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The Psychometric Evaluation of Human Life Histories: A Reply to Figueredo, Cabeza de Baca, Black, Garcia, Fernandes, Wolf, and Woodley (2015)

Lee T. Copping¹, Anne Campbell¹, Steven Muncer², and George B. Richardson³

Abstract

A recent critique of Copping, Campbell, and Muncer raised several issues concerning the validity of psychometric assessment techniques in the study of life history (LH) strategies. In this reply, some of our key concerns about relying on aggregated psychometric measures are explained, and we raise questions generally regarding the use of higher order factor structures. Responses to some of the statistical issues raised by Figueredo et al. are also detailed. We stand by our original conclusions and call for more careful consideration of instruments used to evaluate hypotheses derived from LH theory.

Keywords

life history strategy, psychometrics, methodology, K factor, evolutionary psychology

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Figueredo et al. (2015) commented on Copping, Campbell, and Muncer (2014a) critical examination of psychometric assessment techniques used in the evaluation of human life history (LH) strategies. We welcome the debate that our article has stimulated because only through informed and rational dialogue does a field progress. We have structured our response by first summarizing the aims and findings of our original submission and answering some specific criticisms raised by Figueredo et al. We then raise issues regarding the specification of super factors and their underlying rationale. Finally, we raise a number of statistical issues that we consider to be pertinent to psychometric LH batteries.

The Original Study

In our original study (Copping, Campbell, & Muncer, 2014a), we examined the structure of the High-K Strategy Scale (HKSS; Giosan, 2006), a psychometric index of slow LH strategy, in relation to key life events (pubertal onset, sexual onset, and number of sexual partners) in order to validate the instrument's suitability for use in LH research. Analysis suggested that the HKSS did not measure a single, unidimensional construct as represented in the original conceptualization (Giosan, 2006). A single-factor model did not show a good statistical fit

to the data set (based on a sample of over 800 individuals recruited via a newspaper), and we proposed instead a model that afforded greater statistical parsimony, while retaining conceptual integrity. Decomposing the scale into four domain-specific facets appeared to provide the best conceptual and statistical fit to the data. Several findings emerged that were contrary to LH predictions (although they were consistent with evolutionary predictions), and clear sex differences were evident in the data set. We raised concerns about amalgamating lifestyle, personality, and behavioral items into a single scale as an effective measure of LH strategy and called for further work to clarify the underlying nature of psychometric constructs used in LH research. We highlighted the need to analyze data by sex, culture, and social class in order to more clearly examine LH strategies.

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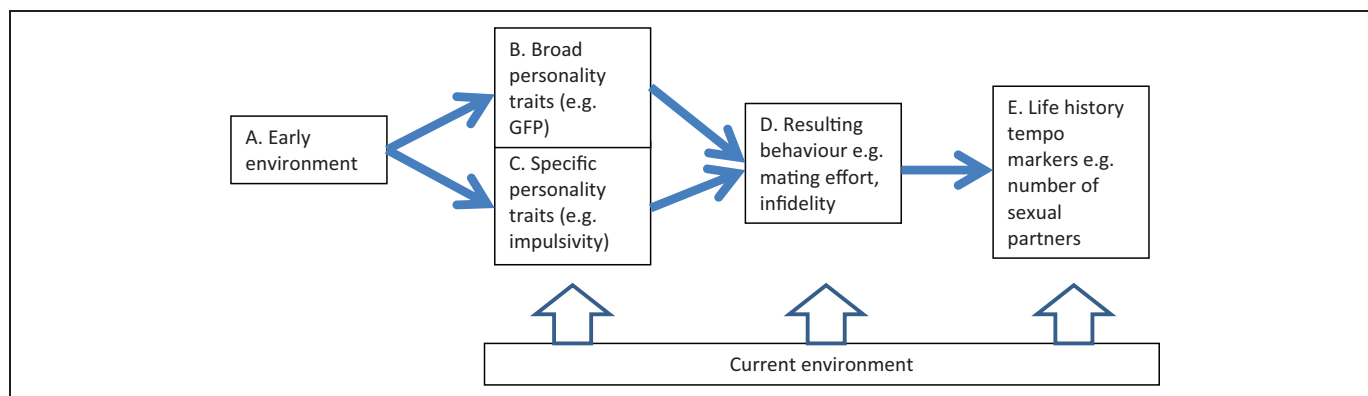


Figure 1. Simplified illustration of associations between some concepts discussed in the article. Psychometric inventories of life history such as Arizona Life History Battery, Mini-K, and Super-K produce a score based on items assessing A, B, C, and D making it impossible to establish the mediating, moderating, or causal relationships between these variables. Because these inventories do not examine associations with E, it is unclear whether their model is a life history model as understood in evolutionary theory.

Ours was effectively a foundation study to evaluate the HKSS as a measurement instrument, a step that is usually considered essential by scale developers prior to its widespread use. Such an analysis allows the scale to be evaluated against recognized psychometric indices and means that potential item and structural misspecifications can be identified in advance. Indeed, at the time of writing, 12 publications using the HKSS had already been conducted on the assumption that the measure was valid. Had a validation study been conducted previously, one wonders if so many researchers would have used this measure. It is important that detailed psychometric work is conducted to validate scales in any discipline before mainstream use.

Given the similar theoretical and empirical basis between the HKSS and other psychometric measures of LH, we tentatively suggested that several of our findings might extend to the growing assortment of psychometric LH indicators. Figueredo's laboratory alone has generated at least five measures of LH strategy: the Arizona Life History Battery (ALHB), the Mini-K (a short form of ALHB), Super-K (composed of ALHB + Covitality + General Factor of Personality [GFP]), Super-K1 (Mini-K + GFP + Mate Value), and Super-K2 (Mini-K + GFP + Mate Value Inventory + Mating Effort Scale + Intentions Towards Infidelity Scale + Self-Monitoring Scale). These are described in Figueredo, Vasquez, Brumbach, and Schneider, (2007) and Olderbak, Gladden, Wolf, and Figueredo (2014) and are not inclusive of all variants of so-called K factors. Figueredo et al.'s response to our article refers, at different points, to these various inventories. To our knowledge, no detailed, item-level analysis or confirmatory factor analysis (CFA) of the ALHB or the Mini-K has been published that (a) clearly shows that its structure is unidimensional and (b) shows consistent relationships with known behavioral indicators of LH theory.

