiotropy* (Williams 1957) predicts that many genes producing fitness-enhancing effects while an organism is young will have detrimental effects on survival and longevity. The fitness-enhancing effects of any such character are, therefore, age-dependent and will decrease the longer the character is expressed (Williams and Day 2003). This may lead selection to produce traits that are beneficial to individuals who are close to peak reproductive age, even at a cost to long-term health and longevity.. Hence younger individuals will tend to be healthier than older individuals.

If low-*K* individuals invest more resources in reproductive effort at an earlier age, there may be a difference in age of peak reproductive effort in comparisons of low and high-*K* individuals. As such, we might expect to find very healthy, robust, low-*K* individuals when young but see a rapid decline in this robustness as they mature. Across their lifespan, there should be higher rates of intrinsic disease and mortality, and we should note an earlier onset and more rapid degradation of health when compared to those who are higher-*K*. This mortality may come from a compromised immune system, a breakdown of some somatic maintenance mechanism (e.g., cellular turnover), or the negative effects of sex hormones associated with antagonistic pleiotropy (e.g., testosterone). Despite this prediction, however, the current sample of 18-year olds might be too young to identify such variation.

Antagonistic pleiotropy also predicts that the gender that engages in higher mating effort will have encountered stronger selection when young, compared to the gender that engages in lower mating effort. In humans, males are the higher mating-effort gender. As such, human males should show lower deleterious effects when young, at a cost for later health and longevity. One example of such an effect can be illustrated with testosterone.

Testosterone is a male sex hormone that increases musculature and aggressiveness. This may have a fitness-enhancing effect when young as it increases competition for mates. However, it also shows many negative effects from prolonged, or heightened, exposure. These negative effects include immune suppression and increased susceptibility

to prostate cancer (leading to poor health) and aggressiveness, recklessness, and risk taking that may lead to injury or death (Wilson and Daly 1985) and may even be related to the 7-year lower life expectancy of human males compared to females (Williams and Nesse 1991). Simply put, selection operates on the young, at a cost to the old; and selection operates more harshly on human males than females.

More research needs to examine this proposition in relation to individual differences in human life-history strategy. Specifically, research should examine whether the relationship between the *K-factor* and *F-factor* reappears for older males. Further, research should examine whether there is a cross-over age, wherein the relationship between the *K-factor* and *F-factor* becomes more pronounced in males than in females. Unfortunately, the regression analysis is unable to determine the causal direction of the *K-factor/F-factor* relationship.

Relationships among the K-factor, F-factor, and g-factor

Counter to the predictions, there were no direct relationships between either *K* or *F* and *g* or a $K \times F$ interaction and *g*. This is, at first, surprising owing to the large amount of literature showing a relationship between intelligence and many key life history (e.g., birth weight, Richards, Hardy, Kuh, and Wadsworth 2001; longevity, Whalley and Deary 2001) and health traits (Gottfredson and Deary 2004). Further, other research (e.g., Smith 1989) has established the connection between brain size and intelligence and shown that brain weight is related to a variety of life history traits (e.g., life span, length of gestation, age of weaning, age at sexual maturity, interbirth interval, and body weight). Although it is intuitive to extrapolate from such research that intelligence and life-history strategy will be linked, alternative hypotheses should also be taken into account

First, though it has been established that in humans there is a moderate relationship between both head size and intelligence (mean $r = .19$) and brain size based on magnetic resonance imaging and intelligence ($r = .40$, $p < .05$; Wickett Vernon, and Lee 1994), much of the variance in intelligence is still unaccounted for by either metric. Arguments using head/brain size/weight as a proxy for intelligence may introduce a high degree of measurement error. Further, whereas most research reports single-item correlations between variables (e.g., brain size and score on a single intelligence measure), the current study was concerned with correlations between higher-order factors composed of a variety of measurements. If, as is argued, both life-history strategy and general intelligence are composite entities, inclusive of a variety of genetically and phenotypically linked traits, results based on higher-order factor modeling, such as in the current study, might be more realistic than results examining bivariate correlations between two separate traits.

A second explanation for such findings stems from the difficulty in extrapolating within-species comparisons based on between-species differences. Rushton (2004) identified positive relationships between brain weight and many life-history traits (e.g., gestation time, birth weight, lactation time, body size, age of first mating, and longevity) when comparing between species. However, other research has shown that when comparing within-species differences, factors such as body size is related to large litters, early maturation, high reproductive rates, and low adult mortality (Altmann and Alberts 2003). Disparate findings such as these suggest that making claims of within-species variation based on between-species comparisons might be unwarranted.

