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On the psychometric study of human life history strategies: State of the science and evidence of two independent dimensions

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Abstract

This article attends to recent discussions of validity in psychometric research on human life history strategy (LHS), provides a constructive critique of the extant literature, and describes strategies for improving construct validity. To place the psychometric study of human LHS on more solid ground, our review indicates that researchers should (a) use approaches to psychometric modeling that are consistent with their philosophies of measurement, (b) confirm the dimensionality of life history indicators, and (c) establish measurement invariance for at least a subset of indicators. Because we see confirming the dimensionality of life history indicators as the next step toward placing the psychometrics of human LHS on more solid ground, we use nationally representative data and structural equation modeling to test the structure of middle adult life history indicators. We found statistically independent mating competition and Super-K dimensions and the effects of parental harshness and childhood unpredictability on Super-K were consistent with past research. However, childhood SES had a moderate positive effect on mating competition and no effect on Super-K, while unpredictability did not predict mating competition. We conclude that human LHS is more complex than previously suggested – there does not seem to be a single dimension of human LHS among Western adults and the effects of environmental components seem to vary between mating competition and Super-K.

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Life history theory (LHT) explains biodiversity in terms of fitness trade-offs faced by organisms, the most prominent of which stem from the costs of reproduction (Stearns, 1976, 1989). According to LHT, the finite nature of resources available to organisms during evolution induced multiple-trait trade-offs among fitness components such as current vs. future reproduction and offspring quality vs. quantity (Hill & Kaplan, 1999). The idea central to LHT is that resources allocated to early reproduction, for instance, cannot also be allocated to somatic effort and longevity. In the absence of constraints, selection presumably maximizes allocation to all fitness components (Agrawal, Conner, & Rasmann, 2010). However, given that resource constraints are ubiquitous in nature, species vary in terms of traits such as developmental tempo, reproductive timing, offspring number, body size, and longevity (Stearns, 1976).

Researchers began applying life history theory to variation within humans in the 1980s and 90s (Belsky, Steinberg, & Draper, 1991; Chisholm, 1999; Draper & Harpending, 1982). Draper and Harpending (1982) proposed that early experience entrains development of reproductive strategies individuals follow throughout life. Belsky, Steinberg, and Draper (1991) proposed that stressful childhood environments (mediated by parental stress and less stable parent-child attachments) accelerate psychosocial development, such that individuals who were stressed early tend to experience earlier maturation, pubertal timing, sexual debut, and eventually more unstable adult pair bonds. According to these models, early environmental cues during the first 5-7 years of life trigger a developmental shift toward allocation of resources to early reproduction and mating effort at the expense of somatic and parental effort.

Recent psychometric research has extended life history theory to a broad suite of psychosocial traits (Figueredo et al., 2006). The underlying rationale is that natural and sexual selection produced clusters of co-adapted traits that function as coherent reproductive strategies,

or life history strategies (Figueredo et al., 2006; Figueredo et al., 2014). In this view, adaptations that allocate resources between somatic and reproductive effort and also between mating effort and parental/nepotistic effort are executed in a coordinated fashion, producing reproductively coherent phenotypes in terms of personality, psychosocial characteristics, and outward behaviors. Consistent with this, a second-order K-factor has subsumed constructs such as planning and control, social contact and support, attachment, religiosity, and altruism (for a review, see Olderbak et al. 2014). Lower scores on this factor are thought to correspond to faster life history strategy (LHS) while higher scores are thought to imply slower LHS.

Copping et al. (2014) recently identified several important areas for improving validity in psychometric research on human life history strategy (LHS), many of which are issues of construct validity (e.g., internal structure of questionnaires designed to measure LHS, including the Mini-K [Figueredo et al., 2006] and high-K strategy scale [HKSS; Giosan, 2006]). In response to this critique, Figueredo and colleagues (2015) argued that the psychometric study of human LHS is on solid footing. Here we elaborate on some of the issues identified by Copping et al. (2014), taking into consideration the Figueredo et al. (2015) response, by discussing approaches to psychometric modeling and also by reviewing steps that can be taken to improve construct validity when factor modeling is employed. We then take stock of the extant psychometric literature and find that the dimensionality of life history indicators has not been adequately confirmed. Given that this is crucial for establishing construct validity, we use nationally representative data and structural equation modeling with bifactor models to test the structure of middle adult life history indicators. We conclude by summarizing findings and providing implications and next steps for studies of human LHS.

Philosophical Considerations

Psychometric modeling is partly guided by philosophical considerations. The very first step in any effort to establish construct validity is selection of a modeling approach that makes sense given a researcher's philosophy of measurement. Modern psychometrics is typically driven by realism, or the notion that latent variables are proxies for *real* variables with explanatory content. As described by Borsboom (2006):

> One of the main breakthroughs of the past century in psychometric thinking about measurement consists in the realization that measurement does not consist of finding the right observed score to substitute for a theoretical attribute, but of devising a model structure to relate an observable to a theoretical attribute. An essential precondition for this realization to occur is that, either intuitively or explicitly, one already holds the philosophical idea that theoretical attributes are, in fact, distinct from a set of observations, i.e., that one rejects the operationalist thesis that theoretical attributes are synonymous with the way they are measured (Bridgman, 1927). (p. 429)

In psychometric research, factor models are commonly used to measure psychological attributes. As Borsboom (2006) explained, these are models of the relationships between observed scores and latent attributes and are used to estimate the properties of the latter. Factor models can be used in a purely descriptive manner that does not invoke realism, at least with respect to latent variables (Jonas & Markon, 2016). The descriptivist approach can be seen as more concerned with statistical parsimony than elucidating the nature of causal forces responsible for patterns of covariation – it attends to *what* more so than *why* (Harms, Wood, & Spain, 2016). The descriptivist approach advances by discovering the shortest possible representation of the data in an information theoretic sense, while the realist approach attends to statistical parsimony but also places a premium on explicating the functional or causal relationships among variables (Borsboom, Mellenbergh, & Jaap van Heerdeen, 2003; Harms, Wood, & Spain, 2016; Jonas & Markon, 2016).

LHS is often invoked as an organizing source or *cause* of covariation among life history indicators. This conception of LHS is not obligatory – a descriptivist approach could also be employed. However, if higher-order latent LHS variables cannot be understood as causing multiple life history traits, research interest would likely shift toward the individual traits. This is because evolutionary psychological researchers typically want to characterize evolved mechanisms, not just find the simplest way to summarize covariance among traits. Importantly, life history theory (LHT) attends to adaptations that evolved to successfully cause genetic propagation given the finite nature of resources and variation in environmental conditions (Stearns, 1976). Thus, in addition to determining the dimensionality of life history indicators (i.e., the most statistically parsimonious way to represent them), we see the psychometrics of human LHS as concerned with realist questions about latent LHS variables: Are the effects of latent LHS variables on their indicators invariant across populations, settings, and time? Do latent LHS variables fully explain the associations between their indicators and other theoretically relevant variables (e.g., environmental conditions)? These questions assume that it is theoretically plausible that latent LHS variables correspond to evolved mechanisms or unitary variables formed by evolved mechanisms. Of course, this is an important question in itself.

From the perspective developed above, several recent discussions about latent LHS variables can be seen as containing problematic claims. According to Figueredo et al. (2015):

> Although the psychometric approach composites multiple indicators present in the developmental pathway of the psychosocial acceleration model for the purpose of constructing latent variables, it can also be used to test components of the psychosocial acceleration model. (p. 313)

Though compositing indicators may serve descriptive purposes well, it seems somewhat antithetical to modeling a mechanistic process such as psychosocial acceleration (see Harms,

Wood, & Spain, 2016). Moreover, this passage is consistent with others in psychometric studies of LHS in that it seems to conflate latent variables (i.e., factors) that subsume their indicators with composites formed by researchers. In a factor model, multiple indicators are not composited to form latent variables. Instead, the relations among the indicators allow researchers to determine the properties of the latent variable (Bollen, 1989; Cohen et al., 1990). From a realist perspective, this variable should be understood as causing and therefore distinct from and temporally precedent to its indicators (Edwards & Bagozzi, 2000; Borsboom, Bellenbergh, & Vaap van Heerden, 2003). This view excludes the use of early childhood events or traits as reflective indicators of adolescent or young adult LHS, unless the latent variable can be understood as time invariant and therefore able to cause a reflective indicators operating early and also later in development.

In another illustrative example, Figueredo et al. (2015) simultaneously describe common factors as relatively agnostic to the causal effects that link their indicators and also as the underlying causes to which these effects are attributable:

> Nevertheless, the critique makes a valid point in stating that common factor models using global inventories such as the ALHB are relatively agnostic with respect to possible causal relations among its various components. Any common factor model, and not just ours, represents the multiple convergent indicators as effects of a common unobserved influence, which is the latent variable hypothesized. The purpose of such "measurement models" is to measure the phenomenon in question by means of whatever manifest indicators can be systematically associated with it. (p. 314)

Agnosticism to the causal relations among indicators is coherent with a descriptivist approach. However, if LHS factors are assumed to represent common unobserved influences on indicators, they are not relatively agnostic to the causal nature of latent variable-indicator relationships. In

turn, many variables will not function as valid indicators of these LHS factors. For instance, models that specify causes of LHS as its reflective indicators would be seen as miss-specified. Unfortunately, specifying such causes in formative measurement models may also be unviable (Edwards, 2010; Lee & Cadogan, 2013; Rhemtulla, Riet van Bork, & Borsboom, 2015).

Finally, we consider an additional example to further illustrate the importance of clarifying the causal status of LHS with respect to its indicators. In their hybrid model (p. 314), Figueredo et al. (2015) regressed several facets of LHS on Mini-K scale scores. Importantly, the Mini-K scores were produced through an aggregation of items that overlap the content of the endogenous variables they impacted. For example, some Mini-K items assess the warmth of the relationships participants have with their parents and romantic partners. In the model, these item contents overlapped domains endogenous to the Mini-K (e.g., *romantic partner attachment* and *biological mother and father*). Thus, the Mini-K was not distinct from the outcomes it influenced, a problem that likely biased estimates of its effects (i.e., a discriminant validity problem; McGrath, 2005). Given the validity problems plaguing this model, we contend that it should not be seen as strong evidence that the Mini-K provides valid measurement of its intended construct.

Researchers can avoid conceptual confusion and produce more unbiased estimates through careful consideration and clarification of their assumptions about latent variables. As we noted, a descriptivist approach can be employed and does not require the assumption that factors are exogenous to their indicators. But if researchers are employing this approach, what rationale is there for using directed graphs to represent their effects? And, what rationale is there for imposing statistical independence between endogenous variables such as factor indicators? It is important to recognize that in structural models, independencies imply strong causal assumptions

(e.g., two variables do not cause one another directly). To date, we have not seen any explicit application of descriptivism in human life history research. Perhaps descriptivism has been implicit in some studies. In the future, we recommend that researchers alert readers if they are deviating from the usual approach to factor modeling by employing descriptivist principles. In the following section, we assume a realist approach to factor modeling and describe steps for establishing construct validity.

Establishing Construct Validity with Factor Models

Indicator selection. Once researchers' have clarified their measurement approach, indicator selection is the next step in establishing construct validity via factor modeling. Importantly, modeling assumptions carry with them implications for how indicators may be selected. Most researchers employing factor models probably recognize the assumption that factors cause indicators allows us to estimate properties of latent variables and attenuate them for measurement error, revealing "true" score variance (Cohen et al., 1990). In contrast, composites and indexes are not attenuated for measurement error. Fewer may be aware that this causal assumption also implies that the indicators in the reflective factor model are interchangeable. That is, the parameters of latent variables with reflective indicators can be invariant to which specific indicators are included in the model (Bollen & Lennox, 1991; Hayduk et al., 2007). In contrast, composites and indexes are determined by their indicators and so their parameters are dependent on which variables are used to form them. This distinction extends to estimates of the effects between constructs. For composites, consistency in such effects across studies depends on the operationalization of the construct, or *which* variables are used in the forming process, while a variety of reflective indicators can be used to measure latent constructs and achieve such consistency.

Simulation research indicates that when confirmatory factor analysis (CFA) is used, researchers can locate the correct latent variable with as few as three indicators or as few as two when they provide broad coverage of the construct space and reflect the construct to the same extent (Little, Lindenberger, & Nesselroade, 1999). Indeed, with some information from prior research and/or a very strong theory, a single indicator may be used (Hayduk & Littvay, 2013). This implies that the task of selecting invariant indicators of LHS should not be too onerous. If a variety of such indicators are identified, life history researchers can avoid a troublesome outcome of operationalism – variance in findings across labs that is due to differences in the way constructs are operationalized. Instead, researchers in different labs may employ varying selections of indicators and as consistent relationships between construct estimates emerge, become increasingly confident in the nature of LHS. Thus, we see no reason why researchers should all opt to use the Arizona Life History Batter (ALHB) or the Mini-K. Indeed, variations in the instrumentation and vantages used by multiple independent labs is important for protecting against researcher bias that may occur in the context of study design (e.g., method or measurement bias; Spector, 2006), population identification and sampling, interviewing and documentation, and citation of previous studies (Pannucci & Wilkins, 2010).