To clarify, we do not necessarily dispute the theoretical rationales for selecting many of the variables in these scales. Research consistently shows that factors such as parental attachments, risk taking, and impulsivity are important factors

associated with strategy trajectory (Belsky, Steinberg, & Draper, 1991; Brumbach, Figueredo, & Ellis, 2009; Chisholm, 1999; Copping, Campbell, & Muncer, 2013, 2014b; Ellis, Figueredo, Brumbach, & Schlomer, 2009; Richardson & Hardesty, 2012). What needs to be considered more carefully is the utility of aggregating various domain-specific factors into one domain-general measure.

Biometric and Psychometric Indicators—A False Dichotomy

In their critique, Figueredo et al. (2015) incorrectly assert that we consider biometric measures preferable to psychometric indicators (p. 302). No claim regarding the superiority of biometric/anthropometric to psychometric indicators was made, nor did we propose a dichotomy between them. Our point was that researchers should employ both types of measures in order to examine the relationships between the two. Hence, in suggesting that, "*LH researchers embrace a position where both measures are incorporated into a more inclusive set of measurement and structural models*" (p. 302), they concur exactly with our proposal. The thrust of our argument was that the scales included on measures such as the ALHB (e.g., Insight, planning and control; Religiosity; Mother/father relationship quality) do not assess LH strategy as it is usually understood but rather represent variables that may predict or mediate LH trajectory (e.g., earlier reproduction, more sexual partners, lower parental investment). Furthermore, as shown in Figure 1, the summing of these different characteristics (traits, relationships, and lifestyles) to produce a composite score makes it impossible to examine the relationships between them. As evolutionary psychologists, we believe our role is to identify the psychological pathways through which environmental stress and resource scarcity ultimately impact upon LH tempo. Figure 1 represents a highly simplified hypothesis about how this might happen, showing only unidirectional causal relationships. Personality traits may act as moderators or mediators of the relationship between early experience and LH tempo. Or

they may be by-products of early experience that are not causally related to outcomes. Or the associations between personality and outcomes may be no more than common genetic effects.

We believe that these are important questions but, following Figueredo et al.'s (2015) reply, we are not much clearer on their position. Not only do they accept that their global inventories "are relatively agnostic with respect to possible causal relations among its various components" (p. 314), but they regard our suggestion of a possible causal relationship (usually called a hypothesis) as impertinent ("the authors of the critique apparently presume to know which of the various LH traits being measured are causal to the others. To a philosopher of science, this degree of confidence would appear remarkable," p. 314). Elsewhere, they hedge their bets by noting a bidirectional relationship between biometric and psychosocial traits (p. 305) and by supporting a developmentally contingent model while citing genetic correlations between indicators and outcomes (pp. 314–315).

LH theory was born out of comparative biological measures (Pianka, 1970; Roff, 1992; Stearns, 1992). Although it is true that the field of human LHs in particular has moved on substantially from earlier incarnations, ignoring markers of reproductive fitness essentially ignores the fundamental principle of LH theory which is about the allocation of effort between key biological tasks (e.g., growth and reproduction) that translates ultimately into lineage continuation. If we fail to measure key life events and instead restrict our measurement to domains such as personal relationships, religiosity, and self-control (as in the ALHB), we are not measuring LHs but *lifestyles*. Psychological mechanisms are doubtlessly important in the development of LHs in humans, and a corpus of literature supports this assertion (Belsky et al., 1991; Brumbach et al., 2009; Chisholm, 1999; Copping et al., 2013, 2014b; Ellis et al., 2009; Richardson & Hardesty, 2012). However, establishing which particular psychological mechanisms are important to different strategies is equally vital. If the purpose of a functional psychological adaptation is to increase the probability of reproductive success, such mechanisms should be demonstrably related to biological indices of that goal. If this is not the case, how can any psychological mechanism be truly called an adaptation? Figueredo et al. make the distinction between the "means [functional processes] and ends [distal achievements] of behaviour" (2015, p. 302) and claim that we endorse a process that would only highlight the ends (fitness outcomes). As clearly noted originally however (Copping et al., 2014a, p. 217) **IAQ1**, most researchers in the modern evolutionary sciences do not advocate for a purely "counting babies" approach nor focus purely on fitness maximization (Nettle, Gibson, Lawson, & Sear, 2013). We are as interested in the *means* as well as the *ends* when it comes to strategy development, but in particular, how the means facilitate the ends. To achieve this goal, what is needed is a closer examination of biological indicators in relation to environmental context and psychological, cognitive, and behavioral data. After all, how can the validity of processes or means that are hypothesized to

be driving strategy be evaluated without reference to the fitness outcomes or ends in which we believe they result?

Fast LH Strategies

In their critique, Figueredo et al. explicitly state that "faster LH strategists should invest more energy in reproductive effort, and particularly in mating effort" (2015, p. 305). Few would disagree with this as a key characterization of faster LHs. For this reason, we (Copping et al., 2014a) deliberately picked 3 items considered to be indicative of a faster LH strategy and greater mating effort: accelerated development (i.e., earlier pubertal onset), earlier age of reproductive onset, and greater numbers of sexual partners. These three variables are widely acknowledged as indicators of the pursuit of faster strategies, and it is not by chance that these particular variables (or their equivalents) feature heavily in many studies exploring human LH (e.g., Belsky, Schlomer, & Ellis, 2012; Chisholm, 1999; Dishion, Ha, & Veronneau, 2012; Ellis et al., 2003; James, Ellis, Schlomer, & Garber, 2012; Quinlan, 2003; Simpson, Giskevicius, Kuo, Sung, & Collins, 2012). These measures are theoretically appropriate criteria for examining the validity of a measure that proposes to index psychological correlates of fast and slow LH strategies.

