Evolution and Human Behavior 29 (2008) 201–210

Evolution and Human Behavior

Assortative mating and offspring well-being: theory and empirical findings from a native Amazonian society in Bolivia

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Initial receipt 8 April 2007; final revision received 14 December 2007

Abstract

Mate choice matters for inclusive fitness, household economic efficiency, assimilation, stratification, and economic inequalities in society. In positive assortative mating, people pair with someone who resembles them along a trait, whereas in negative assortative mating, people pair with someone who differs from them along a trait. In industrial nations, people tend to follow positive assortative mating for fundamental demographic dimensions (e.g., age, schooling) and might practice negative assortative mating for economic outcomes (e.g., earnings). Research on assortative mating has focused on industrial nations, generally compared only one trait between couples, and paid scant attention to the effects of assortative mating for offspring well-being. If assortative mating enhances inclusive fitness, it might also enhance offspring well-being. Drawing on data from a farming–foraging society in the Bolivian Amazon (Tsimane') that practices preferential cross-cousin marriage, we (*a*) identify six parental traits (age, knowledge, wealth, schooling, height, and smiles) for which Tsimane' might practice assortative mating and (*b*) test the hypothesis that assortative mating enhances offspring well-being. Proxies for offspring well-being include height and school attainment. Tsimane' resemble people of industrial nations in practicing mostly positive assortative mating. Pairwise, mother–father and Pearson correlations of age, schooling, and earnings among Tsimane' resemble correlations of industrial nations. Correlation coefficients for the six parental traits were far higher than correlations that might happened just by chance. We found weak support for the hypothesis that assortative mating improves offspring well-being.

Keywords: Amazon; Bolivia; Tsimane'; Sexual selection; Fitness indicators; Latin America; Indigenous populations; Offspring well-being

1. Introduction

Theories from evolutionary biology and economics suggest that mate choice should contribute to inclusive fitness and enhance the economic efficiency of households (Becker, 1991; McGraw, 2002; Payne & Jaffe, 2005). Mate choice affects the socioeconomic fabric of a society because it can abrade or ossify social mobility, assimilation, stratification, and the intergenerational transmissions of socioeconomic inequalities (Kalmijn, 1998; Mare, 1991; Reynolds, Baker, & Pedersen, 2000).

Owing to the importance of mate choice, a large literature in the behavioral and natural sciences has addressed the role of a person's traits in selecting a mate (e.g., Noe, van Hooff, & Hammerstein, 2001; McPherson, Smith-Lovin, & Cook, 2001; Stone, Shackelford, & Buss, 2007). In positive assortative mating, people pair with someone who resembles them in a trait and in negative assortative mating people pair

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doi:10.1016/j.evolhumbehav.2007.12.003

with someone who differs from them in a trait. People may follow positive assortative mating for some traits (e.g., age, race) and pair with someone who resembles them in these traits, and they may follow negative assortative mating for other traits (e.g., earnings) and pair with someone who differs from them in these traits.

Research from industrial nations suggests that, in monogamous heterosexual or homosexual unions, people seek a partner who resembles them in fundamental traits, such as age, race, schooling, physical appearance, morality, personality, religion, and intelligence (Little, Burt, & Perrett, 2006; Miller, 2007; Sadalla, Kenrick, & Vershure, 1987; Sloman & Dunham, 2004; South, 1991). But they may also seek a partner who differs from them in other traits, particularly in economic traits (Becker, 1991; Goldstein & Harknett, 2006). For example, Jepsen & Jepsen (2006) studied cohabitating couples of the same and opposite sex in the United States and found positive assortative mating for some traits (e.g., schooling, age) and negative assortative mating for earnings, that is, among couples who resembled each other in schooling and age, those with higher earnings tended to couple with those of lower earnings. In industrial nations, correlation coefficients for a trait between a wife and a husband vary widely. In one study, these ranged from a high of +0.72 for age to a low of +0.29 for earnings (Jepsen & Jepsen 2004).

As Marlowe (2004) notes, most empirical research on assortative mating known to us has taken place in industrial nations (Hur, 2003), generally compared only one trait between couples (for exception, see Jepsen & Jepsen, 2004), and paid scant attention to the consequences of assortative mating for offspring well-being.

We know of only two studies linking parental assortative mating with offspring outcomes, and both studies suggest that positive assortative mating was associated with poorer offspring outcomes. The comparison with the present study is limited because the traits studied in previous investigations were fitness-reducing. In one study, researchers found that positive assortative mating for body mass index (BMI; kg/m^2) among 8663 Swedish couples during 1987–2000 was positively associated with offspring obesity (Jacobson, Torgerson, Sjostrom, & Bouchard, 2007). Similar to the above Swedish study, in a study of 2612 adolescents from 911 families in the United States, Hartman, Lessem, Hopfer, Crowley, and Stallings (2006) found that spousal resemblance in substance use was positively associated with alcohol abuse by offspring but was not associated with offspring drug dependence.