Exploratory versus confirmatory models. It may seem as though psychometric research on human LHS has already established indicators that provide valid measurement, as well as established that LHS is unidimensional. However, most extant studies (e.g., Dunkel & Decker, 2010; Figueredo, Vasquez, Brumbach, & Schneider, 2007; Gladden, Welch, Figueredo, & Jacobs, 2009; Gladden, Figueredo, & Jacobs, 2009; Sefcek & Figueredo, 2010) have been exploratory in that they used exploratory factor analysis (EFA), an approach that assumes indicators reflect common factors but specifies no structure in advance. Although it is possible to

obtain a chi-square test in the context of EFA (e.g., in MPlus), researchers have generally not used tests or indexes of model fit to the data when conducting these analyses. Thus, EFA studies have been useful for data reduction (i.e., simplifying the world) and exploring structure, but less so for theory testing. One important implication of this reliance on EFA is that by and large, we do not yet know whether higher-order slow LHS or K-factors, or Super-K factors for that matter, are consistent with the data. That is, we do not know whether such higher-order factors provide greater parsimony without compromising model correspondence to observations. Indeed, Copping et al. (2014) reported that, in a study using Giosan's (2006) High-K Strategy Scale (HKSS), a second-order factor model actually fit the data significantly worse than a first-order model with inter-correlated factors. It is not yet clear whether models that include higher-order factors fit Mini-K or ALHB data as well as those without. This is an important area for future research because this sort of confirmatory testing could lead researchers to determine that there is no K-factor after all.

Measurement invariance. Once researchers have selected indicators on the basis of theory and shown that their factor model is consistent with the data, they can proceed to establish that their measure is widely useful, or measures its construct with invariance to setting and population. In addition to addressing the use of psychometric vs. biometric indicators, Figueredo et al. (2015) made an extensive case (providing illustrative examples along the way) that life history measurement is complicated by myriad variables that moderate the effects between individuals' strategies and the indicators used to measure them. Importantly, this is a problem that has received extensive attention in the methodological literature, where it is known as differential item functioning (DIF) or metric variance (Borsboom, 2006; Brown, 2006; Bollen, 1989; Kline, 2011; Zumbo, 1999). DIF occurs when a construct's effects on its indicators depend

on or vary across levels of other variables (e.g., sex, ethnicity, age, socioeconomic status, etc.). This metric variance implies that the construct may not have the same identity across such variables. At least partial measurement invariance is required to establish the equivalence of the construct (Brown, 2006). Importantly, measurement invariance testing is noticeably absent from research on human LHS, leaving the possibility that no single life history construct exists across subgroups of people within populations. This is striking given Figueredo et al. (2015) themselves pointed out the importance of using the same metric for comparing the sexes (p. 309).

Stemming from the above, one serious concern we have regarding the psychometric study of human LHS is that an ever-increasing list of moderators of the effects of LHS on its indicators and other constructs will cause people to lose interest. This may be a very real possibility – it has occurred in other areas of science. In research testing the Contact Hypothesis (Allport, 1954), so many facilitators (i.e., moderators) of contact effects were being identified that the field became concerned the theory had become unfalsifiable (Pettigrew, 1998). Researchers began to think that contact effects might not generalize past the immediate situation. To avoid this outcome, researchers need to establish the essential manifestations of LHS, or the indicators that are invariant to the broader models in which they are embedded. Without establishing this, no unique identity can be ascribed to LHS (Edwards & Bagozzi, 2000). In addition, researchers need to establish which indicators reflect construct(s) with invariance across contexts and groups of people. Without establishing this, we cannot be sure LHS is broadly useful (Brown, 2006).

Directly relevant to the above, life history research has very recently applied something similar to non-linear factor analysis (see McDonald, 1967) to LHS measurement (e.g., Woodley et al., 2015). In these models, which have been termed continuous parameter estimation models

following a theoretical exposition by Gorsuch (2004), the LHS construct's effects on its indicators decrease as factor scores increase. The theory driving these studies is that life history traits covary to a lesser extent among higher-K strategists because they are characterized by greater phenotypic plasticity (Woodley et al., 2015). No doubt this theory is intriguing, but because the newly developed approach employed by Woodley et al. (2015) provides no test or index of model fit to the data, it is not yet clear that non-linear models explain the relationships among life history traits better than linear ones.

The theoretical development described above is also a bit of a departure from prior research on human LHS. If correct, the Woodley et al. (2015) model presumably implies that between construct estimates based on previous linear models were biased. And, the new model seems to run the risk of making the application of life history theory to humans even more unwieldy in that not only is there a laundry list of factors that might moderate LHS factor loadings, but these loadings are also not invariant across its distribution. However, if methodological research bears out the utility of the continuous parameter estimation model and substantive studies bear out the non-linear relationships between LHS and its indicators, our prescription for moving forward is the same. It will be critical to establish measurement invariance for at least a subset of life history indicators. We are not aware of any reason why moderated non-linear factor analysis (Curran et al., 2014) could not be used to tackle the hypothesis that LHS has non-linear effects on its indicators, as well as test for measurement invariance, given that it provides tests of model fit.

Finally, we wish to stress that we are not arguing that life history research must proceed exclusively via factor modeling. Other potentially useful approaches are available. For instance, a network approach could also be applied to understand the effects between indicators

(Borsboom & Cramer, 2013). We do see many benefits to the use of CFA models (e.g., measurement invariance testing, attenuation of constructs for measurement error). If these models are used in a realist sense, researchers need to begin articulating a precise identity for the latent slow LHS or K-factor variables, one that can be reasonably thought of as invariant to other variables that are modeled and also population sampled. While many variables may moderate the effects of LHS, it is important that we identify at least some indicators that manifest invariantly to protect ourselves from circular reasoning or advancing an unfalsifiable theory.

Where are we now?

Methodological limitations aside, a promising literature on human LHS has emerged. Researchers have selected psychometric indicators of LHS and, as mentioned above, largely attempted to establish construct validity via EFA. When factor models are used, dimensionality typically implies that indicators share common causes on some level. As mentioned, past research seems to bear out the existence of a single fast to slow LH spectrum between species (Chisholm, 1993); most discussions of individual differences in human LHS attend to a single dimension of variation in life history indicators; and a number of studies have found that a second-order K-factor subsumed indicators such as planning and control, social contact and support, attachment, religiosity, and altruism (for a review, see Olderbak et al. 2014). Recently, LHS has been broadened to a third-order Super-K factor that subsumes the second-order K-factor, along with Covitality (i.e., health and mental health) and the General Factor of Personality (which encompasses the Big Five personality traits; Olderbak et al., 2014). These findings suggest that on some level, a single source of variation gives rise to the covariation among life history indicators. Consonantly, our discussion hitherto has followed prior literature in assuming

such unidimensionality. As a reminder, however, this assumption has been subjected to few confirmatory tests and more detailed statistical analysis is required to validate this assumption.

In addition to the lack of confirmatory evidence favoring a single LHS dimension, there may also be empirical and theoretical grounds for questioning the existence of a single fast-slow dimension. An assumption accompanying LHS models with a single higher-order dimension is that lower levels on this factor correspond to greater endorsement of mating competition (e.g., mating effort, dominance-seeking, and risk-taking). This is because according to life history theory, the finite nature of resources induces phenotypic trade-offs (see Mace, 2000; Stearns, 1989) such that investments in slow LHS (i.e., somatic and parental effort) occur at the expense of mating competition (Figueredo et al., 2006). Despite some consensus that there is a single life history continuum within humans, particularly relating to developmental tempo (Belsky, Steinburg, & Draper, 1991; Chisholm, 1993), empirical research has not consistently found a single *dimension* that subsumes the wider documented variation in human LH traits, including individual differences in personality and behavior. For example, Brumbach et al. (2009) found that during adolescence, a single dimension did not subsume LH traits and only a social deviance dimension emerged to explain substantial variance in delinquency and drug use. Brumbach et al. (2009) also reported that uncorrelated latent variables representing social deviance and slow LHS subsumed LH traits during young adulthood. Young adult LHS manifested as health, sexual restrictedness, and resource accruing potential, while social deviance manifested as delinquency, Machiavellianism, alcohol use, and impulsivity. The authors suggested that LHS might canalize into a single dimension later in middle adulthood. Consistent with Brumbach et al. (2009), Richardson et al. (2014) found that not all indicators of young adult LHS reflected one life history dimension. In particular, health and neuroticism did not reflect a LHS variable that

subsumed mating effort, delinquency, and liability to greater substance use. Very recently, Richardson et al. (2016) reproduced these findings in adolescence.

In other studies, low levels on K-factors have corresponded to higher levels of neuroticism and lower levels of health, altruism, conscientiousness, parental investment, and earning potential (Figueredo et al., 2007), but they have not necessarily implied greater mating effort (Gladden, Figueredo, & Jacobs, 2008; Olderbak & Figueredo, 2012; but see Figueredo et al., 2005). Recently, Olderbak et al. (2014) found that mating effort did not reflect four of five K-factors, which subsumed five different measures of LHS (i.e., Super K-1, ALHB, Mini-K, and HKSS, but not Super K-2). Moreover, Figueredo, Gladden, and Hohman (2011) reported that instead, mating effort was subsumed by a latent variable named psychopathic and aggressive attitudes. Consonantly, Jonason, Norman, Li, and Schmidtt (2009) linked the Dark Triad (subsuming psychopathy, Narcissism, and Machiavellianism; Jonason & Webster, 2010) to mating effort indicators, including numbers of sexual partners. From this body of work alone, the relationship between mating effort and K factors remains unclear.

Consistent with the findings discussed above, Richardson et al. (2014) suggested that perhaps mating competition varies uniquely from the K dimension that subsumes delay of reproduction, somatic effort, and parenting effort. Complementing this conception, cross-cultural research on perceptions of the reproductive strategies of literary characters revealed two inversely related but unique dimensions representing high parental effort, long-term strategies and high mating-effort, high-risk strategies (Kruger et al., 2015). Holtzman and Senne (2014) have argued that a two-dimensional model of human LHS should be employed on the basis of findings that mating orientation is not unidimensional but rather reflects two relatively independent factors – short and long-term mating orientations (Holtzman & Strube, 2013;

Jackson & Kirkpatrick, 2007; Webster & Bryan, 2007). Moreover, Fisher (2011) provided a review of biochemical, genetic, demographic, and individual differences data that converge to indicate that some humans engage in lifelong or serial monogamy *in conjunction* with clandestine adultery. Following Gangestad and Simpson (2000; see also Fisher, 2009), Jonason et al. (2009) similarly suggested that like mating strategies (short-term vs. long-term), life strategies (selfish vs. altruistic) might be orthogonal or take on pluralistic forms. Perhaps high levels on mating competition and K-factors can co-occur and LHS is not just multidimensional at the first-order level (i.e., the level of traits like conscientiousness as discussed in Figueredo et al., 2015), but also at higher-order levels.

Research on pathological and normal personality also suggests that a two-dimensional structure of life history traits is plausible. In this literature, liability to externalization has subsumed many of the Brumbach et al. (2009) social deviance variables and also those listed by Figueredo, Gladden, and Hohman (2011; e.g., Krueger, Markon, Patrick, Benning, & Kramer, 2007). In addition, many externalizing constructs such as psychopathy, delinquency, and antisocial behavior (Figueredo et al., 2011; Glenn and Raine, 2009; Harris et al., 2007); substance use (Cavazos-Rehg et al., 2011); and impulsivity and sensation seeking (Robbins & Bryan, 2004) have been linked to or subsumed sexual behavior and other indicators of mating effort and success. These findings suggest that perhaps liability to externalization (including social deviance) and mating competition are interchangeable. Similarly, perhaps the Super-K factor represents the inverse of internalization, consistent with findings that higher levels on this construct imply greater mental and physical health (i.e., covitality; Figueredo et al., 2007).

There are several reasons why mating competition and K- or Super-K factors might only be loosely related. First, independence between mating competition and the K-factor might be

possible due to compartmentalization in the expression of mating competition and the K-factor. These dimensions might not be directly related because the former occurs in out-group contexts (e.g., exploration and acquisition of resources) while the latter occurs within one's group or family (e.g., pair-bonding and parental effort). Second, there is some reason to question whether the finite nature of resources imposes many important life history trade-offs on modern humans. Many human investments (e.g., automobiles, houses, status-bearing occupations, and physical fitness) may simultaneously lend themselves to success in mating effort and also success in somatic and parental effort. As Figueredo et al. noted, modern medicine, birth control, nutrition, extra-somatic wealth, and other aspects of modern environments may also help to decouple mating competition from the K-factor (for discussions of how life history trade-offs may be contingent on factors such as access to resources and environmental conditions, see Mace, 2000; Sibly & Brown, 2007, 2009; Stearns, 1989). Importantly, we note that environmental moderation of trade-offs is a distinct issue from environmental effects on LHS dimensions. That is, aspects of modern environments might decouple LHS dimensions (i.e., dampen their inter-correlations) but still impact them as predicted by psychosocial acceleration theory.