Figueredo et al. propose that, due to cultural developments and ecological constraints associated with Western Economic Industrial Rich Democratic societies, "we should not necessarily expect that the main effects of LH indicators like the Mini-K or the HKSS will be statistically significant or very large in magnitude when predicting such fitness outcomes." If fitness outcomes are not associated with LH indicators, surely it raises grave questions either about the relevance of LH theory to an explanation of contemporary western human behavior or about the validity of LH indicators. Remaining with Figueredo et al.'s example of mating effort, research generally shows that attitudes, desires, and beliefs about mating tend to correlate significantly with actual mating behaviors on a population level (Jackson & Kirkpatrick, 2007; Penke & Asendorpf, 2008; Simpson & Gangestad, 1991). A similar case could be made for other behaviors consistent with fast strategies such as aggression (Archer & Graham-Kevan, 2003; Huesmann & Guerra, 1997). If beliefs and intentions toward a given behavior correlate with the same behavior, then we would expect an inventory focusing on processes calibrated toward increased mating effort to be related to actual mating effort. Thus, an index of fast LH strategy should correlate substantially and in the expected direction with measures of mating behavior and aggression (or other indices of fast strategy execution) at the population level. Although several relationships in our study corroborated predictions made from evolutionary theory, a unitary K dimension was not apparent in this data set.

LH indicators should show some relationship to behaviors consistent with the execution of the strategies they purport to measure. Indeed, in studies that do not use aggregated psychometric indices (and instead measure specific ecological, psychological, biological, or behavioral factors), the expected

correlations tend to hold (Belsky et al., 2012; Chisholm, 1999; Copping & Campbell, 2015; Copping et al., 2013; Dishion et al., 2012; Ellis et al., 2003; James et al., 2012; Quinlan, 2003; Simpson et al., 2012). However, studies using LH batteries often fail to find the expected relationships. If specific variables predict strategy patterns in the real world, what is the value of aggregating them in such a way as to mask these relationships? For instance, the relationships of the ALHB with socially antagonistic attitudes and socially antagonistic behaviors were not significant ($r = -.12$ and $-.07$, respectively; Wenner, Bianchi, Figueredo, Rushton, & Jacobs, 2013). Olderbak and Figueredo (2012) reported the relationship between the Mini-K and mating effort as $r = -.03$. Olderbak et al. (2014) found that mating effort was not significantly related to the ALHB ($r = .05$), the Mini-K ($r = .12$) or the HKSS ($r = -.07$). Figueredo, Gladden, and Hohman (2012) showed in a structural model that mating effort and aggression were both subsumed by another latent dimension named “Psychopathic and aggressive attitudes” which was not directly related to slow LH strategy. When developmental trajectory is factored in, the singular dimension of the K strategy is also questionable. Brumbach, Figueredo, and Ellis (2009) concluded that slow LH and social deviance were separate dimensions in adolescence and young adulthood, suggesting that a singular LH dimension may not emerge until later adulthood. Similar findings were made by Richardson, Chen, Dai, Hardesty, and Swoboda (2014) and have recently been corroborated (Richardson, Dariotis, & Lai, in press; Richardson et al., in press). It is clear that the relationship between indices of mating effort, competition, and LH strategy is more complex than a single dimensional approach would have us believe.

Other studies have shown that mating effort does tend to load negatively on K (albeit weakly) when a higher order super factor (Super-K) is employed (Olderbak & Figueredo, 2012; Olderbak, Gladden, Wolf, & Figueredo, 2014). As the nomological net is widened, other factors inevitably begin to be included through their relationships with other variables such as life expectancy (which has strong links to aggression and reproduction: Chisholm, Quinlan, Petersen, & Coall, 2005; DuRant, Cadenhead, Pendergrast, Slavens, & Linder, 1994; Wilson & Daly, 1997), intelligence, personality, and beyond (Olderbak & Figueredo, 2010; Rushton, 2004). Despite this, the relationship between mating effort and the Super-K remains the weakest link (Olderbak & Figueredo, 2012; Olderbak et al., 2014). This is puzzling when one considers the ultimate function of a LH strategy is to facilitate reproductive ends.

The super factor aside (which we return to later), the purpose of the original study was to validate a specific measure; the HKSS. From the point of validating it against indices of mating effort consistent with a fast LH strategy, it would appear that the HKSS does not work as predicted. Alternatives (such as the Mini-K or ALHB), used as stand-alone instruments or as part of a larger super structure, do not appear to consistently demonstrate predicted relationships with other indices of fast LH strategy. This raises questions about what some of these psychometric inventories actually measure and thus their validity.

The Environment

As advocates of plasticity throughout development (West-Eberhard, 2003), we acknowledge the pivotal role of the early environment in the development of LH trajectories. Much of our previous work emphasizes this point (e.g., Copping & Campbell, 2015; Copping et al., 2013) and supports theoretical proposals (Belsky et al., 1991; Chisholm, 1999; Ellis et al., 2009) of key environmental factors that predict levels of crime, aggression, teenage pregnancy, and short-term mating orientation. The wider developmental environment is indeed of paramount importance. However, accurate measurement of the wider environment is difficult and even more difficult if assessed retrospectively. In the absence of a well-validated, easy to administer questionnaire that accurately captures the developmental environment, many researchers are unable to examine the proximate causal factors of LH strategies. Although measuring the environment is easier said than done, some notable attempts have been made (Belsky et al., 2012; James et al., 2012; Simpson et al., 2012). Despite Figueredo et al.’s emphasis on the importance of the early environment, many studies using the HKSS, ALHB, or the Mini-K do not assess it. Although the ALHB asks questions regarding the quality of childhood relationships with parents (an indication of developmental stability), it does not go beyond this. However, theory and research indicate that stress, uncertainty, and unpredictability are transmitted not just via the immediate familial environment (Copping & Campbell, 2015; Copping et al., 2013) but can operate in complex ways in relation to strategy-related variables (Richardson, Chen, Dai, Hardesty, and Swoboda, 2014; Richardson et al., in press). Factors such as local morbidity, extrinsic mortality, unemployment, resource scarcity, mobility, and socioeconomic status have been suggested as being pivotal to strategy formation (see Ellis, Schlomer, Tilley, & Butler, 2012; Chisholm, 1999; Copping & Campbell, 2015; Copping et al., 2013). These however are rarely examined in relation to the ALHB, the Mini-K, the Super-K, or the HKSS.