Drawing on data from an endogamous farming and foraging society in the Bolivian Amazon, the Tsimane', that practices preferential cross-cousin marriage, here, we extend empirical research on assortative mating to achieve three aims. First, we examine six traits of 242 mother–father dyads with offspring in our sample to identify the types of assortative mating practiced by parents. Second, we use multiple regressions to estimate the association between (*a*) two well-being indicators for offspring ages 3–20 years (inclusive), which we use as outcome variables and (*b*) six parental traits that capture a range of assortative mating preferences, which we use as explanatory variables. Third, we test the hypothesis that assortative mating enhances offspring well-being.

2. Theory and hypotheses

We draw on two complementary theories, one from evolutionary biology and one from economics, to frame hypotheses for the empirical analysis. Both theories emphasize the optimization of utility (game theory), where utility equals fitness for the biologist and money (or consumption) for the economist (Hammerstein & Hagen, 2005; Noe et al., 2001).

2.1. Theory: evolutionary biology

Evolutionary biology suggests that assortative mating should enhance reproductive fitness (Buss, 1985; Jones, 1995; Jones & Hill, 1996; Laeng, Mathisen, & Johnsen, 2007; McGraw, 2002; Sloman & Sloman, 1988). One evolutionary theory suggests that assortative mating allows for the maintenance of different adaptive behavioral or physiological profiles in a species (Groothuis & Carere, 2005). Consistent with this theory, assortative mating tends to be more pronounced for more heritable traits (Rushton & Bons, 2005). Evolutionary theory also suggests that assortative mating may result from trying to optimize the reproductive value of one's mates. Everyone wants a mate with the highest mate value, but choosing a mate with a value too much higher than one might result in rejection. Since choosing a mate with low reproductive value is also a poor choice, the result may be matching, or assortative mating (Figueredo, Sefcek, & Jones, 2006; Kirsner, Figueredo, & Jacobs, 2003).

Nevertheless, negative assortative mating might be better because it allows for a more diverse immune system capable of more readily recognizing immunological assaults. An optimal amount of heterogeneity in assortative mating may maximize inclusive fitness (Garver-Apgar, Gangestad, Thornhill, Miller, & Olp, 2006; Penn, Damjanovich, & Potts, 2002; Thornhill, Gangestad, Miller, Scheyd, & McCollough, 2003; Wedekind, Seebeck, Bettens, & Paepke, 1995). Furthermore, the propensity to mate with someone dissimilar to oneself may avoid inbreeding (Penn et al., 2002).

In preindustrial societies, people select mates based on physical and psychological attributes, production skills, and fertility (Marlowe, 2004). Having selected a mate, there are a positive associations between (*a*) hunting skills, (*b*) number of mates, and (*c*) reproductive success (Kaplan & Hill, 1985; Smith, 2004).

This line of research stresses the link between mate attributes and reproductive success but makes few predictions about why people would practice positive or negative assortative mating or about the effects of assortative mating for offspring well-being. Matching on desirable traits might increase the total number of offspring but might not improve offspring quality.

2.2. Theory: economics

The second theoretical strand goes back to the work of Becker (1974, 1991) and complements the work of evolutionary biologists because it explains the conditions that might give rise to positive or to negative assortative mating. Unlike evolutionary biologists, economists have stressed the determinants of different types of assortative mating rather than the consequences of assortative mating.

Becker hypothesized that the household, like a firm, produces goods and services to increase utility. In his view, a mate is an input in the production activities of a household. Some mate attributes allow the household to function more efficiently. In selecting a mate, people seek a partner who resembles them along fundamental traits and do so because positive assortative mating facilitates communication and, in so doing, the efficiency of the household. Becker predicted that people would seek partners who resembled them in age, race, ethnicity, and other fundamental traits. In economic terms, these traits are “complements” because they go together; like bread and butter, the more of one, the more of the other. But he also predicted that to enhance the economic efficiency of the household through the sexual division of labor in the household, people would seek partners who could “substitute” for their traits. Within the pool of people who shared fundamental traits, people would pair with those of, say, higher earnings, more wealth, or those who could work longer hours in the labor market. Such mating would allow for a finer-grained division of labor in the household and raise total household productivity and utility. For economic outcomes such as hours worked in the labor market, earnings, and wealth, Becker predicted negative assortative mating. Much of the empirical literature from industrial nations cited earlier supports Becker’s predictions about positive assortative mating, but support for Becker’s hypothesis about negative assortative mating has been weaker (Jepsen & Jepsen, 2004).