We note that if true, these possibilities would not necessarily imply that there is not a within humans fast-slow life history continuum, as mating competition and K- or Super-K factors might be weakly but negatively correlated directly or through their dependence on general environmental conditions (e.g., unpredictability). However, this *would* imply that there is not a single LHS construct that could be *measured* and scored to capture where people fall from fast to slow. If this were the case, there would be important implications for life history research. For instance, the fast-slow theoretical framework could not be applied to a single life history dimension in a very straightforward manner because someone with a high score on a K- or

Super-K factor might also score highly on mating competition. Importantly, this implication would hold regardless of one's philosophical position regarding the ontology of latent variables.

Finally, life history theory has been extrapolated from between species comparisons to within species variation. Though it seems plausible that the finite nature of resources imposes trade-offs at the within and between species levels, it is not clear that this implies the same structure of life history traits between and within species. Importantly, this issue has been addressed in discussions of the *assumption of local homogeneity* (i.e., models have the same form between and within subjects) and there is evidence that this assumption may hold infrequently (Borsboom, 2006; Borsboom, Mellenbergh, & Jaap van Heerden, 2003; Ellis & Van den Wollenberg, 1993). Critiques of evolutionary theories conflating structure within and between individuals help to illustrate this point (e.g., Kanazawa's Savanah-IQ Hypothesis; see Borsboom & Dolan, 2006; Penke et al., 2011). The implication is that research on human LHS needs to confirm the structure of life history traits and then test whether it is the same between and within species (e.g., as described by Schuurman, Borkenau, Borsboom, & Dolan, 2014). Similarly, it is important to carry out invariance testing across the sexes, ethnicities, and cultures.

The Current Study

We have identified a number of areas for improving validity in research on human LHS. Confirming the structure of life history indicators is the first step in efforts to put the psychometric study of human LHS on more solid ground. Until we use confirmatory modeling to determine the underlying dimensions that subsume life history indicators, we cannot be sure which indicators are most useful or proceed to invariance testing. Despite evidence consistent with a single fast-slow life history continuum in humans, emerging research suggests that life history indicators may reflect two dimensions (i.e., Super-K and mating competition), though

each may coordinate with environmental conditions as predicted by LHT. Further, Brumbach et al. (2009) suggested that life history traits begin to reflect a single dimension in middle adulthood. However, no study has used middle adult data and a model that allows life history indicators to reflect Super-K and also mating competition. Additional research is needed to confirm the dimensionality of life history indicators throughout development, especially in light of recent critiques of the psychological measures of LHS that have stemmed from Differential K theory (e.g., Copping, Campbell, & Muncer, 2014; but also see Figueredo et al., 2015). Here we use nationally representative, longitudinal data to clarify the structure of middle adult life history indicators. If underlying life history dimensions fit the data, we test whether they reflect environmental conditions as predicted by psychosocial acceleration theory (Belsky et al., 1991; Chisholm, 1999).

Methods

Richardson et al. (2014) suggested that relatively independent mating competition and K dimensions might subsume LH traits in the later portion of young adulthood and persist into middle adulthood. In this study, we tested for these two dimensions in middle adulthood using structural equation modeling with bifactor models (Chen, West, & Sousa, 2006) and nationally representative longitudinal data. We also tested whether childhood environmental conditions including unpredictability, parental harshness (both defined below), and socioeconomic status predicted dimensions of middle adult LHS. We conducted these tests to determine whether the predictions of life history theory (LHT) held for all higher-order LHS variables. The inclusion of SES also allowed us to address the possibility that trade-offs between LHS dimensions occur only within levels of access to resources (e.g., see Sibly & Brown, 2007, 2009).

The Bifactor Model

Past CFA studies of human LHS relied on the second-order factor model (see Figure 1), which includes overarching or general constructs (e.g., K or Super-K factors) that subsume individual first-order constructs (e.g., warmth of relationships with parents). Importantly, these models specify the residual variances in first-order constructs (i.e., that unexplained by overarching factors) as orthogonal to second-order factors and usually other first-order factors as well. Moreover, these residuals are usually ignored (Chen, West, & Sousa, 2006). But researchers are sometimes interested in general factors and also the factors that explain unique variance in domains over and above that explained by general factors. For instance, they may want to predict outcomes like academic achievement with general factors such as intelligence and also unique variances in domains like verbal ability. Researchers may also simply wish to estimate the effects of general and also domain specific factors on items, or determine if there are actually domain specific factors at all after accounting for the general factor. Indeed, the absence of domain specific variance in second-order models often goes unnoticed (Chen, West, & Sousa, 2006).

As discussed above, it is not clear that Super-K subsumes mating effort and other indicators of mating competition (e.g., risk-taking). One possibility is that mating competition is relevant to a narrow band of life history traits that generally vary with independence from the Super-K and its domains. Another possibility is that mating competition varies uniquely from Super-K but also subsumes variance in its domains. For instance, extroversion could reflect effort expended to influence people for reasons related to Super-K (e.g., maintaining social relationships and reciprocal transactions) and also mating effort (as noted by MacDonald, 1995). Moreover, investment in health and thereby attractiveness (Nedelec & Beaver, 2014) could produce benefits relevant to Super-K (e.g., long lifespan conducive to investment in offspring)

and also mating competition (e.g., more sexual partners). In attempts to examine such possibilities, life history researchers may find the bifactor model (see Figure 1) useful given that it allows them to estimate the effects of Super-K on its indicators and also examine how variance in life history indicators that is not explained by Super-K may reflect other constructs or dimensions[1].

---Insert Figure 1 about here---

Data

This study analyzed publically available national data from the Midlife in the United States (MIDUS; n = 4,244)[2]. The MIDUS survey investigated the role of behavioral, psychological, and social factors in accounting for age-related variations in health and wellbeing. The data are longitudinal with two rounds (1995-96 and 2004-06). During round 1, participants in our analytic sample were aged 24 to 74 (μ = 46.44) and 50.8% were male. Further, the racial/ethnic composition of the sample was 83% White, 10.6% African American, 1.6% Native American or Aleutian Islander/Eskimo, .7% Multiracial, and 2.2% Other. Finally, 88.6% graduated high school, 7.4% graduated from a two-year college or vocational school with an Associate's degree, 17.7% graduated college with Bachelor's or Master's degree, and 3.9% earned a doctoral degree. 65% percent of the round 1 sample participated during round 2. For more information about the MIDUS samples, please see http://www.midus.wisc.edu/midus1/index.php. Because attrition was a concern, we conducted a

[1] Bifactor and second-order models are closely related. In fact, they are equivalent when the Schmidt-Leiman (1957) solution holds, such that: (1) bifactor model loadings equal the product of second-order models' first- and second-order loadings and (2) the ratio of general factor loadings to domain specific loadings is the same within each domain specific factor. Yung et al. (1999) showed that second-order models are nested within bifactor models, which are nested within "full" second-order models. Thus, the bifactor model can be seen as a less-restrictive version of the second-order model. A graphical comparison of the bifactor, second-order, and "full" second-order models is displayed in Figure 1.

[2] The analytic sample included the core sample of singletons (n = 3,487) and city oversamples (n = 757). See the link below for more information about the MIDUS samples.

missing data analysis. We observed evidence that the missing completely at random assumption (MCAR) for listwise deletion was inappropriate (e.g., several indicators of childhood environment predicted missingness on the substance use items), found the more relaxed assumption of missing at random (MAR) plausible (Little & Rubin, 2002), used multiple imputation and generated five[3] imputed datasets using the NORM 2.03 package for Windows (Schafer, 1997).

Instruments

We used life history theory to select 19 round 2 indicators of middle adult LHS and 3 round 1 retrospective indicators of childhood environment. We selected life history indicators that have been observed to reflect a broad set of LHS domains in prior research (for a review, see Olderbak et al., 2014) and also chose environmental indicators that have been previously studied (for a review, see Ellis et al., 2009). Based on the literature to date, we note the hypothesized valence of each LHS indicator loading in Table 1. We measured the 19 selected life history indicators and constructed 3 environmental components using 73 and 22 items[4], respectively. A major strength of the MIDUS survey was the large selection of measures employed. The survey developers used well-validated scales and also carried out extensive pilot research to develop short-form assessments of many psychosocial constructs, along with condensed assessment inventories. Where possible, we included scale scores computed by the survey developers as factor indicators. We also attempted to include any other available items that reflected our constructs theoretically or empirically. A full list of the items and scale scores we selected is presented in Table 2, along with their MIDUS labels, the constructs they measured, and their

[3] We chose a more limited number of imputations in this case because each additional one required extra factor analyses and we also needed to look at modification indices in each set to diagnose model problems. There is not yet a developed theoretical basis for combining modification indices across imputed sets.
[4] Some of these were scale scores, as described below.

contents. All scale scores computed by the survey developers are marked "computed by the survey developers" (CSD). For further information about these scales, including their alpha coefficients for the MIDUS samples and also references to validation studies, please access the MIDUS I and II scales information here (http://www.midus.wisc.edu/midus1/index.php) and here (http://www.midus.wisc.edu/midus2/project1/).

---Insert Table 1 about here---

Below we describe all indicators used to measure middle adult LHS as well as index childhood environment. Because this study used a very large number of LHS indicators, we do not provide a detailed theoretical rationale for the inclusion of each one in this report. Instead, we provide citations to reviews of life history measures or other publications where the use of each life history indicator is substantiated. We also do not present psychometrics associated with each indicator in this section. Because of the computational demands associated with using structural equation modeling to examine 95 categorical and continuous variables, we conducted a preliminary analysis to assess items for unidimensionality and also compute scores for use in our structural models. These procedures are described in *Analyses* and the psychometric properties of our LHS indicators are summarized in *Results* and presented in Table 2.

Indicators of middle adult LHS. *Super-K.* We measured Super-K (i.e., the general factor) using measures of the Big Five (i.e., agreeableness, openness to experience, conscientiousness, neuroticism, and extroversion; Dunkel & Decker, 2010; Figueredo, Vasquez, Brumbach, & Schneider, 2004, 2007; Olderbak, Gladden, Wolf, & Figueredo, 2014), physical and mental health (Figueredo & Rushton, 2009; Olderbak et al., 2014), positive affect (Olderbak et al., 2014), education (Griskevicius, Tybur, Delton, & Robertson, 2011; Richardson,

Castellano, Stone, & Sanning, 2016), pair-bonding (Olderbak & Figueredo, 2010), sexuality[5], number of children (Chisholm, 1999; Griskevicius, Tybur, Delton, and Robertson, 2011), neighborhood quality (Ellis, Figueredo, Brumbach, & Schlomer, 2009), and social closeness/support (Olderbak et al., 2014). We also extended upon the findings reported by Richardson et al. (2014, 2016) by regressing liability to substance use on Super-K.

Mating competition. This study measured mating competition using risk-taking (Ellis et al., 2012; Figueredo et al., 2005), aggression (Figueredo et al., 2005), number of sex partners (Richardson et al., 2014), sexuality, number of marriages (Jokela, Rotkirch, Rickard, Pettay, & Lummaa, 2010), and neighborhood quality (Ellis et al., 2009). We also attempted to replicate the findings reported by Richardson et al. (2014, 2016) by regressing liability to substance use on mating competition.

Liability to substance use and abuse. Given the theoretical linkage between LHS and substance use developed by Richardson and Hardesty (2012), along with empirical findings indicating that life history dimensions subsumed adolescent and young adult liabilities to substance use (Gibbons et al., 2012; Hampson et al., 2016; Richardson et al., 2014, 2016), we included a measure of liability to substance use/abuse in this study (as mentioned previously). This allowed us to test whether the prior findings extended to middle adulthood. We measured liability to substance use/abuse with indicators including tobacco use (smoking), alcohol use and abuse, illicit drug use, and illicit drug abuse. We used 10 items to measure alcohol use and abuse, 10 to measure breadth in illicit drug use (summed to form an index), and seven items to measure illicit drug abuse (for descriptions of all these items, see Table 2).

[5] We included sexuality as an indicator of Super-K because it is an important aspect of love and attachment formation (Mikulincer, 2006). We also included sexuality as an indicator of mating competition because we theorized that many of its facets (e.g., effort put into sexual aspects of life and frequency of sex) could reflect mating effort in addition to effort devoted to mate retention.