Furthermore, these batteries do not address the complexities of the early family environment (which is often purported to be the main contributing factor: Belsky et al., 1991; Chisholm, 1999). The Mini-K contains just two items asking about early relationships with mother and father (e.g., “While growing up, I had a close and warm relationship with my biological father”). Responses to this item do not address the key factors about paternal and father-figure relationships. Although a vast corpus of literature suggests that father absence is a critical factor in strategy development (Belsky et al., 1991; Draper & Harpending, 1982; Ellis, 2004; Ellis et al., 2003), there are many caveats. For instance, the death of a father does not lead to the same outcomes as abandonment by the father (Hetherington, 1972). Step parenting, alloparental care, and other parenting strategies are also important to the expression of later LH strategy (Sear & Mace, 2008; Sheppard, Garcia, & Sear, 2014; Sheppard, Schaffnit, Garcia, & Sear, 2014; Sheppard, Snopkowski, & Sear, 2014). These are not encompassed in the

ALHB or Mini-K, and the wider environment is rarely considered. Although it is right that measures of parental investment should be considered in studies investigating LH strategies, they should be measured within the broad context of strategies and not aggregated within a wider set of theoretically relevant (or potentially irrelevant) indices. Although Figueredo et al. are right to raise the importance of the environment, most psychometric research employing measures such as the HKSS, the Mini-K, and so on (including their own) does not adequately encompass it.

The Super-K

Figueredo et al. consider the Super-K factor to represent a wider nomological net capturing personality (GFP) and health (Covitality) in addition to domains covered by the ALHB (e.g., see Dunkel, Mathes, & Harbke, 2011; Figueredo et al., 2014; Gladden, Sisco, & Figueredo, 2008; Olderbak & Figueredo, 2010, 2012). Incorporating measures into “more inclusive set of measurement and structural models” is critical to the proper evaluation of theory and few would disagree with this. However, care must be taken in their use and interpretation. The K-factor approach loads scale totals onto one factor or creates a super factor from a series of hierarchically structured factors. To some degree, this approach blurs rather than clarifies the key relationships of interest. Figueredo et al. acknowledge that global inventories are “causally agnostic” (2015, p. 314). With so many indices loading (sometimes weakly) onto one global hierarchical construct, it is impossible to examine key relationships that underpin milestones of developing LH strategies in any meaningful way. In Figure 1 (Biometric and Psychometric Indicators—A False Dichotomy section), we illustrated with a simplistic model how LH traits may emerge through a series of environmental triggers, biological life events, psychological mediators, and behavioral outcomes. In a model using higher order factors, where all of these different events and processes are reduced and loaded onto one scale, we cannot meaningfully discriminate between them. This is particularly problematic when items are parceled (which we will address later). However, examination of these key relationships is crucial to enhance our understanding of how strategies develop, under what conditions, and via which psychological and/or biological mechanisms.

It may be that a series of higher order factors load on to each other in an increasingly hierarchical fashion. As our critics correctly assert, biological traits in animals have been shown to cluster together predictably (Promislow & Harvey, 1990; Rushton, 2004). We do not disagree with the proposal that a similar dimension may exist in humans. What we dispute is the choice of measures within these lower order factors and the lack of evidence that these lower order factors work as measurement instruments prior to aggregation, when a similar approach is applied to humans.

For example, on an all-encompassing measure of the Super-K, imagine that one individual scores highly on measures of mate value and exclusively pursues short-term sex, is very

intelligent (high *g*) and has a long-life expectancy. Another individual scores highly on conscientiousness and agreeableness, favors long-term pair bonds, and has a lower *g* and life expectancy. A final individual is married with children but is also a clandestine adulterer with a high *g* and a long-life expectancy. These three individuals could have very similar overall scores on a Super-K strategy battery, despite the fact that they vary markedly on various subscales and are in reality pursuing radically different strategies. Aggregating many related facets into a global K score means that the ability to discriminate within the range of strategic possibilities is lost and raises questions about what this aggregate score is actually telling us. Figueredo et al. are right to acknowledge that there are a range of contingent LH strategies (see Ellis et al., 2009) that can exist within the scope of the K continuum but does their measurement approach really allow us to identify the range of strategies in play? The complex interplay of factors that represents a person's strategy and their developmental trajectory are lost using this approach (see Del Giudice, 2014; Richardson et al., in press, for an illustrative example of such complexity).

Figueredo et al. (pp. 312–314) consider how their measures might be used to incorporate a developmental dimension, presenting a model purportedly testing a Bronfenbrenner-inspired developmental sequence (Garcia, Cabeza de Baca, Sotomayor-Peterson, Smith-Castro, & Figueredo, in press). Model fitting is used to demonstrate that development is best described by a hybrid model in which Mini-K directly informs different stages in the sequence while each stage also affects the subsequent stage. However, the inclusion of these factors does not conform to the developmental sequence implied by most proponents of psychosocial acceleration theory. The evidence of the last two decades has culminated in a relative consensus that forms the basis of recent proposals of how strategies may emerge, such as the Adaptive Calibration Model (Del Giudice, Ellis, & Shirtcliffe, 2011; Del Giudice, Hinnant, Ellis, & El-Sheikh, 2012). The proposed hybrid model (Figueredo et al., 2015) however bears little relationship to this (or other) models. Although the first developmental stage (biological mother and father) represents a retrospective assessment of parental relationships in childhood, the remaining stages are concurrent measures of existing relationships and activities (culminating in regular religious practices) placed in an arguably arbitrary order. Given that the Mini-K itself is a truncated version of the ALHB scales used to assess each of these “stages”, it is unsurprising that they are correlated—but it is a substantial leap from this correlation to asserting a genetic influence on LH development. Despite Figueredo et al.'s emphasis on the environment, there is no treatment of environmental influences (stressors on parents and the individual, indices of local competition or resource access) that could play a role in the expression of any of these behaviors or traits.