2.3. Hypothesis

Couples practicing positive assortative mating for fundamental traits and negative assortative mating for economic traits should have more efficient, smooth-running households, which should be associated with improved offspring well-being.

H1. A *decrease* in the mother–father gap in traits for which there is *positive* assortative mating will be positively associated with offspring well-being.

H2. An *increase* in the mother-father gap in traits for which there is *negative* assortative mating will be positively associated with offspring well-being.

3. Methods

3.1. Estimation strategy: steps

First, we selected six parental traits to identify the type of assortative mating practiced by couples. We used three criteria to select traits. (1) Traits had to capture economic outcomes and fundamental sociodemographic attributes. See the next paragraph for the rationale behind the choice of traits. (2) Traits had to remain relatively impervious to change after people formed a union (Little et al., 2006; Watson et al., 2004). (3) Traits had to lend themselves to direct, objective measurement. The six parental traits included age, indigenous knowledge of edible plants, wealth, school attainment, height, and happiness (smiling frequency).

Recall from the review of the literature presented earlier that theory and previous studies suggest that people practice positive assortative mating for fundamental traits. In selecting parental traits, we focused on basic demographic (age), human capital (indigenous knowledge of plants, school attainment), appearance (height), and psychological attributes (smiling) because prior studies suggest that there should be positive assortative mating for these traits. If Tsimane’ resembles their peers in industrial nations in patterns of assortative mating, then for these traits, we expect positive assortative mating and therefore we should be able to test Hypothesis 1. But we also selected wealth because it is an economic outcome, and we should therefore expect negative assortative mating on this trait; wealth allows us to test Hypothesis 2. Together, the six traits allow us to explore how a range of positive and negative traits might influence offspring well-being.

Second, for each trait we took the measure of the mother and subtracted the measure of the father. Third, we used multiple regressions with two indices of offspring well-being (school attainment, height) as separate outcome variables against all the mother–father differences for the six traits (explanatory variables). To correct for the nonindependence of siblings with the same parents, we ran regressions with clustering by household.

3.2. Sample

Data come from a panel study in progress that started in 2002 in 13 Tsimane’ villages along the Maniqui River, Department of Beni, Bolivia. Villages differed in their proximity to the nearest market town, San Borja (pop ~19,000). The average village in the sample was 25.96 km in a straight trajectory from San Borja (S.D.=16.70).

For this article, we use data from the 2005 survey. The 2005 survey took place during June–September and included *all* people in *all* households (n=252) of the 13 villages. We stress *all* because the sample does not suffer from an obvious selection bias, though it could be biased if attrition had taken place before the study took place and attrition had been systematically linked with both child outcomes and assortative mating. Unfortunately, we lack data to assess this possibility. The sample included 176 mother–father couples with children 3–20 years of age living in the same household. Mother–father couples had an average of 3.49 children (S.D.=2.00). Three experienced interviewers from the highlands of Bolivia and three Tsimane' translators who had worked in the study from the beginning did the surveys. Interviewers administered the questions directly to any person ≥16 years of age but asked the principal caretaker (chiefly mothers) about the attributes of people <16 years of age.

3.3. Measure of variables: parents

3.3.1. Age

Surveyors asked participants to estimate their age in years. Estimates of reported age contain random rather than systematic measurement errors—some adults guessed and overestimated their age and others guessed and underestimated their age (Godoy, Reyes-García, et al., 2006). Random measurement error in age will attenuate our estimates of how the mother–father age difference affects offspring well-being.

3.3.2. Indigenous knowledge of edible plants

We asked people to name edible plants (McDade et al., 2007; Reyes-García et al., 2005). The questions capture theoretical or passive knowledge—the ability to simply identify the plant, but not necessarily the ability to use the plant. We used cultural consensus analysis (Romney, Weller, & Batchelder, 1986) to develop a score of cultural competence for each respondent.

3.3.3. Wealth in physical assets owned by person

To measure wealth, we did the following: (*a*) asked about the quantity of an assortment of traditional physical assets (e.g., bows, canoes), domesticated animals, and commercial assets (e.g., metal tools) owned by the person, (*b*) multiplied the quantities by the current village price, and (*c*) added the values to arrive at a proxy for total wealth (Godoy, Reyes-García, et al., 2005).

3.3.4. School attainment

We asked people to report the maximum school grade attained (Godoy, Reyes-García, Leonard, et al., 2007).