Childhood environment. ***Environmental unpredictability.*** Environmental unpredictability was indexed using items that have been theoretically related to temporal variation in morbidity-mortality (Ellis et al., 2009) and previously used to form this construct (e.g., see Brumbach et al., 2009). These included six items assessing the number of times participants moved to new neighborhood, ever experienced that their family went on welfare, were ever homeless, or had parents that divorced. The unpredictability index also included two items that assessed the consistency of rules set by participants' mothers and fathers (4-pt scales from "never" to "a lot").

Environmental harshness. *Harsh parenting*. Abusive, unsupportive childrearing can be an important cue to extrinsic morbidity-mortality, or environmental harshness (for a review, see Ellis et al., 2009). We assessed harsh parenting as experience of emotional abuse by mother, emotional abuse by father, physical abuse by mother, physical abuse by father, severe physical abuse by mother, and severe physical abuse by father (all 4-pt items from "not at all" to "a lot").

Socioeconomic status (SES). SES is another important cue to environmental harshness (Ellis et al., 2009) and is traditionally indexed by forming a composite of indicators such as parental income, educational attainment, and occupational status (NCES, 2012). In this study, we indexed SES using father and mother SES indexes created by the survey developers and also items that assessed respondents' perceived financial level growing up (6-pt item from "a lot worse off than average" to "a lot better off") and self-reported highest educational levels achieved by mother and father.

---Insert Table 2 about here---

Analyses

Because of the computational demands associated with using structural equation modeling to examine 95 categorical and continuous variables[6], we used Bartlett's method to compute scores for the LHS domains within each imputed dataset. Using EFA and Bartlett's method allowed us to be sure scales were unidimensional and scoring was thus appropriate, produce unbiased estimates of the true factor scores (Hershberger, 2005), and avoid sequences of model modifications (e.g., the addition of error covariances) that could be required if CFA were applied to all 95 observed variables and scale scores across the life history domains (we return to this point in *Limitations*). We used SPSS 23 to conduct our factor analyses, Unweighted Least Squares (ULS) to factor scales that contained categorical items, Maximum Likelihood (ML) to factor scales with only continuous items, Promax rotations if scales were not unidimensional, and saved scores for each dimension that emerged. We chose an oblique rotation (Promax) because we expected correlations between factors for scales that were multidimensional (e.g., liability to substance use/abuse). Principle components analysis (PCA)[7] was used to construct composite parental harshness and SES. We summed across indicators of unpredictability to construct composite or total unpredictability given that these indicators can vary non-systematically. Single indicators of Super-K and mating competition were analyzed as they were.

This study used structural equation modeling (SEM) to test the structure of middle adult life history indicators, along with whether middle adult life history dimensions reflected childhood environment as predicted by LHT. We used the MPlus 7.11 software package to test our models and used the Robust Weighted Least Squares (WLSMV; Muthén, du Toit, & Spisic,

[6] Numerical integration is required to estimate structural equations models that include categorical and continuous observed variables. Unfortunately, numerical integration becomes extremely computationally demanding as the number of latent variables increases (see Muthén & Muthén, 2015). At eight or more latent variables, models tend to fail to converge. Our study would have included more than 25 latent variables, far too many for inclusion of all the measurement portions.

[7] We did not impose single component solutions on the data.

1997) estimator because we treated variables such as number of sexual partners and number of marriages as ordinal[8]. Because we analyzed very large samples that provided a great deal of statistical power, all significance tests were conducted at the $p < .001$ level.

Goodness of fit criteria. This study used a variety of fit indices in order to obtain a robust assessment of model fit. We considered the substantive meaningfulness of the model, Tucker-Lewis (TLI) and comparative fit (CFI) indices greater than .95 (Byrne, 2001; Hu & Bentler, 1999), and root mean square error of approximation values of less than .05 (RMSEA; Browne & Cudeck, 1993) as evidence of acceptable fit to the data. MPlus 7.11 provides average fit indices and an average χ^2 likelihood ratio statistic (Kline, 2010) when multiple imputed sets are analyzed using WLSMV, but not a pooled likelihood ratio test. As mentioned, we observed modification indices across the imputed sets to identify sources of misfit to the data.

Hypothesized models. ***Model I.*** We first hypothesized a bifactor model in which all indicators of Super-K (described above) reflected a single latent variable (i.e., the general factor). Further, the model included domain specific personality and covitality factors that represented the variance in the five factors of personality and health and mental health, respectively, not explained by Super-K (the general factor). We also specified all indicators of mating competition as reflecting a common factor and examined whether the variance in the domain specific personality and covitality factors (i.e., that unexplained by Super-K) reflected mating competition by regressing the former on the latter. Building on findings (e.g., Richardson et al., 2014, 2016) that liability to greater substance use reflected life history dimensions, we regressed liability to substance use/abuse on mating competition and also Super-K. We specified residual

[8] We considered using a Poisson model because these were count data, but decided to treat them as ordinal because the vast majority of participants endorsed just a few of the possible counts (e.g., 99.4% of middle adults had three or fewer sexual partners and 99.0% had three or fewer marriages). In addition, in the case of number of sex partners, the highest endorsable count was actually a category – "more than six partners".

covariances between alcohol use and abuse, and between illicit drug use and abuse, given that we expected associations between these constructs that were not explained by common liability to substance use/abuse. We also examined modification indices to discover any *direct* effects of mating competition on the Big Five, as well as identify any cross-loadings of Super-K indicators on mating competition and vice versa. Finally, we observed the correlation between the Super-K factor and mating competition for evidence they reflected the same underlying dimension (i.e., a moderate or large correlation would suggest that we needed to test a unidimensional model).

Model II. If Model I fit the data well, we specified a second model that included our environmental constructs (Model II). Drawing upon LHT, research driven by psychosocial acceleration theory, and our discussion of the dimensionality of LHS, we hypothesized that (a) harsh parenting and unpredictability would predict greater mating competition and lower levels on Super-K in middle adulthood, while (b) higher SES would predict greater mating competition and Super-K levels. The hypothesized SES effect on mating competition, which may seem surprising, was rooted in the finding that access to resources corresponds to higher levels on r and also K strategies between species (e.g., Sibly & Brown, 2007, 2009). We encoded these hypotheses into Model II and regressed the domain specific factors, along with liability to substance use/abuse, on the environmental dimensions given that it was unlikely that mating competition and Super-K mediated all environmental effects on personality and behavior, and also given that past research has linked substance use/abuse to environmental dimensions (Ronel & Haimoff-Ayali, 2010). Finally, we specified a covariance between childhood SES and the middle adult neighborhood quality residual because research suggests that parent SES is a robust correlate of offspring SES (Griskevicius, Tybur, Delton, & Robertson, 2011).

Results

As mentioned, we carried out preliminary factor analyses to compute scores for the life history and environmental domains within each imputed set. The results of these analyses are detailed in Table 2, which includes loadings for all items and scores that reflected factors or were used to form composites. Across the imputed sets, all items and scores loaded on their factor or component at $\beta = .30$ or above. Table 2 illustrates the patterns of loadings with estimates from imputation #1. All life history indicators were unidimensional except alcohol use/abuse and parental harshness. Two factors subsumed the alcohol items – alcohol use and alcohol abuse (r = .40). We computed and saved scores for both factors and included them in our structural models. Two components emerged from the parental harshness items – mother harshness and father harshness (r = .50). We computed scores on these two components and included their average in our structural models. Below we describe the results of our SEM analyses.

Model I

We tested our first hypothesized model (Model I) and it was over-identified with 187 degrees of freedom. Fit indices (see Table 3) suggested the model did not fit the data well (χ^2 = 4725.58, CFI = .86, TLI = .82, RMSEA = .08) and should be rejected. We first examined the model for misspecification as evidenced by non-significant factor loadings. We observed that the effects of mating competition on social support (p = .57) and number of marriages (p = .75) were non-significant. We thus removed these parameters and did not include number of marriages in any further analyses because modification indices did not suggest that it was related to any other factors. We then carried out a sequence of modifications to the model on the basis of large modification indices (i.e., > 100) and theoretical rationale (i.e., there was a substantive basis for each change). Modifications ceased when no potential changes met both of these criteria. As we carried out the sequence of changes, any factor loadings that became non-significant were

removed. We note that though this study was confirmatory in nature, the need for model modifications was not surprising given the very large number of constructs under study. Table 3 displays each modification and the corresponding improvement in fit to the data. The theoretical rationale for each change is provided in *Supplementary Materials*. After carrying out the tabled modifications, we found that the resulting model fit the data well (χ^2 [154] = 4725.58, CFI = .96, TLI = .94, RMSEA = .04). Strikingly, we observed that mating competition and Super-K were uncorrelated (r = -.02, p = .12).

---Insert Table 3 about here---

Model II

Next, we specified Model II by including our environmental variables as a part of the model to be estimated. This model had 202 degrees of freedom and fit the data marginally well (χ^2 = 1959.59, CFI = .945, TLI = .93, RMSEA = .05). As a reminder, this model included environmental effects on all latent variables as well as a covariance between childhood SES and the middle adult neighborhood quality residual. Consistent with past research (Griskevicius et al., 2011), the latter was observed at r = .54. Modification indices suggested that aggression should also be regressed on childhood SES. This effect was consistent with prior research linking lower childhood SES to greater antisociality (Piotrowska, Stride, Croft, & Rowe, 2015). We added this parameter and the resulting model had 201 degrees of freedom and fit the data reasonably well (χ^2 = 1874.54, CFI = .95, TLI = .93, RMSEA = .04)[9].

[9] In an additional step, we tested this model for differential indicator functioning by age due to the substantial range observed. We included age as a covariate of the environmental components and regressed the mating competition and Super-K on it. One large modification index suggested that alcohol abuse should be regressed on age. We added this parameter and the resulting model fit the data slightly worse (CFI = .94, TLI = .91, RMSEA = .05) than Model II, but no large modification indices were observed. Thus, only alcohol abuse appeared to function differentially by age. Within levels of mating competition, older participants appeared to be more likely to abuse alcohol (β = .23).

Life history strategy indicators. Our next step was examining the magnitude of the factor loadings (see Figure 2 and Table 4, and for a graphic that displays loadings only, see *Supplementary Materials*). The Super-K factor's final 14 indicators were health/mental health, neuroticism (-), extroversion, agreeableness, conscientiousness, openness to experience, positive affect, social support, aggression (-), neighborhood quality, education, pair-bonding, sexuality, and # of children. Standardized factor loadings ranged from β = .07 (# of children) to β = .76 (social support). Loadings equal to or above .30 were considered evidence suggesting that indicators provided sufficiently valid measurement of their constructs. The loadings for health/mental health, neuroticism, extroversion, agreeableness, conscientiousness, openness to experience, positive affect, social support, aggression (-), education, and pair-bonding satisfied this criterion. The loadings for neighborhood quality, sexuality, and number of children were below .30.

We also regressed liability to substance use/abuse on Super-K in an attempt to extend the findings (e.g., Richardson et al., 2014, 2016) that substance use reflects life history dimensions to middle adulthood. We found that Super-K had a moderate negative effect on liability to substance use/abuse (β = -.43), which did not subsume alcohol abuse holding mating competition constant. This implied that alcohol abuse was not scalar invariant as an indicator of liability to substance use. Super-K was unrelated to alcohol abuse. In the end, our findings suggest that 12 indicators (i.e., health/mental health, neuroticism, extroversion, agreeableness, conscientiousness, openness to experience, positive affect, social support, aggression, education, pair-bonding, and liability to substance use/abuse) may provide valid measurement of Super-K in future research, while four others (i.e., neighborhood quality, sexuality, # of children, and alcohol abuse) may not.

For the domain specific personality variable, the final indicators were extroversion, agreeableness, openness to experience, conscientiousness, and pair-bonding (-). Loadings ranged from β = .36 (pair-bonding) to .72 (openness). For the domain specific covitality factor, the final indicators were health/mental health, neuroticism (-), positive affect, agreeableness (-), neighborhood quality, and aggression (-). Loadings ranged from β = .11 (agreeableness) to .67 (health/mental health) and only health/mental health and neuroticism had loadings above β = .30.