Our second objection relates to how these higher order factors are constructed. The underlying logic of the Super-K relies on an increasingly hierarchical model of theoretically related factors that culminate in a representation of an individual's strategy. However, research shows that in some complex

constructs, this is not a valid way to represent a phenomenon. For instance, the GFP is one of three factors composing the Super-K along with the K factor and covitality (Musek, 2007; Rushton, Bons, & Hur, 2008; Rushton & Irwing, 2011). The GFP is often constructed from either constituent personality traits (such as agreeableness, conscientiousness, extraversion, neuroticism, and openness) or from loading multiple personality inventories onto one factor assuming that all relate to a single common latent. This approach to the measurement of personality however has been widely questioned recently (e.g., Hopwood, Wright, & Donnellan, 2011; Muncer, 2011). Revelle and Wilt (2013), in a review of existing GFP studies concluded that (a) this analytical approach to personality is often fundamentally flawed, (b) the overall magnitude of a general personality factor is not great enough to be genuinely meaningful, and (c) GFP is a less useful approach to analyzing individual differences than using lower level constructs. More recently, evolutionary psychologists have also claimed that GFP is not “a clean indicator of fast-slow variation in personality” (Del Giudice, 2014, p. 397). Similar to our earlier point, merging personality traits onto a single dimension simply distorts the real impact of personality traits on LH strategies. If, like GFP, the lower order factors in their own right are more useful, why load them into higher order structures?

Our point here (since the wider debate regarding GFP is not the central theme of this article) is that if we cannot apply such an analytic technique effectively to one dimension subsumed by a supposed Super-K factor, why should we expect it to work with (a) other higher order constructs such as K and covitality and (b) even higher level latent variables such as the Super-K itself? If we cannot meaningfully interpret a higher order factor such as GFP on its own, what does it represent when aggregated into a single super factor structure or factor score? Most studies employing the Super-K report only the final factor loadings rather than providing data on the underlying structure of the constituent latent traits. Instead they rely on parceled inventory scores (a limitation to which we will return shortly), so that we are unable to establish with confidence whether factors (from higher order GFP to lower orders such as religiosity, altruism, mating effort) are valid representations of the facet(s) they purport to measure. This potentially obscures the meaning of the Super-K factor and may cause over or underestimations of relationships between it and other relevant LH traits.

Furthermore, some incorporations of the Super-K may overestimate factor loadings and thus make the Super-K appear psychometrically stronger than it actually is. For instance, Olderbak et al. (2014), present data of a proposed Super-K structure that includes the subscales of the ALHB and the Mini-K loaded onto one factor. One must question why this has been done when the Mini-K is effectively a short form of the ALHB. There is considerable overlap of the content domain which is likely to inflate estimates of factor loadings. Interestingly, correlations between the components of the ALHB and the Mini-K itself are by Cohen's (1969) criteria small to medium at best. Olderbak et al. concluded that “the Mini-K, ALHB, and Super-K factor 1 are the most convergent measures of LHS” (2014,

p. 86) with the HKSS loading less cohesively with these measures. This is hardly surprising when one considers that the Mini-K and the ALHB are effectively the same thing: Why would they not be expected to load together? The proposed developmental hybrid model (p. 313) presumably is similarly flawed given that the Mini-K is being used to predict factors that the Mini-K actually includes in its measures.

Finally, Figueredo et al. emphasize the importance of higher order single-factor structures for the purposes of studying LH theory. If these models are to have utility, we should expect to see that these single-factor structures offer greater parsimony at no expense to model fit when compared to lower order multidimensional structures. In studies that have explicitly tested this assumption, this has not been found to be the case. **[AQ2]** Copping et al. (2014) found that a four-factor model, not a unidimensional one, fit data from the HKSS inventory better. Richardson et al. (2014), using data from the National Longitudinal Survey of Youth 1997 (Bureau of Labor Statistics, U.S. Department of Labor, 2013) found that a unidimensional structure did not fit the data, or that a single LH strategy factor did not subsume all LH indicators. Richardson et al. (in press) also found statistically independent mating competition and Super-K dimensions (implying that a single dimension was not plausible) when modeling LH strategy from Midlife in the United States data. Finally, Richardson, Dariotis, and Lai (in press) also found that a two-dimensional model fits the data better than a single-factor model in a predominantly urban sample of young adults. We, therefore, echo Revelle et al. (2013) and suggest that in-depth analyses of lower order constructs is ultimately much more useful to study the specifics of LH strategy than higher order super factors.

Statistical Issues

We now briefly turn to three issues we consider important in the interpretation of the results of LH studies which use psychometric measures such as the ALHB, the Mini-K, and the HKSS.

Reliability of Measurement

The use of reliability coefficients (Cronbach's α) and the use of fit statistics were questioned by Figueredo et al. in relation to our interpretation of the HKSS as a measure. The HKSS in our study showed a high α (.86) and thus demonstrated a high degree of internal consistency. Figueredo et al. make the point that this is an impressive result given how short the inventory is (only 26 items). This is an odd claim, considering that the Mini-K, which is held to be the superior measure, is shorter still (at only 20 items) and often yields similar reliabilities, with an average around .70 according to Figueredo et al. (2015). Even stranger is the fact that colleagues of Figueredo have reported even higher reliabilities (.90) for the HKSS (Gladden, Welch, Figueredo, & Jacobs, 2009).