3.3.5. Height

To measure height, we followed the protocol of Lohman, Roche, & Martorell (1988) and measured standing physical stature in cm while people stood in an upright position on a flat surface, without hats or shoes (Foster et al., 2005; McDade et al., 2005).

3.3.6. Smiling

During the interview, surveyors noted how often people smiled and coded answers as follow: 1 (somber, no smile or laughter), 2 (smiled without laughter), 3 (smiled and laughed many times), 4 (cachinnate) (Godoy, Huanca, et al., 2005, 2006). Elsewhere (Godoy, Huanca, et al., 2005), we review evidence suggesting that smiles reflect both a stable personality trait and situational factors. That said, among the six parental traits considered, smiles is probably the one most likely to change in the short run.

3.4. Measure of variables: offspring

Indices of offspring well-being included two relatively stable traits: height and school attainment. Height is a canonical indicator of long-run nutritional status and schooling is associated with improved indices of quality of life (e.g., earnings, health) across many societies (Godoy, Reyes-García, Seyfried, et al., 2007).

4. The people

The Tsimane' number ~8,000 people and live in the rainforests and Savannahs at the foothills of the Andes, mostly in the Department of Beni, Bolivia. Relatively isolated until the mid 20th century, they started to engage in more frequent and prolonged contact with Westerners after the arrival of Protestant missionaries in the late 1940s and early 1950s. Like many native Amazonians, Tsimane' combine slash-and-burn farming with hunting, gathering, and fishing (Vadez et al., 2004).

The Tsimane' follow a sexual division of labor. Women do all farm chores (except for cutting large trees), cook, prepare and serve home-brewed beverages, and provide child care. Men hunt, cut large trees in the forests as they prepare plots to farm, do routine farm chores, and work for wages in cattle ranches and logging firms. These tasks aside, women and men substitute for each other in other tasks.

Like other native Amazonians, Tsimane' practice preferential cross-cousin marriage, meaning that a man should mate with his mother's brother's or father's sister's daughter. In ethnographic research in progress, we found that ~75% of Tsimane' couples had married their cross cousin, with a higher share in more remote villages (Patel et al., 2006). Tsimane' stigmatize those who do not marry their cross-cousin and say that, after they die, offenders become jaguars and eat living people. Unfortunately, we do not have quantitative data on cross-cousin marriage to control for it in the statistical analysis, but later, we discuss the implications for our results of omitting a measure for cross-cousin marriage.

People form new households when they decide to live together, but there is no marriage ritual. Couples make a new house when they have their first child. Residence after marriage is fluid, with some couples following matrilocal residence and others following patrilocal residence. After the birth of their first child, couples follow neolocal residence, but we do not have data to know whether neolocal residence is in the same community as their parents or in an entirely different community. Polygynous in the past, the Tsimane' at present practice mostly monogamy; only six of the 242 adult men we interviewed practiced polygyny.

Couples have many opportunities to learn about future mates. Tsimane' frequently visit each other to socialize (Ellis, 1996) and likely obtain information about potential mates from the visits. For 216 couples in our sample, we had information about the village in which they had grown up. Of the 216 couples, 45 couples (20.83%) had grown up in the same village; most of the couples (79.17%) consisted of pairs of people who had grown up in different villages.

Tsimane' parents alert their young children of their eligible mates are. Open-ended, qualitative interviews suggest that Tsimane' choose their own mates, though parents exert informal pressure on who to marry. Parents of girls exert more pressure than parents of boys. The pressure takes the form of jokes about the best mate for their daughters; the jokes take place while drinking fermented beverages. The future mother-in-law sees in the in-marrying young men an extra purveyor of game meat, and the future father-in-law sees in his son-in-law a companion when farming or hunting. Males typically form unions by the time they reach ~16 years of age, and females form unions as young as 13 years of age but typically also at ~16 years of age.

Besides kinship status, Tsimane' search for a range of personal traits in their mates. Men value women who know how to weave, wash clothes, cook wild game, prepare fermented beverages, and spin cotton. Men search for women who enjoy accompanying men on hunting and fishing trips. Men value beauty and long hair in their mates and want mates of about the same age but say that they do not want taller women. Women value men who farm and hunt well, who know how to fish with a bow and arrow, who enjoy drinking fermented beverages, and who work hard. Women prefer a mate of roughly the same height. In the past, women did not value fluency in spoken Spanish in their potential mate, but today, more women say that they want a man who can speak Spanish because Spanish fluency opens employment opportunities in the regional economy.