For mating competition, the final indicators were # of sexual partners, sexuality, risk-taking, aggression, # of children (-), pair-bonding, neighborhood quality, agreeableness (-), and neuroticism. Loadings ranged from β = .14 (neighborhood quality) to .48 (aggression). The loadings for six indicators appeared to be equal to or greater than .30: # of sexual partners, sexuality, risk-taking, pair-bonding, aggression, and agreeableness (-). By comparison, # of children, neighborhood quality, and neuroticism did not seem to adequately reflect their factor. However, we note that we regressed the domain specific covitality and personality factors onto mating competition to test whether variance in the indicators of these two factors, not explained by Super-K, was explained by mating competition. We found that this was indeed the case. The effects of mating competition on covitality and personality were both moderate in size (β = .42 and .47, respectively), suggesting that mating competition was another important source of common variation in indicators of Super-K. We note that, consistent with our Model I findings, the covariance between mating competition and Super-K was non-significant (*cov* = -.004, *p* = .759). In an additional step, we constrained this covariance to zero to test the hypothesis that the two dimensions were statistically independent. We found that model fit was not significantly different across the imputed sets (e.g., imputation 1: $\Delta\chi^2$ [1] = .09, *p* = .76; CFI = .95; TLI = .93; RMSEA = .04), implying that we should not reject the hypothesis that the covariance was nil.

Given that mating competition had direct effects as well as indirect effects through the domain specific factors on some life history indicators, we needed to estimate its total effects on these indicators to better understand its influence. To explain this further, mating competition could be understood as having effects common to indicators of the domain specific factors through its impact on their factors. However, for some indicators, there was also a direct effect that reflected influence not common to the other traits. Consistent with this, the direct (β = .31) and indirect personality mediated (β = -.17) effects on pair-bonding produced a total effect of β = .15; the direct (β = -.39) and indirect personality (β = .18) and covitality (β = -.06) mediated effects on agreeableness produced a total effect of β = -.27; the direct (β = .14) and indirect covitality mediated (β = .08) effects on neighborhood quality produced a total effect of β = .22; and finally, the direct (β = .19) and indirect covitality mediated effects (β = -.18) on neuroticism produced a nil total effect (p = .824). We also saw that the indirect effect on aggression was non-significant (p = .003) and therefore the direct and total effects were equal (β = .48). In light of these findings, we reasoned that the total effect of pair-bonding was too small to be retained (conceptually) as an adequate indicator of mating competition.

For some indicators of the domain specific factors, mating competition had only indirect effects. Specifically, mating competition had significant indirect effects, but no direct effects, on extroversion (β = .26), openness to experience (β = .33), conscientiousness (β = .18), health/mental health (β = .28), and positive affect (β = .09). Thus, we concluded that extroversion, openness, and health/mental health might function as adequate indicators of mating competition. We note that given the smaller effects of mating competition on positive affect and neuroticism, relative to health/mental health, the latter effect may be more attributable to an effect on health than mental health.

We also regressed liability to substance use/abuse on mating competition to test whether the findings that substance use reflects life history dimensions (e.g., Richardson et al., 2014, 2016) extended to middle adulthood. We found that mating competition had a small to moderate effect on liability to substance use/abuse (β = .29) and also a moderate effect on alcohol abuse (β = .35). As a reminder, alcohol abuse did not reflect common liability to substance use/abuse, holding mating competition constant. In the end, our findings suggest that 10 indicators (i.e., # of sexual partners, sexuality, risk-taking, aggression, agreeableness, extroversion, openness, health, alcohol abuse, and liability to substance use/abuse) can likely provide valid measurement of mating competition in future research, while five others (i.e., # of children, neighborhood quality, neuroticism, positive affect, and pair-bonding) may not.

Finally, for liability to substance use/abuse, the final indicators were smoking (β = .29), illicit drug use (β = .45), illicit drug abuse (β = .40), and alcohol use (β = .32). As mentioned, surprisingly, alcohol abuse did not reflect common liability to substance use/abuse though it was residually correlated with alcohol use at r = .30, as expected. This suggested that alcohol abuse's etiology may be somewhat unique. We return to this point in our description of the structural regression coefficients and in *Discussion*. Finally, as expected, the illicit drug use and abuse residuals were correlated at r = .50. These two correlations implied these variables were associated for reasons not captured in our SEM. Notably, our model explained 33% of the variance in common liability to substance use/abuse and 12% of the variance in alcohol abuse.

---Insert Table 4 about here---

Environmental effects. After examining latent variable effects on life history indicators, we moved on to interpret the magnitude of the environmental effects on our dimensions of middle adult LHS (see Figure 2 and Table 5). We found that unpredictability and harsh parenting

had small negative effects on Super-K (both rounded to β = -.18), while childhood SES did not have a significant effect on this life history dimension. By contrast, childhood SES and parental harshness had moderate and small effects on mating competition (β = .43 and .14, respectively), while the effect of unpredictability on this life history dimension was non-significant[10]. This implies that the effects of childhood environment on middle adult LHS are not homogeneous. We return to this point in *Discussion*. Notably, our model explained 19% of the variance in mating competition but just 8% of the variance in Super-K.

Childhood SES also had a small effect (β = .12) on the domain specific covitality factor and all three environmental variables had small positive effects on the domain specific personality factor (βs ranged from .12 to .14). Thus, there appear to be multiple pathways by which childhood environment may impact personality traits and also physical and mental health. Childhood unpredictability had a small direct effect (β = .17) on liability to substance use/abuse and childhood SES had a small negative effect (β = -.19) on aggression. We observed small negative correlations of childhood SES with unpredictability and parental harshness, and a small positive correlation between unpredictability and harshness. Finally, for those who may be interested in practical public health and well-being implications, we tested the indirect effects of the environmental variables on each life history indicator closely related to health promotion and illness prevention efforts and included a description of these results in *Supplementary Materials*.

---Insert Tables 5 and 6 about here---

---Insert Figure 2 about here---

Discussion

[10] We also tested whether the environmental components interacted to predict the latent variables in the model. With interactions specified, the model fit the data well (CFI = .96, TLI = .94, RMSEA = .04) and no large modifications indices were observed. Unpredictability and harshness interacted to predict liability to substance use (β = .12) but no other significant effects were observed. These findings seem to be in line with Brumbach et al. (2009).

This study applied SEM with bifactor models to test the dimensionality of middle adult LHS indicators drawn from the MIDUS study. From a factor modeling perspective, confirming the dimensionality of human life history indicators is the first step in placing the psychometric study of human LHS on more solid ground. The Brumbach et al. (2009) and Richardson et al. (2014, 2016) findings combine to suggest that in adolescence and young adulthood, a coherent mating competition dimension manifests as higher levels on indicators such as antisociality, multi-partner sex, aggression, risk-taking and delinquency, and substance use and abuse. Our findings suggest that this dimension persists into middle adulthood, by which time a coherent Super-K factor also subsumes indicators of LHS. As suggested by Richardson et al. (2016), this Super-K factor may emerge through the normative process of self-regulatory development.

Our findings strongly suggest that middle adult LHS is not unidimensional on the second-order level, but rather two-dimensional. Strikingly, mating competition and the Super-K factor were *statistically independent* even though childhood SES was controlled. Though their pattern of correlation through environmental conditions seems consistent with LHT, there appears to be no direct trade-off between them and no single score can locate the LHS of the participants in our sample. This finding challenges the growing literature that assumes a single fast-slow dimension (as described in our review) and also neurobiological models contending that the fast-slow trade-off occurs at the neural level, such that activity may *generally* shift from novelty to familiarity (i.e., internal working model and attachment related) processing or in the reverse direction (Tops, Koole, IJzerman, & Buisman-Pijlman, 2014). Indeed, our findings suggest that some people may be engaged in both sorts of processing while others are scarcely engaged in either. This is consistent with the Holtzman and Senne (2014) argument that a two-dimensional model is more consistent with the human data and should be employed. While adaptations may

be regulating resource allocations in response to environment as predicted by LHT, the same proximate mechanisms do not seem to be governing investment into indicators of mating competition and Super-K.

Future research should attempt to determine how our findings of statistical independence might be reconciled with LHT. For instance, researchers could try to identify the factors that enable some people to invest highly in mating competition and also Super-K. They could also examine if change in environmental factors over time explains the independence we found. Perhaps this could explain why early harshness and unpredictability were related to personality, which develops early and remains reasonably stable, and less related to covitality, which might be reflecting more recent conditions. Also, more research like Kruger et al. (2015) should also be carried out to determine how people perceive and/or detect LHS in others. In this vein, it is interesting to note that variables like substance use/abuse, agreeableness, aggression, and harsh parenting are inversely related to one LHS dimension but not the other – humans could use them to infer levels on both dimensions. Finally, the idea of a fast-slow dimension seems remarkably intuitive and this in itself might be valuable to examine. Perhaps it occurs partly because humans focus on the detection of long-term mates low on mating competition (i.e., who will not invest resources elsewhere or engage in cuckoldry) and short-term mates that are "available" (i.e., without a mate who will mate guard). Similarly, perhaps it occurs partly because people invested in Super-K benefit from concealing mating effort from long-term mates and those invested in mating competition benefit from concealing that they have a long-term partner.

Our findings suggest 12 indicators (i.e., health/mental health, neuroticism, extroversion, agreeableness, conscientiousness, openness to experience, positive affect, social support, aggression [-], education, pair-bonding, and liability to substance use/abuse [-]) may provide

valid measurement of Super-K in future research. These findings are consistent with past research (e.g., Olderbak et al., 2014). Of course, more validation studies are needed to confirm this possibility, which means that it is not yet appropriate to treat these indicators as a scale. Although they may not provide very good indicators of Super-K, we note that the effects on neighborhood quality and sexuality were consistent with LHT given that (a) selection into safer and higher quality environments is consistent with investment in the safe but low-yield decisions that are characteristic of slower LHS (Griskevicius, Tybur, Delton, and Robertson, 2011), as well as parental effort, and (b) sexuality is an important aspect of love and attachment formation (Mikulincer, 2006).

Higher Super-K levels implied slightly greater numbers of children, not fewer children as predicted by life history theorists studying humans (Figueredo et al., 2005). We note that in our two-dimensional model, mating competition and Super-K might both be seen as fitness components and thus higher levels on both could imply greater numbers of offspring. In ancestral environments, the effect of mating competition might have been large while the effect of Super-K was small, such that very fast strategists (high mating competition and low-K) had the most offspring and very slow strategists (high-K and low mating competition) had fewer but higher quality offspring than fast strategists. Notably, people with the lowest scores on both dimensions would have had the fewest offspring. Thus, perhaps the availability of birth control in modern environments disrupts the effect of mating competition on number of offspring and this tends to limit childbirth to those who intend to have children because they want to parent (i.e., higher K people attempt to have children while lower K, higher mating competition people use birth control to decouple sexual activity and reproduction). As another possibility, post-demographic transition parents are often more isolated from their own parents and kin (Sear,

2015). Perhaps higher K people are more likely to stay near their families and experience greater stability as a result of accessible kin networks. In turn, this may facilitate greater alloparental care, enabling them to comfortably support more offspring compared with their lower K counterparts. Future research should test these possibilities by incorporating data from more traditional populations and examining whether the same pattern is detected.

Our findings suggest 10 indicators (i.e., # of sexual partners, sexuality, risk-taking, aggression, agreeableness [-], extroversion, openness, health, alcohol abuse, and liability to substance use/abuse) may provide valid measurement of mating competition in future research. These findings are generally consistent with past research (e.g., Richardson et al., 2014, 2016). It was notable that mating competition did not have substantial effects on numbers of marriages and children. The latter likely reflects the availability of birth control in modern environments. Although they may not provide great indicators of mating competition, the positive effects on neighborhood quality and pair-bonding are notable given that previous research suggested that greater mating effort, dominance seeking, and risk-taking should be negatively related to attachment formation and investment in safe environments that are amenable to raising children (e.g., Figueredo et al., 2006). These findings combine with the literature we reviewed, along with our finding that mating competition and Super-K were statistically independent, to provide strong indication that humans engage in pluralistic survival and reproductive strategies. Again, more research is needed to attempt to reconcile these findings with LHT.

We found that indeed, it was important to attend to the variance in life history indicators not explained by Super-K. We used bifactor models to accomplish this and the payoff was information about mating competition's effects on personality and covitality. Mating competition had substantial positive effects on extroversion and openness to experience, consistent with past

research (see Holtzman & Senne, 2014) and the notion that traits such as extroversion could reflect effort expended to influence people for reasons related to Super-K and also mating competition. Surprisingly, mating competition also had a small positive effect on conscientiousness, which may reflect the fact that some self-regulation and awareness is needed to influence others, whatever one's motives. Finally, mating competition had a small to moderate positive effect on health/mental health. This may reflect the fact that, similar to income and investment in markers of higher status, health is a cue to mate value (Nedelec & Beaver, 2014) that can facilitate mating effort and also extended periods of parental and nepotistic effort.

Building upon Richardson and Hardesty's (2012) theoretical synthesis and the subsequent empirical findings that liability to substance use reflects LHS dimensions (e.g., Richardson et al., 2014, 2016), we found that middle adult mating competition and Super-K both appeared to drive liability to substance use/abuse. However, only mating competition seemed to impact alcohol abuse, suggesting the etiology of alcohol abuse may be somewhat unique. This finding may inform future substance abuse etiology research.