Our critics also criticize the reliability of one-item measures. Although the general convention is to avoid the use of

single-item measures, greater use of single-item measures is becoming prevalent in the social sciences and arguments for their use have been made (Hayduk & Littvay, 2012). Cronbach's α statistics are dependent on the number of items present in a scale and the number of respondents in the sample. Simply increasing the number of items and/or participants will normally increase reliability. Worryingly, many often believe α can be used on its own as a proxy for unidimensionality. This is of course not so. As demonstrated by Green, Lissitz, and Mulaik (1977), merging a series of orthogonal scales into one larger scale will still yield high reliability estimates despite the fact that the underlying items do not represent a unidimensional construct. The revised HKSS with separate subscales that we proposed in our analysis is a case in point (where the individual subscales have lower reliabilities than a single scale). Across many fields within the social and behavioral sciences, researchers have composited scales on the basis of large Cronbach's α coefficients, despite decades of research demonstrating that coefficient α 's assumptions are rarely satisfied in practice (Bentler, 2009; Green & Yang, 2009; Sijtsma, 2009) and that it does not provide information about internal structure (Sijtsma, 2009).

Reliability alone does not ensure validity. Validity of a construct is much more important to establish. Although it is good news that the constructs had at least acceptable internal consistency, this is redundant if the reliably measured constructs are themselves misspecified. It is for this reason that models are compared and evaluated using a range of fit statistics and their relationships with theoretically pertinent variables associated with the construct examined. In this way, the question of what K actually is and how it should be measured can be addressed. The use of fit statistics in our study is consistent with general practice in the field of psychometrics (including previous works by our critics; e.g., Brumbach et al., 2009; Gladden, Sisco, & Figueredo, 2008; Olderbak et al., 2014) and the interpretations regarding the validity of this measure are justified based on the available data set. We thus maintain that our original work was far from "psychometrically invalid," as our critics claim it to be.

Problems of Statistical Conclusion Validity

One of the criticisms we made in our original article was the over reliance on undergraduate samples to draw conclusions about strategy development in the wider population. In order to establish comparability between samples and hence validate generalization between them, Figueredo et al. reviewed evidence that distributions among undergraduate students on measures such as the ALHB and Mini-K do not appear to differ appreciably from those found in the general population (pp. 309–311; see Figueredo et al., 2014). Although this evidence helps to establish descriptive similarity between samples, it does not ensure that undergraduate students share the same pattern of causal relationships with other young adult subpopulations or the general young adult population. We cannot be sure we are looking at the same construct across samples

without first establishing measurement invariance (Brown, 2006). In other words, it is not clear that the relationships among indicators believed pertinent to LH strategies are manifestations of the same common construct (the K or super factor) across samples. In addition, even if measurement invariance holds, the associations of a factor representing strategies with other variables may vary across samples even when its means and variances do not (Little, 2000). Of course, it is not easy to identify subpopulations that are causally homogeneous for the functional relations linking predictor or outcome variables with LH measures. Painstaking efforts are required to test these relations for invariance (e.g., see Kline, 2011; Bollen, 1989; Brown, 2006). In the end, researchers may find causal heterogeneity such that generalization to a broader (e.g., national) population is not warranted. However, without testing for causal invariance, researchers risk accepting estimates that are inaccurate descriptors of some or possibly many groups. One methodological approach that can help LH researchers discover and model heterogeneity is factor mixture modeling, in which researchers can discover latent classes with the same structure but allow parameters to vary (see Henson, Reise, & Kim, 2007; Lubke & Muthén, 2005; Lubke & Spies, 2008). When the identity of groups is known, multiple group structural equation modeling can also be used to test a K factor for construct level metric invariance (e.g., across cultures; Frazier, Tix, & Baron, 2004). Because the K factor is purportedly an adaptation, it is important to show that its structure does not differ across human groups. On an additional note, although Figueredo et al. (2015) identified studies of LH measures that used nationally representative data (e.g., Brumbach et al., 2009, see also Richardson et al., 2014), it is still clearly the case that the vast majority relied on undergraduate student data. Efforts to address this limitation should continue.

Sex Differences in LH Strategy

In our original article, we found significant sex differences and pointed out that insufficient attention had been paid to sex in terms of both measurement (data are often not disaggregated by sex and neither sex invariance nor differences are tested) and theory (given the different reproductive roles of males and females it would be surprising if LH trajectories were not affected). Figueredo et al. claim that sex has been well explored in the literature in relation to measures of K and cite four studies. Yet Figueredo, Cabeza de Baca, and Woodley (2013) is a review that makes no real mention of sex differences specific to K. The remaining three studies are jointly composed of an undergraduate sample of approximately 431 males and 450 females (Figueredo, Andrzejczak, Jones, Smith-Castro, & Montero-Rojas, 2011; Gladden, Figueredo, Andrzejczak, Jones, & Smith-Castro, 2013; Gladden et al., 2008). While some sex differences are reported, there is little discussion regarding their nature and little exploration of sex differences within the measures themselves. Gladden, Sisco, and Figueredo (2008) is perhaps the most detailed of the four cited papers, but no invariance testing is performed. Due to the small sample sizes and

large numbers of items, the Mini-K has been parceled and aggregated into a higher order K structure (discussed earlier) making it impossible to test for item invariance across males and females. Figueredo et al. (2015, p. 309) claim to find “systematic sex differences of between one-quarter to one-third of a standard deviation between sexes, with males being predictably “faster” than females.” However, as the cited papers do not present sufficient data to allow readers to make sense of this small effect size, it is difficult to interpret the true significance of this finding. It also raises further questions. In which inventories, domains, and items are the sex differences located in the K factor? Is there any evidence of structural invariance over sex on any of the measures employed? These important questions require answers given the extensive evolutionary literature on sex differences in mating competition, aggression, parenting, risk taking, and sexual behavior, to name but a few (Archer, 2004, 2009; Buss & Schmitt, 1993; Campbell, 1999; Cross, Copping, & Campbell, 2011; Jackson & Kirkpatrick, 2007; Penke & Asendorpf, 2008; Trivers, 1972; Wilson & Daly, 1985). It is likely that sex has a much larger part to play in strategy development than the current psychometric literature suggests. Below we detail the reasons why we would expect biological sex to impact upon LH strategy formation.