Tsimane' value reproduction and, in their myths, speak of wanting to resemble spiders because spiders have many offspring. Tsimane' cannot conceive of a union without children and they do not form a union unless they can have offspring. In unions without offspring, one of the partners leaves, or else, they seek assistance from people with local medicinal knowledge to help them redress infertility.

5. Results

5.1. Bivariate analysis: mother–father, pairwise, Pearson correlations and mother–father difference in traits

Table 1, column [3], contains the results of mother–father, pairwise, Pearson correlations for six parental traits. We use the Šidák method so that levels of statistical significance take into account multiple comparisons. Three findings stand out.

First, all correlations were positive and all were statistically significant ($p<.01$), suggesting that Tsimane' practice positive rather than negative assortative mating for the traits under study. We found no negative correlations, particularly for economic outcomes, such as wealth, as one might have expected from Becker's hypothesis. Second, correlation coefficients varied widely, from a high of +0.88 for age and +0.63 for indigenous knowledge of edible plants to +0.16 for height and smiles. Third, to assess whether bivariate relations remained after controlling for the role of parental age, we regressed mother's attribute (outcome variable) against father's attribute (explanatory variable) while controlling for the age of each parent separately. The results, shown in column [6] of Table 1, suggest that the

Table 1
Test of assortative mating for mothers and fathers and mother–father comparison of selected traits among Tsimane', 2005

		Test of assortative mating for couples				Mean and standard deviation (SD) of trait for each parent					
		Pearson correlation coefficient of			OLS regression controlling for age	Mother		Father		Mother–father difference	
		Actual dyad	10 random pairings								
Trait	N		Mean	Median		Mean	SD	Mean	SD	Mean	SD
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
Age	242	0.88*	−0.004	0.0005	NA	37.00	16.97	39.61	17.22	−2.61*	8.32
Knowledge	241	0.63*	0.05	0.02	0.60*	10.54	2.78	11.08	2.79	−0.53*	2.38
Wealth	242	0.40*	−0.03	−0.03	0.07*	590	485	2263	1870	−1673*	1732
School	237	0.30*	0.02	0.03	0.07	1.24	1.49	2.56	2.93	−1.32*	2.86
Height	240	0.16*	0.008	0.008	0.16*	151.11	4.92	163.09	4.76	−11.98*	6.25
Smiles	242	0.16*	0.02	0.001	0.16*	2.44	0.78	2.46	0.78	−0.02	1.01

Notes: * $p<.01$. In columns [3]–[5], Šidák method used to adjust significance levels to take into account multiple comparisons. Columns [4]–[5] summarize the mean and median Pearson correlation coefficients for 10 random pairings of a mother with a father (Glicksohn & Golan, 2001); see text for details. [6] is an ordinary least squares (OLS) regression with robust standard errors of mother's attribute (outcome) against father's attribute controlling for the age of each parent. Except for the row "Smiles", column [11] contains results of t test comparing mean difference between mother and father; for row "Smiles", column 11 contains results of chi-squared test. Definition of traits: Age=age of person in years. Knowledge=local or indigenous knowledge of wild edible plants using cultural consensus analysis. Wealth=monetary value in *bolivianos* for selected physical assets owned by person (1 US dollar ≈ 7.98 *bolivianos* at time of fieldwork). School=maximum school grade attained. Height=standing physical stature (cm). Smiles=person smiled during interview=1 (somber, no smile or laughter), 2 (smiled without laughter), 3 (smiled and laughed many times), 4 (cachinnate). NA=not applicable.

positive associations of column [3] for knowledge, height, and smiles persists after controlling for parental age, and remained statistically significant at the 99% confidence level or higher. Controlling for the age of each spouse did not affect the wife–husband bivariate relations of height or knowledge because these outcomes do not change much with age among adults. Among Tsimane', height peaks by the time people reach their early 20s (Godoy, Leonard, et al., 2006) and theoretical knowledge of plants also peaks by the time people reach their late teens (Godoy et al., 2007). Smiles have a strong hereditary basis (Godoy, Huanca, et al., 2005) and so might also not change much with age. On the other hand, wealth and schooling vary with age. Wealth has a strong life-cycle component, so we would expect the bivariate association to change after conditioning for age, and the introduction of schooling among Tsimane' is recent (dating to the 1950s) so we expect schooling levels to differ between young and old cohorts.

In sum, bivariate analysis suggests that when they form a union, Tsimane' mate with people who resemble them in the traits under study.