Finally, we found that dimensions of environment did not have homogeneous effects on the two dimensions of LHS. Super-K appeared to be directly responsive to childhood unpredictability and parental harshness, but not to childhood SES (though parental harshness and childhood SES were negatively associated). In contrast, mating competition appeared to be directly responsive to childhood SES and parental harshness, but not unpredictability. Parental harshness was therefore the only aspect of childhood environment that could be seen as cuing a diversion of resources from slower to faster LHS or vice versa (i.e., from Super-K to mating competition). This finding is consistent with psychosocial acceleration theory (e.g., Belsky, Steinburg, and Draper, 1991; Chisholm, 1993). In addition, SES might be seen as having effects

consistent with psychosocial acceleration theory, in that it is possible that harsher parental practices mediated an indirect effect on mating competition and Super-K.

Childhood SES and unpredictability appeared to directly impact only one LHS dimension apiece (i.e., Super-K or mating competition). These findings suggest that not only do at least two dimensions subsume LHS indicators, these dimensions do not reflect childhood environment in a homogeneous manner. This picture of human LHS is more complex but offers some intriguing avenues for future research. For instance, our model implies that the fastest strategists (i.e., high mating competition and low Super-K) experienced high SES, greater unpredictability, and greater parental harshness, while the slowest strategists experienced low SES, less harsh parenting, and more predictable childhoods. This seems inconsistent with the current life history literature, but suggests that those who have the resources may use them to achieve mating success in addition to investing in safety and parenting effort. This is also consistent with between species findings that access to resources corresponds to higher levels of r-selected strategies, holding other factors constant (Sibly & Brown, 2007, 2009). We discuss these SES effects further in *Future Directions*.

Potential practical implications for public health initiatives flow from the findings reviewed above. First, high SES individuals have been largely neglected as the targets of health promotion and prevention efforts because they are not viewed as "at-risk" (Humensky, 2010). However, our model suggests that adults who experienced high SES, harsh parenting, and unpredictability were more likely to manifest health-relevant traits and behaviors like risk-taking, substance abuse, and multi-partner sex. Our findings confirm what past research has implied about the effects of environment on Super-K – those who experienced harsher parenting and greater unpredictability were more likely to be characterized by lower Super-K scores and thus,

holding mating competition constant, poorer mental and physical health, less social support, less educational attainment, and more severe substance use. Finally, our findings suggest that intervention on middle adult Super-K and mating competition could produce broad and substantial improvements in population health and well-being, while intervention on childhood environment could produce similarly broad but very modest effects (i.e., very small to small). Of course, such intervention may still be worthwhile from an economic perspective.

Limitations

This study is limited by the use of self-report data and it is widely recognized that such data can be affected by error in the retrieval processes associated with memory and self-presentation bias. This limitation applies most significantly to the retrospective childhood measures, but because we are aware of no datasets that contain measures broadly relevant to LHT that span from childhood to middle adulthood, we see the MIDUS data as an important albeit imperfect source of information about LHS development. Second, causal inferences based on the results presented here should remain tentative. Childhood environment cannot be understood as completely exogenous to middle adult LHS due to genetic inheritance. Given that the effects of environmental conditions were all small and given that genetic effects on these variables as well as the middle adult LHS dimensions could be as large or larger, genetic confounding is a significant concern (Barnes, Boutwell, Beaver, Gibson, & Wright, 2014) and future research should use genetic information to address this limitation. This concern extends to most research that has estimated environmental effects on life history indicators or their underlying dimensions. Future research should employ behavioral genetic designs to control for genetic confounding when estimating the extent to which LHS dimensions translate

environmental harshness and unpredictability into life history indicators. Such studies may provide important information about whether LHS development is conditional and/or alternative.

A final limitation that should be considered is that this study assumed, at least in part, the validity of the many psychological constructs used as indicators of LHS. These constructs have been studied extensively with factor modeling and we established the unidimensionality of each scale before saving factor scores. We also used a method (i.e., Bartlett's) that produces unbiased estimates of the true factor scores (Hershberger, 2005) and most of our life history domains contained one or more survey developer created scale scores, which were produced using validated scales. However, it is possible that one or more of the issues raised in our critique of psychometric studies of LHS also apply to the literatures establishing these constructs' validities. Indeed, recent work suggests that stationarity (i.e., measurement invariance over time) does not hold for depression, a construct that has been studied extensively (Fried et al., 2016). Unfortunately, it was simply outside the scope of this study to establish fit and measurement invariance for all the constructs included, or essentially an analysis of the validity of the broader psychological literature. To the extent that LHS indicator items used in this study do not actually share proximate common causes that correspond to the factors subsuming them in factor models, it may be correspondingly unreasonable to posit higher-order LHS factors.

Future Directions

We touched upon directions for future research throughout *Discussion*. Here we provide a concise summary of our model's implications for researchers wishing to carry out psychometric studies applying LHT to human variation. First, we have followed Figueredo et al. (2006) in theorizing that common adaptations underlie allocations of resources to fitness components. One or more adaptations may carry out these allocations – our study suggests that it

is not the same proximate mechanisms that explain levels of investment in indicators of mating competition and Super-K. Importantly, this does not imply that the fast-slow LHS continuum is not useful for understanding human variation. Rather, a single factor simply doesn't seem to capture all the important human life history variation. Thus, future studies should measure Super-K and also mating competition (see *Discussion* for lists of promising indicators).

Second, we contend that existing measures of K-factors will likely continue to be useful, but more studies are needed to confirm their structure and test them for measurement invariance (e.g., across the sexes). In addition, mating effort scales can used along with indicators such as sensation-seeking and risk-taking to measure mating competition. Once the dimensionality of LHS indicators is better confirmed, future studies can attempt to clarify the identities of the mating competition and Super-K factors by determining their core aspects (e.g., perhaps internal working model formation and empathy form the core of Super-K). They can also attempt to identify psychological and physiological mechanisms that mediate any trade-offs between the two factors (e.g., testosterone or stress responsivity). Finally, future studies should incorporate additional life history indicators such as pubertal timing, sexual debut, and lifespan to ensure that we are not simply documenting variation in lifestyle (see Copping et al., in press). They should also determine whether these indicators reflect or are antecedents of mating competition and Super-K. This can be determined, for instance, by using SEM and longitudinal panel data to test the whether the Super-K factor is invariant across time and manifests as things like pubertal timing earlier and also parenting effort later.

Third, our study provides some implications for future tests of psychosocial acceleration theory (see, e.g., Belsky, Steinberg, & Draper, 1991; Draper & Harpending, 1982). In particular, SES had a moderate positive effect on mating competition and no direct effect on Super-K

holding parental harshness and unpredictability constant, while harshness had effects consistent prior research and unpredictability had only a negative direct effect on Super-K. Thus, higher childhood SES may actually increase mating competition despite a possible small indirect dampening effect through decreased parental harshness. Many studies have used SES as the sole indicator of harshness and this is probably inadequate because harshness (cues to mortality risk) and status/access to resources are unique in Western environments and likely have unique effects. Thus, we suggest that future studies measure multiple aspects of environment so that they can disentangle effects of status and access to resources from the effects of exposure to mortality cues. However, we also note that relying on SES may be less problematic in traditional societies where variation in wealth is probably more directly relevant to survival. Future research can address this point.

Conclusions

This study used nationally representative data and SEM with bifactor models to confirm the structure of middle adult life history indicators. We found statistically independent mating competition and Super-K dimensions. The effects of parental harshness and childhood unpredictability on Super-K were consistent with past research. However, childhood SES had a moderate positive effect on mating competition and no effect on Super-K. Moreover, unpredictability did not predict mating competition. We conclude that human LHS is more complex that previously suggested, at least among adults in the United States. In combination with our review, these findings suggest that psychometric research on human LHS is in its early stages. Future research should explore the absence of an effect between mating competition and Super-K, test these dimensions for invariance by sex, race/ethnicity, and geographic region, conduct additional tests of whether the indicators that functioned well in this study may provide

valid measurement of LHS, and address the potential for genetic and shared environmental confounding of the associations between childhood environment and adult LHS.

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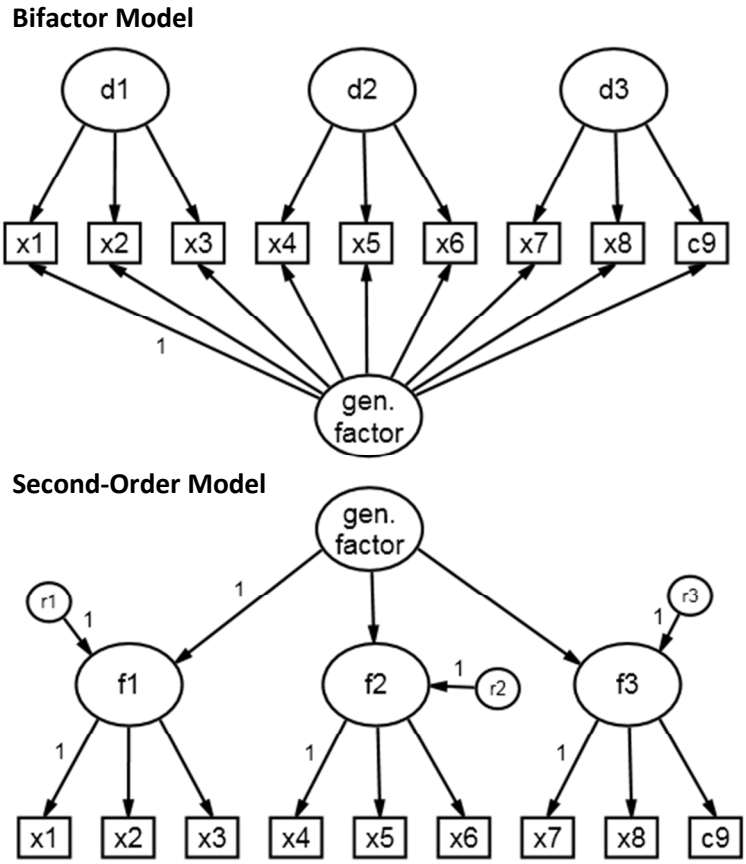


Figure 1

Bifactor Versus Second-Order Factor Model

Note: d = domain-specific; f = first-order factor; gen. = general; and r = residual.

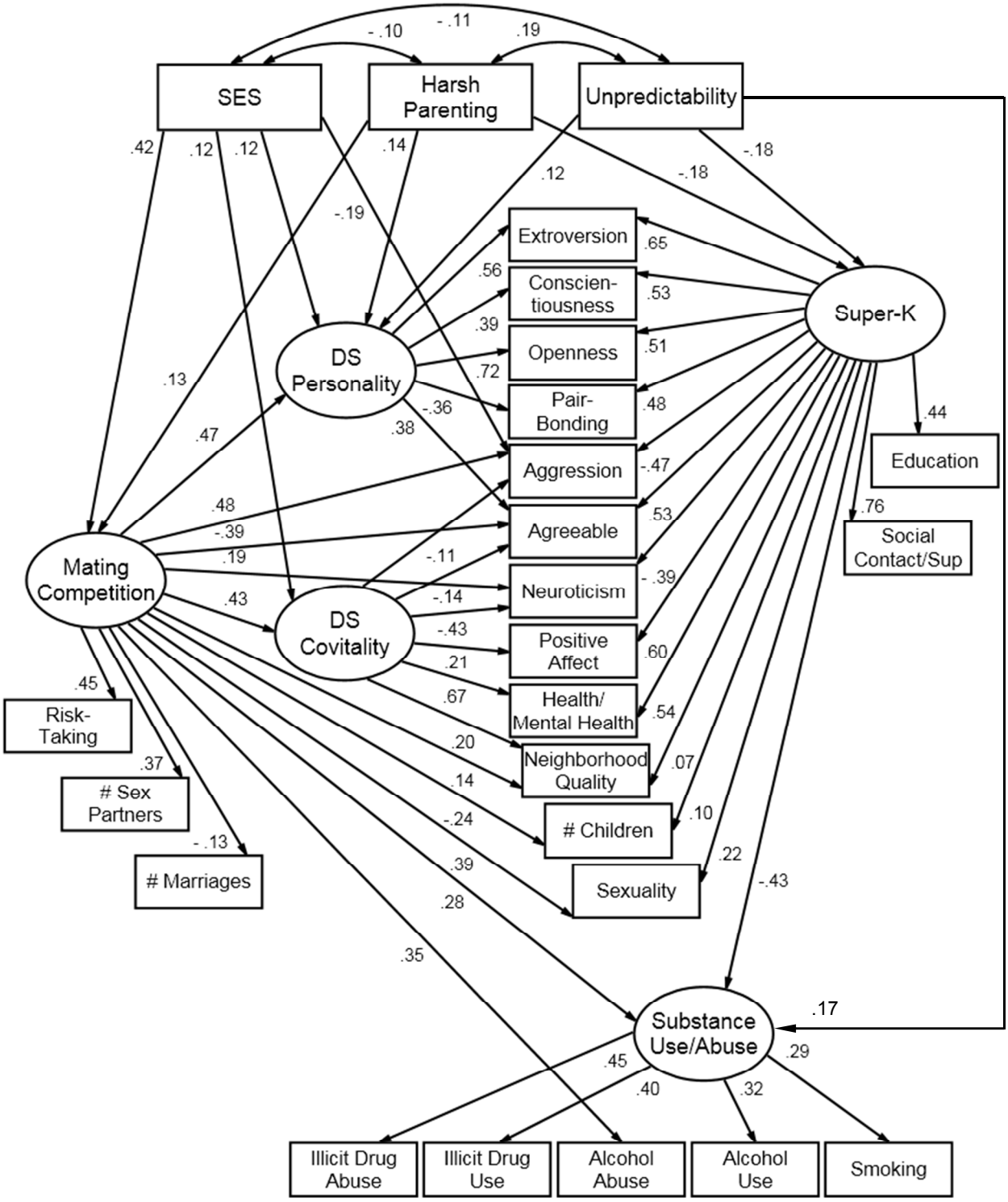


Figure 2

Final Model of LHS Indicators

Table 1
Valence of Hypothesized Loadings on Mating Competition and Super-K

Life History Indicator/Domain	Super-K	DS Covitality	DS Personality	Mating Competition
Neuroticism	-	-	+	+
Extroversion	+		+	+
Openness	+		+	
Agreeableness	+		+	-
Conscientiousness	+		+	-
Social Closeness/Support	+			-
Education	+			-
Positive Affect	+	+		-
Mental/Physical Health	+	+		-
Neighborhood Quality	+			-
Pair-Bonding	+			-
Sexuality	+			+
Risk-Taking	-			+
Aggression	-			+
# Sexual Partners	-			+
# Times Married	-			+
# Children	-			+