A faster LH tempo prioritizes earlier reproduction over somatic growth, current over future reproduction, mating over parenting, and offspring quantity over quality. Given women's higher parental investment and men's consequently greater fitness variance, men as a sex are characterized by a faster LH tempo, as evidenced in physical (e.g., upper body strength) and psychological (e.g., aggressiveness) sex differences. A shift toward a fast LH tempo for women may entail different adjustments as a result of sex differences in minimum parental investment. There may also be sex differences in (sensitivity to) the cues that signal environmental stress and trigger LH trajectory change.

For men, women are a limiting resource. Mating with multiple women offers the opportunity for extreme reproductive success. Paternal investment is facultative and deserted mothers generally assume the burden of child care. There is little evidence that father absence results in decreased offspring fitness (Sear & Mace, 2008), but such costs could be compensated for by the extra offspring resulting from a serial short-term reproductive strategy. We would expect that male traits enhancing mating success would be selected for, both those associated with intrasexual competition (aggression, dominance striving, sensation seeking) and intersexual competition (facial features signaling “good genes,” e.g., symmetry, masculinity, dominance). According to Del Giudice (2009), environmental stress, signaled to the developing boy through disrupted family relationships, fosters the development of avoidant attachment (correlated with aggression, self-reliance, and inflated self-esteem) which serves as a psychological adaptation for short-term relationships in adulthood. Dark Triad traits have also been implicated in a fast LH strategy (McDonald, Donnellan, & Navarrete, 2012) via strategic deception

(Machiavellianism), egocentrism (Narcissism), and absence of empathy (Psychopathy). Not yet explored is the possibility of downregulation of typical “fathering” adaptations seen following fatherhood such as the testosterone reduction and oxytocin enhancement.

Women's adoption of a fast LH strategy has focused on earlier age of sexual maturity, sexual initiation, and first birth. A meta-analysis of 33 independent effect sizes confirms an association between father absence and earlier menarche, $d = 0.28$ (Webster, Graber, Gesselman, Crosier, & Schember, 2014) and in father-present families, a closer relationship with daughters predicts later menarche (Ellis, 2004). Earlier menarche is associated with a longer reproductive lifespan, early initiation into sexual activity, earlier age of first pregnancy, and increased risk of teenage pregnancy (Coall, Tickner, McAllister, & Sheppard, 2016). Although Del Giudice proposed that boys are more likely to respond to early family dysfunction by forming avoidant attachments, girls are more likely to form anxious/ambivalent attachments. Such attachments are associated with abandonment anxiety and over-dependency and in adulthood earlier initiation into sexual activity and willingness to engage in sex to secure their partner's attention. An unrestricted sociosexual orientation appears to be more closely allied to the quality of parenting rather than father absence (Coall et al., 2016; Ellis et al., 2012). Evidence for an association between lifetime fertility and early familial stress and menarche is mixed (Coall et al., 2016).

In terms of reducing maternal commitment, women cannot escape the minimum obligation of gestation although under conditions of high extrinsic risk such as famine and warfare, mothers reduce infant-directed care (Quinlan, 2007). In low-risk environments, offspring fitness shows a linear increase as a function of maternal effort before reaching a saturation point of diminishing returns. In high-risk environments (such as those associated with a faster LH strategy) this saturation point and the corresponding reduction in maternal care are reached much earlier. A fast strategy prioritizes offspring quantity over quality, leading to the expectation that maternal investment will be reduced, although not so markedly as has been found in men (Szepeswol, Simpson, Giskevicius, & Raby, 2015). Pregnant women, who have a history of early life adversity, are poorly attached and experience high levels of stress have lower oxytocin levels, a hormone associated with positive mother–infant interactions (Garfield, Mathews, & Janusek, 2016; Samuel et al., 2015). Child neglect and abuse are associated with poverty (Coulton, Crampton, Irwin, Spillsbury, & Korbin, 2007), as are lower maternal warmth, lower positive control, and greater negativity (Belsky, Bell, Bradley, Stallard, & Stewart-Brown, 2007). In poor families, mothers' inability to empathize with their children's mental states is associated with children's heightened vulnerability to internalizing and externalizing behaviors (Hurtig et al., 2007; Meins, Centifanti, Fernyhough, & Fishburn, 2013).

Maternal investment in children may be truncated in favor of a quicker return to the mating arena. Although the advantages of multiple mating for women are less well-established

than for men, one clear benefit is offspring genetic diversity (“bet hedging”) and another may be cryptic female choice for “good” or compatible genes (Jennions & Petrie, 2000). As long-term investment is not anticipated, women are expected to show a preference for indirect benefits indexed by facial features indicating health and dominance. Short-term relationships can also supply some direct (if brief) financial benefits and the sporadic episodes of conspicuous consumption associated with criminal enterprises (“earning-and burning”) may make some men attractive to women. Given the laws of supply and demand, securing the favor of such men will involve assuming an appearance and demeanor that advertises willingness to engage in a short-term relationship. Conditions of poverty intensify women’s intersexual and intrasexual competition for mates (Campbell, 2013, 2015).

In addition to seeking resources through associations with men, women living in situations of high extrinsic stress are more vulnerable to involvement in crime although their involvement is cross-culturally lower than men’s. In Britain, women are arrested for nearly 15% of detected crime (Parity, 2013) and, as in the United States, they are disproportionately represented in petty financially motivated crimes such as fraud and forgery (24.9%) and theft and handling (22.1%) reflecting resource-based motivation. A high proportion of women offenders are undereducated, unemployed, receiving welfare benefits, and supporting dependent family members (Chesney-Lind, 1997). Traits associated with offending (including sensation seeking, impulsivity, shortened time horizons) may be elevated among women pursuing a faster LH strategy.

Ideally, future studies will consider the implementation of research designs that allow us to look at many of these factors and traits within a LH framework in more detail. Men and women will respond to different environmental cues and (obviously) different biological events via differentially attuned psychological mechanisms to facilitate fitness goals. As such, measures and analyses that can help us look more closely at their differences will be invaluablely informative, particularly from an interventionist or social policy perspective.