Additionally, the theoretical nature of intelligence needs to be addressed. For example, *differential-K theory* posits that general intelligence was shaped by selection to solve problems associated with newly encountered harsh, but predictable, ecological conditions.

It would seem that in such an ecological context, selection would be better served to create inflexible, instinctual mechanisms based on such predictability. Other theories of general intelligence tend to focus on novel adaptive problems as being the drive for its evolution (e.g., Kanazawa 2003). If true, this might explain why there is no difference in the *g-factor* between high-*K* and low-*K* individuals, as novel encounters are likely to occur across ecological niches.

Perhaps though general intelligence may not be a product of life-history strategy, social intelligence is. Social intelligence deals with behaviors such as social technique, “knowledge of social matters, susceptibility to stimuli from other members of a group, and insight into the temporary moods and underlying personality traits of strangers,” which together aid an individual in getting along with others, in general (Vernon 1933, p. 44). The larger social group size, higher group cohesion and altruism, yet more intersexual aggression thought to be associated with *K*-selection might provide a selective pressure for the ability to be able to gauge and react correctly to social situations (i.e., socially intelligent). Indeed, Andrzejczak et al. (2007) recently reported that various convergent indicators of a high-*K* life-history correlated positively and significantly with a short-form measure of emotional intelligence.

Other cognitive capacities may also be related to life-history strategy. As Pianka (1970) argued, the *r/K* dichotomy of life-history is an adaptive solutions to problems associated with the predictability and stability of environments. Many cognitive capacities associated with executive function may therefore be better candidates as indicators of life-history. For example, the abilities to update information, inhibit behavior, and shift between multiple tasks are each components of executive function. Because a harsh, predictable environment would necessitate the ability to delay gratification, plan ahead, and live in large social groups; high-*K* individuals should have the ability to control impulsive behaviors, shift attention in a quick, flexible manner, and integrate, organize, and monitor their performance. These abilities have been shown to be unrelated to general intelligence (Friedman, Miyake, Corley, Young, DeFries, and Hewitt 2006). Indeed, MacDonald, Figueredo, Wenner, & Howrigan (2007) have reported a significant positive correlation between the *K-factor* and an executive function factor composed of three such measures, with none of them being significantly correlated with general intelligence.

Many previous studies report a relationship between measures of general intelligence and single proposed indicators of fitness such as; body symmetry (Furlow, Armijo-Prewitt, Gangestad, and Thornhill 1997; Prokosch, Yeo, and Miller 2005); physical attractiveness (Zebrowitz, Hall, Murphy, and Rhodes 2002); general health (Jensen and Sinha 1993); and longevity (Whalley and Deary 2001). The current data are, however, inconsistent with these findings.

This is a difficult issue to resolve as the available literature examining the proposed “fitness factor” has been met with positive results (i.e., there is a strong relationship between single measures of morphodevelopmental stability, such as body symmetry and hormone markers, and neurodevelopmental stability (i.e., general intelligence, psychopathology, personality). The only explanation offered here is that again, though previous studies were utilizing single-trait indicators of these constructs, the current study used higher-order factors composed of many different indicators. It may be that not all proposed indicators are equally representative of the proposed construct, and therefore inclusion in the construct mediates this relationship. Further work is necessary to resolve this issue.

Limitations and Future Directions

There are several limitations associated with the current study. First, the age of this sample may not be a representative age for exploring the evolutionary psychology of human

mating behavior (Sefcek, BRumbach, Vasquez, and Miller 2006). Because both fertility and mating effort peak in the mid- to late twenties, looking for variation in mating behavior among 18-year-old college students might be unwise. Additionally, the college environment is likely to be very different than what was experienced over the course of both the developmental history of the student and the evolutionary history of humans. College students experience novel stimuli (e.g., little direct familial contact and supervision, large groups of unknown same-sex and other-sex peers) that may necessitate both a restructuring of already learned strategies and an adoption of new ones. Future research needs to incorporate samples that are more varied in ages, cultures, and developmental histories.