Table 2
LHS Indicator Information

Factor/Index	# Indicators	Label	Content	β (loading)	Est.	% Var.
Neuroticism	5	B1SA24B	Felt nervous frequency (30 dys)	.66	ML	51
		B1SA24H	Felt afraid frequency (30 dys)	.49		
		B1SE1EE	Worry about what others think of me	.41		
		B1SE6H	Worrying describes you how well	.71		
		B1SE6M	Nervous describes you how well	.80		
Extroversion	4	B1SE6CC	Adventurous describes you how well	.65	ML	57
		B1SE7AA	Life is a great adventure	.69		
		B1SE7GG	Have something exciting to look forward	.64		
		B1SEXTRA	Extraversion adjectives scale score (CSD)	.64		
Openness	1	B1SOPEN	Openness to experience scale score (CSD)	N/A	N/A	N/A
Agreeableness	6	B1SAGREE	Agreeableness adjectives scale score (CSD)	.98	ML	57
		B1SE1D	Most see me as loving/affectionate	.51		
		B1SE1BB	Others describe me as giving/share time	.57		
		B1SE6F	Friendly describes you how well	.62		
		B1SE6Z	Sympathetic describes you how well	.77		
		B1SE7H	I am a warm person, not cool/distant	.63		
Conscientiousness	8	B1SCONS2	Conscientiousness adjective scale score (CSD)	.48	ML	49
		B1SPERSI	Persist in goal striving	.67		
		B1SE12AA	When goal decided, keep in mind benefits	.53		
		B1SDIREC	Self-directedness and planning scale score (CSD)	.64		
		B1SE13C	Make plan of action (stressful event)	.69		
		B1SE13J	Strategy what to do (stressful event)	.74		
		B1SE13Q	Think how best handle (stressful event)	.69		
		B1SE13W	Think hard what steps (stressful event)	.69		
Social Closeness/Support	4	B1SPWBR1	Positive relations with others scale score (CSD)	.69	ML	54
		B1SMPQSC	Social closeness scale score (CSD)	.54		
		B1SFDSOL	Friendship affectual solidarity scale score (CSD)	.70		
		B1SFAMSO	Family affectual solidarity scale score (CSD)	.57		
Education	1	B1PB1	Highest level of education completed	N/A	N/A	N/A

Positive Affect	3	B1SA26A	Felt cheerful frequency (30 dys)	.77	ML	72
		B1SA26C	Felt extremely happy frequency (30 dys)	.77		
		B1SA26I	Felt enthusiastic frequency (30 dys)	.75		
Mental/Physical Health	5	B1PA1	Physical health self-evaluated	.73	ML	53
		B1PA2	Mental/emotional health self-evaluated	.68		
		B1PA3	Health compared to others your age	.62		
		B1SSATIS2	Life Satisfaction scale score (CSD)	.64		
		B1SESTEE	Self-esteem	.55		
Neighborhood Quality	1	B1SHOMET	Perceived Quality of Neighborhood scale score (CSD)	N/A	N/A	N/A
Pair-bond	3	B1SSPSOL	Spouse Affectual Solidarity (CSD)	.89	ULS	69
		B1SL1	Rate current marriage/relationship	.85		
		B1SM1	Rate sexual aspect of life currently	.48		
Sexuality	7	B1SM3	Rate sexual aspect of life ten yrs futur	.79	ULS	53
		B1SM4	Rate control over sexual aspect of life	.56		
		B1SM5	Rate thought/effort sexual aspect life	.76		
		B1SM8	Sex frequency over (past 6 mo)	.73		
		B1SM9	Sexual expressn imprtnt part of reltnshp	.71		
		B1SM10	Sexual rltnshps includ emotionl intimacy	.56		
		B1SM12	Pleasure in sexual interactions	.55		
Risk-Taking	4	B1SE7D	Please indicate how well each of the following describes you – It might be fun/exciting to be in an earthquake	.54	ULS	59
		B1SE9	Dislike more: Lions loose at circus or clerk sold wrong tickets	.53		
		B1SE8	Dislike more: Riding rapids or waiting for someone who is late	.56		
		B1SMPQHA	Harm avoidance scale score (CSD)	-.99		
Aggression	1	B1SMPQAG	Aggression scale score (CSD)	N/A	N/A	N/A
# Sexual Partners	1	B1SM7	Number of sex partners (past yr)	N/A	N/A	N/A
# Times Married	1	B1PB20	Number times married altogether	N/A	N/A	N/A
# Children	1	B1PC2	Number of children	N/A	N/A	N/A

Alcohol Use/Abuse – 2 factors (r = .40), Scores for both included in model Right column = Alcohol use Left column = Alcohol abuse	10	B1PA50	Had at least one drink (past mo)	.11	.52	ULS	53
		B1PA51	How often at least one drink (past mo)	.21	.73		
		B1PA53	Times had 5+ drinks same occsn (past mo)	.36	.44		
		B1SA11U	Drug/Alc problem ever (12 mo)	.40	.16		
		B1SA66A	Emotional problems from drinking (12 mo)	.62	.19		
		B1SA66C	1+ month much time drinking (12 mo)	.60	.21		
		B1SA66D	Had drink more to get effects (12 mo)	.52	.20		
		B1SALCOH	Alcohol Problem (12 mo)	.83	.30		
		B1SA67	# times alcoh more than intended (12mo)	.52	.55		
		B1SA68	# times alcoh effects at work/etc (12mo)	.39	.35		
Illicit Drug Use	1	B1SA62A-B1SA62J (Sum)	Sum of types of illicit substances used in past 12 months: sedatives, tranquilizers, stimulants, painkillers, depress meds, inhalants, marijuana/hash, cocaine/crack, LSD/oth halluc, and/or heroin	N/A		N/A	N/A
Illicit Drug Abuse	7	B1SA63	# times subst more than intended (12mo)	.66		ULS	53
		B1SA64	# times subst effects at work/etc (12mo)	.52			
		B1SA65A	Subst increased chance of hurt (12 mo)	.58			
		B1SA65B	Emotional problems from subst (12 mo)	.68			
		B1SA65C	Strong desire for substance (12 mo)	.79			
		B1SA65D	1+ month a lot time using subst (12 mo)	.71			
		B1SA65E	Needed more subst to get effect (12 mo)	.73			
Parental Harshness – 2 Component Scores (r = .50) Averaged Right column = Mother abuse Left column = Father abuse	6	A1SE17A	Emotional abuse - mother	.38	.85	PCA	73
		A1SE17B	Emotional abuse - father	.86	.38		
		A1SE17F	Physical abuse - mother	.40	.87		
		A1SE17G	Physical abuse - father	.90	.38		
		A1SE17K	Severe physical abuse - mother	.34	.81		
		A1SE17L	Severe physical abuse - father	.82	.40		
Unpredictability	13	A1SE8	# Times moved to new neighborhood	Summed		N/A	N/A
		A1PC14	Family on welfare or ADC				
		A1PCA6	Adopted not at birth				
		A1PE2	Ever homeless				
		A1SE16G	M - Consistent rules (Reverse-coded)				
		A1SE14G	F - Consistent rules (Reverse-coded)				

		A1PCA3	Parents separated/divorced			
SES	92	A1SE9	Financial level growing up	.53	PCA	53
		A1PC2	Father highest level of education	.82		
		A1PC8	Mother highest level of education	.61		
		A1PTSEID	Father SEI 80 (CSD)	.83		
		A1PTSEIM	Mother SEI 80 (CSD)	.80		

Note: All items/scores loaded on their factors/components at β = .30 or above across the imputed sets. The loadings displayed are from imputation #1. CSD = Scale scores computed by survey developers; ML = Maximum Likelihood; ULS = Unweighted Least Squares; PCA = Principle Components Analysis; M = Mother; F = Father; SEI = Socioeconomic Index; Subst. = Substance.

Table 3
Modifications to Model I

Action	Model/Parameter	*df*	χ^2	CFI	TLI	RMSEA
N/A	Baseline	187	4725.578	.856	.822	.076
-	Mating competition BY social support and BY number of marriages; number of marriages removed from analysis	170	4364.065	.864	.832	.076
+	DS Personality BY pair-bonding	169	3819.488	.881	.853	.071
+	Mating competition BY neighborhood quality	168	3434.395	.894	.867	.068
+	Alcohol abuse ON mating competition	164	3069.652	.906	.879	.065
+	Mating competition BY agreeableness	163	2566.933	.922	.899	.059
+	DS Personality BY sexuality	162	2417.801	.927	.905	.057
+	DS Covitality BY agreeableness	161	2288.431	.921	.910	.056
	DS Covitality BY neighborhood quality	160	2111.648	.937	.917	.054
+	Mating competition BY neuroticism	159	1975.157	.941	.922	.052
+	Sexuality WITH # sex partners	158	1778.628	.947	.930	.049
+	Neighborhood quality WITH smoking	157	1679.458	.951	.934	.048
+	Neighborhood quality WITH aggression	156	1561.269	.954	.939	.046
+	Sexuality WITH pair-bonding	155	1490.295	.957	.941	.045
-	DS Personality BY sexuality	156	1488.533	.957	.942	.045
+	Agreeableness WITH neuroticism	155	1436.498	.958	.944	.044
+	DS Covitality BY aggression	154	1414.258	.959	.944	.044

Note: + = Added parameter. - = Removed parameter.