To assess how far results deviate from correlations that might have happened from purely random mating, we build on the work of Glicksohn and Golan (2001). First, since we had roughly the same number of mothers and fathers (~250) we assigned each mother a random integer from 1 to 250, and we did the same for each father. Second, we created random pairs of mothers and fathers by using the random integer to match a mother with a father. Third, we computed pairwise, Pearson correlation coefficients using the Šidák method for each of the six parental traits for the randomly assigned couples. Fourth, we repeated 10 times the first three steps, with each parent assigned a new random integer and a new random mate each time. Columns [4]–[5] contain the mean and median Pearson correlation coefficients for each of the six traits for the ten iterations.

The Pearson correlation coefficients for the randomly assigned mother–father dyads (columns [4]–[5]) were considerably lower than the Pearson correlation coefficients for the actual mother–father dyads (column [3]). For example, the highest mean Pearson correlation coefficient for randomly assigned parents was 0.05 for indigenous knowledge of edible plants (column [4]); among actual mother–father dyads, the Pearson correlation coefficient for indigenous knowledge of edible plants was 0.63. Furthermore, no coefficient for the randomly assigned mother–father dyads (columns [4]–[5]) was statistically significant at the 99% confidence level or higher. In contrast, the Pearson correlation coefficients for actual mother–father dyads were all ≥ 0.16 and all were statistically significant at the 99% confidence level or higher. Even if we take the two traits from the actual mother–father dyads with the lowest Pearson correlations (height and smiles) we find that the values were each 0.16. The mean Pearson correlation coefficients for these traits for randomly assigned parents were much lower: 0.008 for height and 0.02 for smiles. In sum, we find strong evidence for positive assortative mating; it is highly unlikely that results could reflect pure chance.

Columns [7]–[12] of Table 1 show the raw scores of mothers and fathers and the mother-father difference in the score for each of the six traits. Fathers scored higher than mothers in all traits.

5.2. Multivariate regressions

In Table 2 we show the results of multivariate regressions to estimate the association between: (a) the two indices of offspring well-being (height and schooling) used as outcome variables and (b) mother–father difference for the six parental traits (explanatory variables), along with several control variables described in the notes to Table 2.

5.2.1. Height

The most striking result of Table 2 is the absence of any large or statistically significant relation between parental assortative mating and offspring height. None of the six mother–father difference in traits bore a statistically significant relation with offspring height at the 95% confidence level or higher. If we put aside statistical significance because it might reflect a small sample size of effective observations (see section 6) and focus instead on the magnitude of the coefficients, we again find very small effects. For example, the coefficients of Table 2 imply that doubling the mother–father difference in age from, say, a mean difference of 2.61 years (Table 1, column [11]) to 5.22 years would be associated with an increase in the height of an offspring of only ~0.20% (~0.18 cm; $p<.83$), an insignificant biological amount.

Table 2
Regression results: Association between offspring height and schooling (dependent variables) and indices of parental assortative mating, Tsimane', 2005

Explanatory variables	Indices of offspring well-being (dependent variables): Natural log of standing height (3≥age≤20)	Maximum school grade attained (6≥age≤20)
Mother–father difference in:		
Natural log of age	0.002	−0.34
Natural log of knowledge	0.002	−0.04
Natural log of wealth	−0.002	0.01
School	0.0003	−0.001
Natural log of height	0.0008	3.73§
Smile	0.001	−0.06
Offspring		
Age in years	0.001	0.27*
Natural log of weight	0.36*	NA
Sex (male=1; female=0)	0.005	0.49*
Constant	3.60*	−0.91§
R squared	0.95	0.54
N	653	481

Notes: * and § significant at <1% and <5%. Regressions are OLS with clustering by household and with a full set (n=13−1=12) of village dummy variables (not shown). Notes to Table 1 contain definition of variables. Weight=offspring's weight in kg in light clothing, without shoes or hat.

A convincing proof of hypothesis #1 would have yielded both negative signs for all the coefficients of mother–father difference (except for wealth), and reasonable levels of statistical significance for those coefficients, neither of which we found. Similarly, a convincing proof of hypothesis #2 would have produced a large and statistically meaningful positive coefficient for the mother–father difference in wealth; the sign of the coefficient was positive but statistically insignificant (p<.32).

5.2.2. School attainment

The regression results with offspring school attainment as an outcome variable also did not support hypothesis #1. Only one of the five coefficients for which we expected positive assortative mating was statistically significant, but it had the wrong (positive) sign. Doubling the mother–father difference in height was associated with 3.73 more years of offspring schooling (p<.016). Of the five coefficients related to mother–father differences in traits for which we expected positive assortative mating, four coefficients (age, indigenous knowledge of plants, schooling, and smiles) bore the correct negative sign predicted by hypothesis #1, but none of the coefficients was statistically significant at the 95% confidence level or higher. Hypothesis #2 says that the mother–father difference in wealth should have been positively associated with offspring school achievement; the coefficient for the wealth variable bore the correct positive sign predicted by hypothesis #2, but was statistically insignificant (p<.82).