A second limitation concerns the structure of the *K-factor* itself. *Differential-K theory* predicts the use of a coherent behavioral strategy in the execution of one's life-history. Associated with this strategy should be a variety of attitudes, behaviors, and physiological features. To date, the measures used in the Arizona Life History Battery to define the *K-factor* have focused on self-reports of recalled past behaviors, attitudes concerning past behaviors, and attitudes and predictions of future behaviors. For the Arizona Life History Battery to become better established as a valid indicator of life-history strategy, it will need to (1) incorporate more objective measures of past, current, and future behavior and (2) incorporate more direct measures of sexual and reproductive behaviors (e.g., counting babies, counting past/current number of sexual partners). Research will also need to include observational data collection focusing on different aspects of theoretically important behaviors (e.g., do those who are measured as being low-*K* actively seek out more sexual partners than those who are measured as high-*K*)?

References

- Altmann, J., and S. C. Alberts. 2003. Intraspecific variability in fertility and offspring survival in a non-human primate: Behavioral control of ecological and social sources. In *Biodemography of fertility and family behavior*, eds. K. W. Wachter and R. A. Bulatao, 140–169. Washington, DC: National Academy Press.
- Andrzejczak, D. J., D. N. Jones, V. Smith, E. Montero, and A. J. Figueredo. 2007. Ethnocentrism and life history strategy. In *Correlates of life history strategy*. Paper presented at Annual Meeting of the Human Behavior and Evolution Society, Williamsburg, Virginia.
- Barton, K., T. E. Dielman, and R. B. Cattell. 1971. The prediction of school grades from personality and IQ measures. *Personality* 2(4):325–333.
- Bartzokis, G., M. Beckson, P. H. Lu, K. H. Neuchterlein, N. Edwards, and J. Mintz. 2001. Age-related changes in frontal and temporal lobe volumes in men: A magnetic resonance imaging study. *Arch Gen Psychiatry* 58:461–465.
- Bassili, J. N. 1995. Response latency and the accessibility of voting intentions: What contributes to accessibility and how it affects vote choice. *Pers Soc Psychol B* 21:686–695.
- Beck, A. T., R. A. Steer, and G. K. Brown. 1996. *Beck Depression Inventory Manual* (2nd ed.). San Antonio, TX: The Psychological Corporation.
- Bock, G., J. Goode, and K. Webb. 2000. The nature of intelligence. In *Novartis Foundation Symposium* 233. New York: John Wiley & Sons.
- Brim, O. G., P. B. Baltes, L. L. Bumpass, P. D. Cleary, D. L. Featherman, W. R. Hazzard, et al. 2000. National survey of midlife development in the United States (MIDUS), 1995–1996. ICPSR version. Ann Arbor, MI: DataStat, Inc.
- Brown, M. W. 1994. Cognitive, interest, and personality variables predicting first-semester GPA. *Psychol Rep* 74(2):605–606.
- Brumbach, B. H., A. J. Figueredo, and B. J. Ellis. 2009. Effects of harsh and unpredictable environments in adolescence on development of life history strategies: A longitudinal test of an evolutionary model. *Hum Nat* 20:25–51.