Table 4

Final SEM Unstandardized and Standardized Factor Loadings

			b	*SE*	*p*	β
Smoking	←	Liability to Sub. Use/Abuse	1.000	.00	-	.29
Drug Abuse	←	Liability to Sub. Use/Abuse	3.23	.26	< .000	.45
Illicit Drug Use	←	Liability to Sub. Use/Abuse	1.30	.11	< .000	.40
Alcohol Use	←	Liability to Sub. Use/Abuse	2.40	.17	< .000	.32
Mental/Physical Health	←	Super-K	.59	.02	< .000	.54
Neuroticism	←	Super-K	-.42	.02	< .000	-.39
Extroversion	←	Super-K	.72	.02	< .000	.65
Agreeableness	←	Super-K	.52	.02	< .000	.53
Conscientiousness	←	Super-K	.55	.02	< .000	.53
Openness	←	Super-K	.25	.01	< .000	.51
Positive Affect	←	Super-K	.64	.02	< .000	.60
Social Support	←	Super-K	.86	.02	< .000	.76
Aggression	←	Super-K	-.66	.02	< .000	-.47
Education	←	Super-K	.45	.02	< .000	.44
Neighborhood Quality	←	Super-K	.08	.02	< .000	.07
Pair-bonding	←	Super-K	.50	.01	< .000	.48
Sexuality	←	Super-K	.23	.02	< .000	.22
# Children	←	Super-K	.10	.02	< .000	.10
Extroversion	←	DS Personality	.53	.02	< .000	.56
Agreeableness	←	DS Personality	.32	.02	< .000	.38
Openness	←	DS Personality	.30	.01	< .000	.72
Conscientiousness	←	DS Personality	.35	.02	< .000	.39

Pair-bonding	←	DS Personality	-.32	.02	< .000	-.36
Mental/Physical Health	←	DS Covitality	.65	.04	< .000	.67
Neuroticism	←	DS Covitality	-.42	.03	< .000	-.43
Positive Affect	←	DS Covitality	.20	.02	< .000	.21
Agreeableness	←	DS Covitality	-.13	.03	< .000	-.14
Neighborhood Quality	←	DS Covitality	.20	.02	< .000	.20
Aggression	←	DS Covitality	-.14	.03	< .000	-.11
# Sexual Partners	←	Mating Competition	1.00	.00	-	.37
Sexuality	←	Mating Competition	1.05	.07	< .000	.39
Risk-Taking	←	Mating Competition	1.07	.08	< .000	.45
Aggression	←	Mating Competition	1.73	.15	< .000	.48
# Children	←	Mating Competition	-.61	.06	< .000	-.24
Pair-bonding	←	Mating Competition	.84	.09	< .000	.32
Neighborhood Quality	←	Mating Competition	.40	.08	< .000	.14
Agreeableness	←	Mating Competition	-.98	.10	< .000	-.39
Neuroticism	←	Mating Competition	.52	.08	< .000	.19

Table 5

Final SEM Unstandardized and Standardized Between Construct Regression Coefficients

			b	*SE*	*p*	β
DS Covitality	←	Mating Competition	1.22	.16	< .000	.43
DS Personality	←	Mating Competition	1.42	.14	< .000	.47
Liability to Sub. Use/Abuse	←	Mating Competition	.11	.01	< .000	.28
Liability to Sub. Use/Abuse	←	Super-K	-.06	.01	< .000	-.43
Super-K	←	SES	-.03	.02	< .095	-.03
Super-K	←	Unpredictability	-.18	.02	< .000	-.18
Super-K	←	Harsh Parenting	-.19	.02	< .000	-.18
Mating Competition	←	SES	.17	.01	< .000	.42
Mating Competition	←	Unpredictability	-.02	.01	.024	-.04
Mating Competition	←	Harsh Parenting	.05	.01	< .000	.13
DS Covitality	←	SES	.14	.03	< .000	.12
DS Covitality	←	Unpredictability	-.02	.02	.356	-.02
DS Covitality	←	Harsh Parenting	-.08	.03	.001	-.07
DS Personality	←	SES	.14	.03	< .000	.11
DS Personality	←	Unpredictability	.15	.02	< .000	.12
DS Personality	←	Harsh Parenting	.17	.02	< .000	.14
Liability to Sub. Use/Abuse	←	SES	-.02	.01	.001	-.10
Liability to Sub. Use/Abuse	←	Unpredictability	.03	.003	< .000	.17
Liability to Sub. Use/Abuse	←	Harsh Parenting	.01	.003	.155	.03
Alcohol Abuse	←	Mating Competition	1.04	.08	< .000	.35

Aggression	←	SES	-.28	.03	< .000	-.19

Table 6

Final SEM Covariances and Correlations

			Cov	*SE*	*p*	*r*
Super-K	↔	DS Personality	.00	.00	-	.00
Super-K	↔	DS Covitality	.00	.00	-	.00
DS Personality	↔	DS Covitality	.00	.00	-	.00
DS Personality	↔	Liability to Sub. Use/Abuse	.04	.01	< .000	.31
Mating Competition	↔	Super-K	-.01	.01	.759	-.01
DS Covitality	↔	Liability to Sub. Use/Abuse	-.02	.01	< .000	-.18
Alcohol Abuse	↔	Liability to Sub. Use/Abuse	.01	.01	.027	.06
Alcohol Abuse	↔	DS Personality	-.07	.03	.008	-.07
Alcohol Abuse	↔	DS Covitality	.10	.03	.002	.09
Alcohol Use	↔	Alcohol Abuse	.36	.02	< .000	.30
Illicit Drug Abuse	↔	Illicit Drug Use	.21	.01	< .000	.50
Sexuality	↔	# Sexual Partners	.36	.02	< .000	.38
Sexuality	↔	Pairbonding	.26	.01	< .000	.31
Neighborhood Quality	↔	Smoking	-.09	.01	< .000	-.17
Neighborhood Quality	↔	Aggression	-.18	.02	< .000	-.16
Agreeableness	↔	Neuroticism	-.19	.02	< .000	.27
SES	↔	Unpredictability	-.11	.02	< .000	-.11
SES	↔	Harsh Parenting	-.10	.02	< .000	-.10
SES	↔	Neighborhood Quality	.54	.02	< .000	.52
Unpredictability	↔	Harsh Parenting	.19	.02	< .000	.19

Supplementary Materials

1. Substantive Rationales for Measurement Model Modifications

Factor loadings

DS Personality BY pair-bonding. Personality and love and attachment have been linked in past research (e.g., see Fraley, Roisman, Booth-LaForce, Tresch Owen, & Holland, 2013).

Mating competition BY neighborhood quality. Access to resources has been linked to higher levels on fast and also slow traits between species (e.g., Sibly & Brown, 2007) and research suggests mating effort may be linked to resource access in that males may seek out and acquire resources to enhance success in mating effort, while females may use mating effort to accrue resources (Buss, 2007).

Mating competition BY agreeableness. Mating competition manifests as antisocial, more disagreeable attitudes and behaviors (e.g., risk-taking, delinquency, sexual coercion, aggression, etc.). Consistent with this, indicators of mating competition have frequently correlated with lower levels of agreeableness (e.g., Weiss, Egan, & Figueredo, 2004; Nedelec & Beaver, 2012).

DS Personality BY sexuality. Sexuality reflects personality traits associated with extroversion and also traits associated with lack of constraint, or disinhibition (Simpson & Gangestad, 1991). Super-K and mating competition likely function as sources of covariation between sexuality and these traits. Thus, in addition to reflecting Super-K, sexuality should reflect domain-specific personality variation that is explained by mating competition.

DS Covitality BY agreeableness. Agreeableness is a reliable correlate of facets of health and wellbeing (e.g., Turiano et al., 2011).

DS Covitality BY neighborhood quality. Neighborhood quality has been linked to physical and mental health (Schafer-McDaniel, 2009). In addition, mutation load may contribute to active or passive selection into poorer quality neighborhoods through effects on mental illness.

Mating competition BY neuroticism. Past research has linked neuroticism to faster LHS (Figueredo et al., 2005).

Structural Regression Coefficients

Alcohol abuse ON mating competition. Heightened alcohol use may be unique from higher levels of other types of substance use in that it seems to amplify pre-drinking intention to have sex (Steele & Josephs, 1990). Alcohol abuse may play a special role in facilitating mating success (Richardson et al., in review).

Covariances

Sexuality WITH # sex partners. The latent variables in our model could not be expected to explain all the association between these variables because facets of sexuality such as pleasure in sexual interactions could contribute to motivation to have sex, perhaps with additional partners. Similar, sex frequency could reflect number of partners to some extent.

Neighborhood quality WITH smoking. This covariance was specified because research has established that lower levels of SES correspond to greater smoking (Gilman, Abrams, & Buka, 2003).

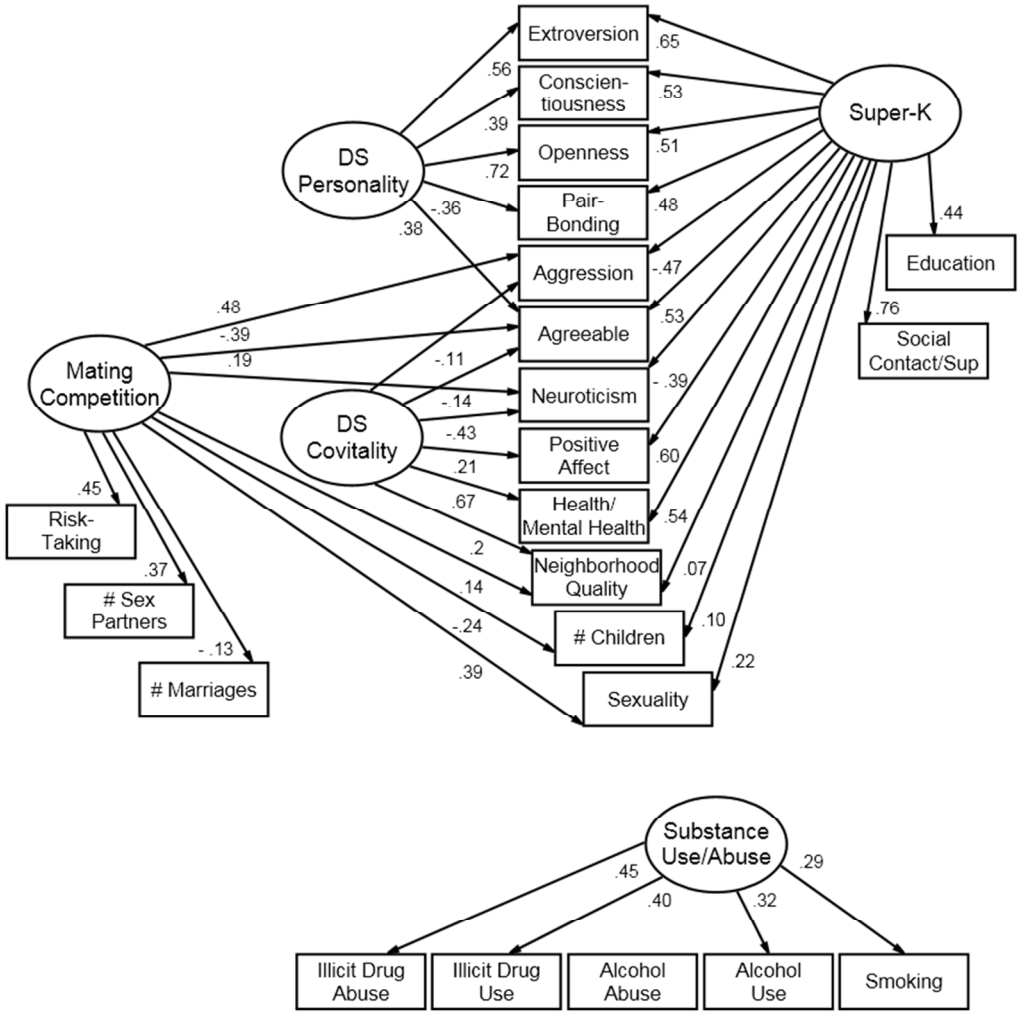
Neighborhood quality WITH aggression. There were many reasons to specify this effect. For instance, although mating competition may increase aggression and also predict greater neighborhood quality, aggression itself may be less useful in higher quality neighborhoods where residents have the resources and status necessary to ensure that it is punished by the authorities.

Sexuality WITH pair-bonding. We added an error covariance between sexuality and pair-bonding because the latent variables in our model could not be expected to explain all the association between these variables. This is because, for instance, rating of current relationships and also the sexual aspects of current relationships may depend partly on sexuality (e.g., the effort invested into sexual aspects of life, the importance of sexual expression, or pleasure experienced in sexual interactions).

Agreeableness WITH neuroticism. These are negatively correlated in a very large body of research (John & Srivastava, 1999).

DS Covitality BY aggression. Past research has linked mental illness to violence over and above substance use (e.g., Van Dorn, Volavka, & Johnson, 2012).

2. Graphic Display of Factor Loadings Only



3. Indirect Effects of Environmental Variables on Life History Indicators

For those who may be interested in practical public health and well-being implications, we tested the indirect effects of the environmental variables on each life history indicator closely related to health promotion and illness prevention efforts. We found that childhood SES had small mating competition mediated effects on sexuality (β = .17), number of sexual partners (β = .16), aggression (β = .21; this cancelled out its direct effect), and risk-taking (β = .19). Childhood SES also had small Super-K (β = -.09) and domain specific personality (β = -.04) mediated effects on pair-bonding. No SES effects on neuroticism were detected.

Unpredictability had small Super-K mediated effects on neuroticism (β = .07), positive affect (β = -.11), health/mental health (β = -.10), sexuality (β = - .04), aggression (β = .08), social support (β = -.13), education (β = -.08), and liability to substance use/abuse (β = .06). Harsh parenting had small mating competition, Super-K, and domain specific covitality mediated effects on neuroticism (totaled to β = .11); small effects through all the latent variables on pair-bonding (totaled to β = -12); small Super-K mediated effects on positive affect (β = -.11), agreeableness (β = -.10), social support (β = -.14), education (β = -.08); and small Super-K and mating competition mediated effects on aggression (β = .09 and .07), domain specific covitality (β = -.10 and .04), and liability to substance use/abuse (β = .08 and .04). Finally, harsh parenting had small mating competition mediated effects (β = .05) on alcohol abuse and number of sexual partners (β = .05).

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