One very useful psychometric tool for exploring such differences is multigroup CFA (MGCFA; see Frazier et al., 2004). In the MGCFA framework, sex differences in LH strategy might manifest as configural variance (i.e., different items load on different factors), metric variance (i.e., different loading magnitudes), scalar variance (i.e., different item intercepts or thresholds), and/or factor level differences in parameters including means and variances. By identifying sex differences in MGCFA models, researchers can discover if LH factors are proxies for different constructs (or mechanisms) between the sexes, as they are if at least partial metric and scalar invariance do not hold. If we are indeed measuring the same constructs across the sexes, these models can help us determine what differences exist at the construct level, or in terms of factor variances or means.

In sum, MGCFA can address important questions about LH dimensions, such as (a) Does the K factor exist and have the same meaning across the sexes? (b) Given that measurement

invariance holds, do the K factor means and variances differ significantly between the sexes? Importantly, differences in the means cannot be interpreted if measurement invariance does not hold. This is because the same construct is not measured across groups. Similar, sex differences in the correlates of the K factor (or other LH factor) could simply reflect the fact that the construct does not have the same identity in males and females. If measurement invariance holds, then sex differences can be interpreted in terms of differences in means and variances. And, sex differences in the K factor’s nomological net can be traced to factor variance differences (with males expected to exhibit greater variance) or otherwise explained with reference to the evolved sex differences discussed above. At this early stage, the dimensionality of LH indicators is not well-established and it is not yet clear that any LH dimensions are invariant by sex. These issues should be a focus for LH researchers.

Item Parcels

Figueredo et al.’s critique strongly advocated the use of item parcels when evaluating LH models. Item parcels are created either by averaging or aggregating the scores of multiple indices of a theoretical construct. Thus, a scale of five items can be reduced to only one number for the purposes of analysis. As many inventories can potentially have hundreds of items, parceling is a pragmatic way of reducing the case-to-variable ratio for the purposes of analysis. Further advantages have been suggested, such as improving item fit, improving internal consistency, more stable parameter estimates and reducing the level of idiosyncratic behavior from individual items (Bandalos & Finney, 2001; Little, Cunningham, Shahar, & Widaman, 2002; Little, Rhemtulla, Gibson, & Schoemann, 2013; Marsh, Hau, Balla, & Grayson, 1998; Marsh & O’Neill, 1984; Williams & O’Boyle, 2008; Yang, Nay, & Hoyle, 2010).

However, creating a factor via an item parcel is not the same as examining the same factor as a manifestation of its original indicators because the parcel is a new variable and fundamentally changes the nature of the data. It is for this reason some argue that item parceling is not an acceptable way to treat data for the purposes of analysis (Marsh, Ludtke, Nagengast, Morin, & Von Davier, 2013). Many researchers ignore the fact that parceled items should be demonstrably unidimensional and that acceptable fit should be achievable when using CFA to model the parceled factor without cross loadings or secondary factors (Marsh & O’Neill, 1984). The field of psychometrics has generally accepted that if these basic assumptions are met and have been replicated consistently, parceling in this manner is acceptable. Unfortunately, these guidelines are not always adhered to: Parcelled scales are often assumed to be valid and reliable measures representing the underlying construct without being tested formally via other methods (Marsh et al., 2013). Marsh et al. provide a series of examples and simulations that demonstrate how scales that do not work as conceptually specified can nonetheless achieve acceptable statistical fit when parcels are used instead (including *random* parcels).

Often, as mentioned earlier, Cronbach's α alone is used as a proxy to justify unidimensionality without formal testing.

With regards to the HKSS, no such assumptions regarding its structure could be made as no test of the underlying factor structure had ever been conducted to examine the original theoretical proposal. Our analysis of the HKSS suggested that the original specification was not unidimensional and that cross loadings between the proposed factors were evident. Treating the originally suggested subscales independently was equally problematic. The revision of the original items creates a better model with four factors that did not cross load at item level (although the resulting factors are not independent). Given this, what justification would there have been to parcel the HKSS in the manner Figueredo et al. suggested? Had this been done, the problems inherent in the measure would have been effectively hidden from view and thus we would have created a measure with a presumably near perfect fit with only four items. Misspecification would have been masked by the creation of four new variables. What would this new scale mean? Would it accurately reflect responses to items? Would the relationships between factors now be meaningful? This all seems unlikely.

When interpreting models, it is important to consider what they actually represent. Can a model using parcels (including nonrandom parcels) really reflect anything conceptually relevant? The concept underlying the measure must be kept in mind during model construction in CFA. If not, what is being confirmed? The decision in our study to treat the models by specifying the underlying structure in full (rather than by parceling) was the correct way to treat these data, particularly in the absence of historic evidence that the proposed structure was acceptable to begin with. Considering that our sample size was large enough to evaluate the full scale on an item level, what reason would there be to reduce this model down to three or four parcels? To parcel the items post hoc as suggested by our critics would achieve statistical parsimony at the expense of validity. This would not advance our understanding of LH strategies. The structural analysis we employed helped to develop a scale that could reconcile theory with the available data set. Had the model not been specified in full, it would have been impossible to perform detailed examination of specific items to determine which were problematic for the scale.

Summary

While accepting many of the comments made by Figueredo et al., we feel our original work was far from "psychometrically invalid" and reiterate calls for further consideration to be given to actual life events and for greater synthesis of these with psychological variables deemed important to the LH strategies. In doing so, researchers should be able to determine if the nomological net as described by Rushton (1985), Figueredo et al. (2015), and others exists in a form that can be reduced to an aggregated factor score. Furthermore, we urge researchers to pay more attention to the constituent latent traits on higher order factors prior to aggregation and to publish more data regarding their structure ensuring that the lower order traits are

valid structural measures of relevant LH traits before aggregating them into higher order factors and/or using parceled measures will afford greater confidence in the interpretation of results. Invariance testing across groups will also allow us to more adequately generalize findings across different populations including culture, class, and sex. The validity of K-based measures in relation to adaptively relevant behaviors must be considered in greater detail if further substantial progress is to be made in the field.

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