- Buchner, A., E. Erdfelder, and F. Faul. 1997. How to use G*Power. The University of Dusseldorf, Institute for Experimental Psychology. Retrieved September 3, 2008, from http://www.psych.uni-duesseldorf.de/aap/projects/gpower/how_to_use_gpower.html
- Caspi, A., B. Williams, J. Kim-Cohen, I. W. Craig, B. J. Milne, R. Poulton, et al. 2007. Moderation of breastfeeding effects on the IQ by genetic variation in fatty acid metabolism. *Proc Natl Acad Sci USA* 104(47):18860–18865.
- Cattell, R. B. 1978. *The scientific use of factor analysis in behavioral and life sciences*. New York: Plenum.
- Chamberlin, T. C. 1890/1965. The method of multiple working hypotheses. *Science* 148:754–759.
- Charles, K. E., and V. Egan. 2005. Mating effort strongly predicts self-reported delinquency in a normal adolescent sample. *Pers Individ Differ* 38:1035–1045.
- Cohen, J., P. Cohen, S.A. West, and L.S. Aiken. 2003. *Applied multiple regression/correlation analysis for the behavioral sciences*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Derogatis, L. R., R. S. Lipman, K. Rickels, E. H. Uhlenhuth, and L. Covi. 1974. The Hopkins Symptom Checklist: A self report symptom inventory. *Behav Sci* 19:1–15.
- Dyer, E. D. 1987. Can university success and first-year job performance be predicted from academic achievement, vocational interest, personality and biographical measures? *Psychol Rep* 61(2):655–671.
- Egan, V., A. J. Figueredo, P. Wolf, K. McBride, J. Sefcek, G. Vasquez, et al. 2005. Sensational interests, mating effort, and personality: Evidence for cross-cultural validity. *J Individ Differ* 26:11–19.
- Ellis, L. 1988. Criminal behavior and r/K selection: An extension of gene-based evolutionary theory. *Pers Individ Differ* 9:697–708.
- Figueredo, A. J., B.H. Brumbach, D.N. Jones, J.A. Sefcek, G. Vásquez, and W.J. Jacobs. 2007. Ecological constraints on mating tactics. In *Mating Intelligence: Theoretical and Empirical Insights into Intimate Relationships*, ed. G. Geher, and G.F. Miller. Mahwah, NJ: Lawrence Erlbaum.
- Figueredo, A. J., J. Sefcek, G. Vasquez, B. H. Brumbach, J. E. King, and W. J. Jacobs. 2005. Evolutionary theories of personality. In *Handbook of evolutionary psychology*, ed. D. M. Buss, 851–877. Hoboken, NJ: John Wiley & Sons.
- Figueredo, A. J., and J. P. Rushton. 2009. Evidence for shared genetic dominance between the general factor of personality, mental and physical health, and life history traits. *Twin Res Hum Genet* 12(6):555–563.
- Figueredo, A. J., G. Vásquez, B. H. Brumbach, and S. M. R. Schneider. 2007. The K-factor, covitality, and personality: A psychometric test of life history theory. *Hum Nat* 18(1):47–73.
- Figueredo, A. J., G. Vásquez, B. H. Brumbach, and S. M. R. Schneider. 2004. The heritability of life history strategy: The K-factor, covitality, and personality. *Soc Biol* 51:121–143.
- Figueredo, A. J., G. Vásquez, B. H. Brumbach, S. M. R. Schneider, J. A. Sefcek, I. R. Tal, et al. 2006. Consilience and life history theory: From genes to brain to reproductive strategy. *Dev Rev* 26:243–275.
- Figueredo, A. J., G. Vásquez, B. H. Brumbach, J. A. Sefcek, B. R. Kirsner, and W. J. Jacobs. 2005. The K-factor: Individual differences in life history strategy. *Pers Individ Differ* 39:1349–1360.
- Friedman, N. P., A. Miyake, R. P. Corley, S. E. Young, J. C. Defries, and J. K. Hewitt. 2006. Not all executive functions are related to intelligence. *Psychol Sci* 17:172–179.
- Furlow B. F, T. Armijo-Prewitt, S.W. Gangestad, and R. Thornhill. 1997. Fluctuating asymmetry and psychometric intelligence. *Proc R Soc B* 264:823–829.
- Galton, F. 1869/1962. *Hereditary genius: An inquiry into its laws and consequences*. London: Macmillan/Fontana.
- Gottfredson, L. S., and I. J. Deary. 2004. Intelligence predicts health and longevity, but why? *Curr Dir Psychol Sci* 13(1):1–4.
- Gottfredson, L. S. 2004. Intelligence: Is it the epidemiologists' elusive "fundamental cause" of social class inequities in health? *J Pers Soc Psychol* 86:174–199.
- Hare, R. D. 1993. *Without conscience: The disturbing world of the psychopaths among us*. New York: Guilford Press.
- Horn, J. L. 1965. A rationale and test for the number of factors in factor analysis. *Psychometrika* 30:179–185.