5.3. Extensions and robustness

We did further analyses to assess whether the main results held up. First, we re-estimated the regressions of Table 2 using other methods to compute difference in a trait between mothers and fathers (e.g., absolute value of the difference in the measure of the trait, interaction of parental traits) (Luo & Klohnen, 2005; Griffin, Murray, & González, 1999; Kenny, 1988) and found essentially the same results.

Second, recall from the earlier discussion that assortative mating should enhance reproductive success. The ideal test would include a measure of fertility as an outcome. We lack such data, so we could not directly test the idea, but we tested it using household size as a proxy for fertility. Household size is an imperfect proxy for fertility because the household might include people without blood links to the mother–father heading the household. Nor does household size pick up offspring mortality, or offspring living in other households or villages besides the ones we studied. Bearing those caveats in mind, we ran an OLS regression (not shown) with the natural logarithm of household size as an outcome variable, the six variables of Table 2 measuring mother–father difference in a trait as explanatory variables, and clustering by household. We found mixed support for the idea. A one-percent increase in the mother–father difference in the monetary value of total wealth was associated with 0.09% (p<.001) smaller household size, consistent with hypothesis 1. However, an increase of one point in the discrepancy between mothers and fathers in the smiling variable was associated with 12.80% (p<.001) larger household size. We re-estimated the regression including not the mother–father difference in the smile variables, but the actual measure of smiling of the mother and the father and found that each bore a statistically significant association with household size, but in the opposite directions. A one point increase in the smile variable (e.g., from *(i)* somber to *(ii)* smile without laughter) of the father was associated with 15.85% smaller household size (p<.001), but a similar increase in the smile variable of the mothers was associated with a 9.72% (p<.007) increase in household size. Possibly larger families tire one parent more than the other; hence the discrepancy. It is also possible that the mother and the father differ in their ideal family size and that the achieved household size caused one parent to be less happy.

Third, we re-estimated the regression of offspring height of Table 2, but only for offspring 3–13 years of age because the well-being of younger offspring may have a tighter link with parental attributes since older siblings might be more independent. The main conclusions persisted after lowering the top age of the cohort.

Last, we tested an alternative hypothesis suggested by one reviewer that people may not try to mate in an assortative way, but rather try to mate to maximize the total amount of resources in the households. To test the hypothesis, we re-estimated the regressions of Table 2, but added (rather than subtracted) the measure of the mother plus the measure of the father. The coefficients generally supported the hypothesis; most of the coefficients were positive, though none was statistically significant at the 95% confidence level or higher. The two models, assortment and maximization, fit the data about equally well; the r square values with either model were ~0.95 for the regression with offspring height as an outcome and ~0.54 for the regression with offspring school achievement as an outcome.

6. Strengths and limitations

Strengths of the study include: (a) a focus on a preindustrial farming–foraging society, (b) a relatively large sample of observations for a field-based biocultural anthropological study, (c) many years of field experience in the site as part of a panel study in progress, and (d) the use of a multivariate approach.

The study contains at least four shortcomings. First, random measurement error in some explanatory variables (e.g., age) contribute to an attenuation bias. Second, the sample size may have been too small to produce strong statistical relations if true relations were, in fact, small. We had 481 children with data on schooling and 653 children with data on height, but since many of these children were siblings and we controlled for household effects through clustering by household, our effective sample size of truly independent observations of children is smaller than these numbers suggest.

Third, we may have focused on inappropriate parental traits. Mates might select each other based on traits we did not measure (e.g., intelligence). These missing traits might bear a stronger association with offspring well-being than the traits we included.

Fourth, we could not correct for the endogeneity of assortative mating, including whether couples followed the rule of cross-cousin marriage. If unobserved or unmeasured factors that drive assortative mating also influence offspring well-being, then the parameters we have estimated will contain biases of an unknown size and magnitude.

The implications of a cross-cousin marriage system for studies of assortative mating and for our results are unclear. Cross-cousin marriage could be a cultural adaptation to promote assortative mating. In exploratory work in progress in only two villages we estimate that marriageable Tsimane' have an average of 5.10 potential partners to choose from, 1.80 of whom are eligible cross cousins. We do not know the background level of association between traits among randomly selected cousins. Additionally, in a society that over centuries has consistently practiced cross-cousin marriage the genetic relatedness between cousins may be greater than in a society without preferential cross-cousin marriage. The correlations in Table 1 all being positive could reflect this background and the variation in the coefficients could reflect differential heritability of traits (except for age). This might be difficult to separate because more heritable traits tend to show stronger signals of assortative mating (Rushton & Bons, 2005).