- Jensen, A. 2000. The g factor: Psychometrics and biology. In *The nature of intelligence*. Novartis Foundation Symposium 233, eds. G. Bock, J. Goode, and K. Webb, 37–47. New York: John Wiley & Sons.
- Jensen, A. R., and S. N. Sinha. 1993. *Physical correlates of human intelligence*. *Biological approaches to the study of human intelligence*, ed. P. A. Vernon. Norwood, NJ: Ablex.
- Kanazawa, S. 2003. General intelligence as a domain-specific adaptation. *Psychol Rev* 111:1761–1776.
- Kirk, K. M., S. P. Blomberg, D. L. Duffy, A. C. Heath, I. P. F. Owens, and N. G. Martin. 2001. Natural selection and quantitative genetics of life-history traits in western women: A twin study. *Evolution* 55:423–435.
- Lapierre, R. T. 1934. Attitudes vs. actions. *Soc Forces* 13:230–237.
- Lilienfeld, S. O., and B. P. Andrews. 1996. Development and preliminary validation of a self-report measure of psychopathic personality traits in noncriminal populations. *J Pers Assess* 66:488–524.
- Macdonald, K. M., A. J. Figueredo, C. Wenner, and D. Howrigan. 2007. Life history strategy, executive functions, and personality. In *Correlates of life history strategy*. Paper presented at Annual Meeting of the Human Behavior and Evolution Society, Williamsburg, Virginia.
- Mcarthur, R. H., and E. O. Wilson. 1967. *The theory of island biogeography*. Princeton, NJ: Princeton University Press.
- Mealey, L. 1995. The sociobiology of sociopathy: An integrated evolutionary model. *Behav Brain Sci* 8(3):523–599.
- Miller, E. M. 1994. Paternal provisioning versus mate seeking in human populations. *Pers Individ Differ* 17(2):227–255.
- Miller, G. F. 2000a. Mental traits as fitness indicators: Expanding evolutionary psychology's adaptationism. *Evolutionary approaches to human reproductive behavior*. *Ann N Y Acad Sci* 907:62–74.
- Miller, G. F. 2000b. *The mating mind: How sexual choice shaped the evolution of human nature*. New York: Doubleday.
- Miller, G. F. 1998. How mate choice shaped human nature: A review of sexual selection and human evolution. In *Handbook of evolutionary psychology: Ideas, issues, and applications*, ed. C. Crawford and D. Krebs, 87–129. Hillsdale, NJ: Lawrence Erlbaum.
- Mouw, J. T., and R. K. Khanna. 1993. Prediction of academic success: A review of the literature and some recommendations. *Coll Stud J* 27(3):328–336.
- Murray, C. 1998. *Income inequality and IQ*. Washington, DC: AEI Press.
- Nunnally, J. 1978. *Psychometric theory*. New York: McGraw-Hill.
- Pedhazur, E. J. and Schmelkin, L. P. 1991. *Measurement design, and analysis: An integrated approach*. Hillsdale, NJ: Erlbaum.
- Pianka, E. R. 1970. On r-and K-selection. *Am Nat* 104:592–596.
- Platt, J. R. 1964. Strong inference. *Science* 146:347–353.
- Prokosch, M. D., R. A. Yeo, and G. F. Miller. 2005. Intelligence tests with higher g- loadings show higher correlations with body symmetry: Evidence for a general fitness factor mediated by developmental stability. *Intelligence* 33:203–213.
- Raven, J. C., J. H. Court, and J. Raven. 1998. *Manual for Raven's Standard Progressive Matrices* [1998 edition]. Oxford, UK: Oxford Psychologists Press.
- Raven, J. C. Raven, and J. H. Court. 1997. *Mill Hill Vocabulary Scale* [1998 edition]. Oxford, UK: Oxford Psychologists Press.
- Richards, M., R. Hardy, D. Kuh, and M. E. J. Wadsworth. 2001. Birth weight and cognitive function in the British 1946 birth cohort: Longitudinal population based study. *Br Med J* 322:199–203.
- Richards, M., R. Hardy, D. Kuh, and M.E. Wadsworth. 2001. Birth weight and cognitive function in the British 1946 birth cohort: Longitudinal population based study. *BMJ (Clinical Research Ed)* 322:199–203.
- Rodgers, J. L., D. Bard, and W. B. Miller. 2007. Multivariate Cholesky models of human female fertility patterns in the NLSY. *Behav Genet* 37:345–361.
- Rodgers, J. L., M. Buster, and D. C. Rowe. 2001. Genetic and environmental influences on delinquency: DF analysis of NLSY kinship data. *J Quant Crim* 17:145–168.

- Rodgers, J. L., K. Hughes, H.-P. Kohler, K. Christensen, D. Dougherty, D. C. Rowe, et al. 2001. Genetic influence helps explain variation in human fertility outcomes: Evidence from recent behavioral and molecular genetic studies. *Curr Direct Psychol Sci* 10:184–188.
- Rowe, D. C. (2000). Environmental and genetic influences on pubertal development: Evolutionary life history traits? In *Genetic influences on human fertility and sexuality: Recent empirical and theoretical findings*, eds. J. L. Rodgers, D. C. Rowe, and W. B. Miller, 147–168. Boston: Kluwer.
- Rowe, D. C., and D. J. Flannery. 1994. An examination of environmental and trait influences on adolescent delinquency. *J Res Crime Delinq* 31:374–379.
- Rowe, D. C., and J. L. Rodgers. 1989. Behavior genetics, adolescent deviance, and “d”: Contributions and issues. In *Advances in adolescent development*, eds. G. Adams, R. Montemayor, and T. Gullotta, 38–70. Newbury Park, CA: Sage Publications.
- Rowe, D. C., A. T. Vazsonyi, and A. J. Figueredo. 1997. Mating effort in adolescence: Conditional or alternative strategy? *Pers Indiv Diff* 23(1):105–115.
- Rowe, L., and D. Houle. 1996. The lek paradox, condition dependence and genetic variance in sexually selected traits. *Proc R Soc B Biol Sci* 263:1415–1421
- Rushton, J. P. 2004. Placing intelligence into an evolutionary framework or how g fits into the r-K matrix of life history traits including longevity. *Intelligence* 32:321–328.
- Rushton, J. P. 2000. *Race, evolution, and behavior: A life-history perspective* (3rd ed). Port Huron, MI: Charles Darwin Research Institute.
- Rushton, J. P. 1985. Differential K theory: The sociobiology of individual and group differences. *Pers Indiv Diff* 6(4): 441–452.
- SAS Institute, Inc. 1999. SAS/STAT User’s Guide, Version 8, Volumes 1, 2, and 3. Cary, NC: SAS Institute.
- Sefcek, J. A., B. H. Brumbach, G. Vásquez, and G. F. Miller. 2006. The evolutionary psychology of human mate choice: How ecology, genes, fertility, and fashion influence our mating behavior. Handbook of the Evolution of Human Sexuality, Part 1 [Special issue]. *J Psychol Hum Sex* 18(2/3): 125–182.
- Sefcek, J. A., G. F. Miller, and A. J. Figueredo. 2007. Development and of an 18-item short form of the Ravens Advanced Progressive Matrices (RAPM-18). (Submitted)
- Sivacek, J., and W. D. Crano. 1982. Vested interest as a moderator of attitude-behavior consistency. *J Pers Soc Psychol* 43:210–221.
- Spearman, C. 1904. “General intelligence” objectively determined and measured. *Am J Psychol* 15:201–293.
- Smith, B. H. (1989). Dental development as a measure of life-history in primates. *Evolution* 43: 683–688.
- Vernon, P. E. 1933. Some characteristics of the good judge of personality. *J Soc Psychol* 4:42–57.
- Whalley, L. J., and I. J. Deary. 2001. Longitudinal cohort study of childhood IQ and survival up to age 76. *Br Med J* 322:819–822.
- Ware, J. E., and C. D. Sherbourne. 1992. The MOS 36-Item Short-Form Health Care Survey (SF-36): I. Conceptual framework and item selection. *Med Care* 30:473–483.
- Wicker, A. W. 1969. Attitudes vs. action: The relationship of verbal and over behavioral responses to attitude objects. *J Soc Issues* 25:41–78.
- Wickett, J. C., P. A. Vernon, and D. H. Lee. 1994. In vivo brain size, head perimeter, and intelligence in a sample of healthy adult females. *Pers Indiv Differ* 16:831–838.
- Williams, G. C. 1957. Pleiotropy, natural selection, and the evolution of senescence. *Evolution* 11:398–411.
- Williams, G. C., and R. M. Nesse. 1991. The dawn of Darwinian medicine. *Q Rev Biol* 66:1–22.
- Williams, P. D., and T. Day. 2003. Antagonistic pleiotropy, mortality source interactions, and the evolutionary theory of senescence. *Evolution* 57(7):1478–1488.
- Wilson, M., and M. Daly. 1985. Competitiveness, risk-taking, and violence: The young male syndrome. *Ethol Sociobiol* 6:59–73.

- Zachary, R. A. 1986. *Shipley Institute of Living Scale, Revised Manual*. Los Angeles: Western Psychological Services.
- Zahavi, A. 1975. Mate selection—a selection for a handicap. *J Theor Biol* 53:205–214.
- Zahavi, A. 1991. On the definition of sexual selection, Fisher's model, and the evolution of waste and of signals in general. *Anim Behav* 42:501–503.
- Zebrowitz, L. A., J. A. Hall, N. A. Murphy, and G. Rhodes. 2002. Looking smart and looking good: Facial cues to intelligence and their origins. *Pers Soc Psychol Bull* 28(2):238–249.