Our inability to control for cross-cousin marriage produces a bias of unknown size and direction in the coefficients of Table 2. Cross-cousin marriage is likely positively correlated with positive assortative mating for human biological traits of couples. For example, due to the heritable (be it genetic, epigenetic or cultural heritability) nature of height (Weedon et al., 2007) and intelligence (Gray & Thompson, 2004), couples who follow the rule of cross-cousin marriage might be more likely to resemble each other in these two traits than couples who do not follow the rule of cross-cousin marriage. Intelligence or heritable personality traits such as impulsivity (Hur & Bouchard, 1997; Eisenberg et al., 2007; Isles, Humby, & Walters, 2004) might determine education levels (e.g. Godoy et al., 2004).

Of course, it is also possible that cross-cousin marriage itself might be directly associated with offspring height and school achievement. For example, it is possible that couples who follow the cross-cousin marriage rule have particular beliefs about human capital accumulation, nutrition, and health that set them apart from couples who do not follow the marriage rule. If so, then our failure to control for cross-cousin marriage would produce bias parameter estimates. Unfortunately, our data does not allow us to assess these possibilities.

7. Discussion and conclusions

7.1. Comparison with other studies

The pairwise, wife–husband Pearson correlations of Table 1 for the Tsimane' resemble pairwise Pearson correlations from industrial nations. Jepsen and Jepsen (2004) drew on the 1990 census of the USA to assess assortative mating using 10 traits that captured economic and sociodemographic outcomes and found that Pearson correlations for cohabitating (but not married) couples were +0.72 for age (Tsimane'=+0.88), +0.49 for schooling (Tsimane'= +0.30), and +0.29 for monetary earnings (Tsimane'=+0.25, not shown). Like us, they found evidence only for positive assortative mating. Hur (2003) studied assortative mating among 501 married Korean twins using a mail questionnaire, and found high (+0.67) age-adjusted, pairwise correlation for schooling (Tsimane'=+0.30 uncorrected for age, +0.07 corrected for age), modest correlations (range: −0.10 to +0.26) for personality traits (Tsimane'=+0.16, with or without adjustment for age), and low correlation for height (+0.04) and BMI (+0.11) (Tsimane': height=+0.16, with or without adjustment for age; BMI=+0.021, with or without adjustment for age, not shown).

In sum, in the USA, Korea, and among the Tsimane', couples practice mainly positive assortative mating. The magnitudes of the correlations are broadly similar across the three sites, but the reasons for assortative mating might differ. In industrial nations, assortative mating reflects chiefly individual choice, whereas among the Tsimane' assortative mating might reflect both individual choice and preferential cross-cousin marriage.

7.2. Other possible explanations for weak statistical results

Besides some of the technical deficiencies discussed earlier, there are at least two other reasons that might explain the weak statistical associations between parental assortative mating and offspring well-being.

First, positive assortative mating might reflect a conflict between the interests of the parent and the interests of the child. With high extrinsic mortality or low competition, parents can maximize their fitness by prioritizing quantity over quality, thereby reducing the individual fitness of any given offspring.

Second, perhaps couples increase investment of time and other resources in offspring when they mate assortatively and, in so doing, enhance what might otherwise have been poorer offspring outcomes. For example, if less assortative couples have lower fertility and poorer quality offspring, they might have more resources to invest in fewer offspring.

As noted in the introduction, all studies of assortative mating known to us come from industrial societies and those studies have stressed the adverse consequences of positive assortative mating for the transgenerational transmission of socioeconomic stratification or inequality. We know next to nothing about assortative mating in small-scale, preindustrial societies that follow rules of preferential kin marriage. This study raises the intriguing possibility for future research that assortative mating partly induced by rules of preferential kin marriage might help level the socioeconomic playing field, or might reinforce an already level playing field. If we are right, then the breakdown of preferential kin marriage would allow more individual freedom in the choice of a mate, and with more individual freedom in assortative mating might also come more socioeconomic inequality.

Acknowledgments

Grants from the programs of Biological and Cultural Anthropology of the National Science Foundation (0134225, 0200767, and 0322380) financed the research. The IRB boards of Brandeis and Northwestern University approved the protocol and procedures used to collect information. Thanks to the Gran Consejo Tsimane', translators, and to villagers of the panel study for their continuous support. Thanks also to Naveen Jha for excellent research assistance, Victor Luevano for commenting on an earlier draft, and to the editor, Dan Fessler, and anonymous reviewers of EHB for several waves of challenging comments.

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